RFP FA483024R0007
Attachment 1b

MOODY AIR FORCE BASE
GEORGIA

MOODY INSTALLATION GUIDE
SPECIFICATIONS
June 2024

VOLUME 2
DIVISIONS 21-42

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		21 12 00	SD-02 Shop Drawings														
			Standpipe System	1.4.4	G												
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			Alarm Valves	2.1.10	G												
			Water Motor Alarms	2.1.11	G												
			Pressure Switch	2.1.12													
			G]														
			Waterflow Detector	2.1.13	G												
			Fire hose Cabinets	2.1.14	G												
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			Buried Pipe and Fittings	2.2.1	G												
			SD-06 Test Reports														
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		21 12 00	SD-11 Closeout Submittals														
			System As-Built Drawings	1.6.2	G												
		21 13 13	SD-01 Preconstruction Submittals														
			Qualified Fire Protection	1.2.3	G												
			Engineer (QFPE)														
			Sprinkler System Designer	1.4.2.1	G												
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			SD-03 Product Data														
			Pipe	2.2.1	G												
			Fittings	2.3.1.2	G												
			Valves	2.3.5	G												
			Alarm Valves	2.3.6	G												
			Relief Valves	2.8.5	G												
			Sprinklers	2.7	G												
			Pipe Hangers and Supports	2.3.4	G												
			Sprinkler Alarm Switch	2.4.1	G												
			Valve Supervisory (Tamper)	2.4.2	G												
			Switch														
			Fire Department Connection	2.6	G												
			Backflow Prevention Assembly	2.5	G												
			Air Vent	2.8.6	G												
			Hose Valve	2.5.1	G												
			Seismic Bracing	2.3.4	G												
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		21 13 13	SD-05 Design Data														
			Seismic Bracing	2.3.4	G												
			Hydraulic Calculations	1.2.1.2	G												
			SD-06 Test Reports														
			Test Procedures	3.7.1	G												
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			Verification of Compliant	3.7.2.1	G												
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			Operating and Maintenance	3.9	G												
			(O&M) Instructions														
			Spare Parts	1.6	G												
			SD-11 Closeout Submittals														
			As-built drawings	3.9													
		21 13 25	SD-01 Preconstruction Submittals														
			OPTICAL FLAME DETECTOR	3.23	G												
			AND FOAM/WATER DISCHARGE														
			TESTING, SAFETY, AND														
			ENVIRONMENTAL PLAN														
			SD-02 Shop Drawings														
			High-Expansion Foam Systems	1.2	G												
			SD-03 Product Data														
			Pipe	2.3.1													

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		21 13 25	Fittings and Couplings	2.3.5	G												
			Valves	1.3.8	G												
			hangers	2.3.8	G												
			Waterflow Pressure Alarm Switch	2.15.2	G												
			Surge Arresters	3.1.3	G												
			Surge Arresters	3.1.3	G												
			Foam System Control Panel	2.14.1	G												
			(FSCP)														
			Foam System Control Panel	2.14.1	G												
			(FSCP)														
			Foam System Control Panel	2.14.2	G												
			(FSCP)														
			Foam System Control Panel	2.14.2	G												
			(FSCP)														
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			Batteries	2.14.6.1	G												
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		21 13 25	Optical Flame Detectors and Controller	2.20	G													
			In-Line Balanced Pressure Proportioner Assembly	2.11.5	G													
			In-Line Balanced Pressure Proportioner Assembly	3.11	G													
			FOAM GENERATORS	2.12	G													
			Sway Bracing	3.1.1	G													
			Water Tight Junction Boxes	3.3.1	G													
			Foam/Water Flow Control Valves	2.6	G													
			Foam/Water Flow Control Valves	3.1.4	G													
			Strainer	2.5	G													
			Foam Concentrate	2.8	G													
			CONCENTRATE STORAGE TANK	2.9	G													
			Containment Tank Remote Capacity Monitoring and Diverter Valve Panel - Army	2.13	G													
			Foam Concentrate Pump	2.11.1	G													
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		21 13 25	OPTICAL FLAME DETECTION	3.18	G												
			SUPERVISED DISCONNECT IN														
			HANGAR BAY														
			FOAM/WATER	2.10	G												
			PROPORTIONING BY														
			INDUCTOR														
			Spare Parts	1.8	G												
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			Sprinkler System Designer	1.5.2	G												
			Fire Protection Specialist	1.5.1	G												
			Installer's Qualifications	1.6	G												
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			System hydraulic surge analysis	1.3.12	G												
			Test Data	3.34	G												
			Hydraulic Calculations	1.3.7	G												
			Foam Spread/Coverage	1.3.7	G												
			Calculations														
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		21 13 25	INSTALLER'S QUALIFICATIONS	1.6	G												
			Materials and Equipment	1.7.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Foam System	1.3.14	G												
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			As-built Drawings	3.38	G												
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			Fire Extinguishing System	1.2	G												
			SD-03 Product Data														
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			Fusible Links	2.2	G												
			Release Mechanisms	2.2	G												
			Valve	1.2.1	G												
			Discharge Nozzle	3.2.1	G												
			Pipe and Fittings	3.2.1	G												
			Piping and Accessories	2.1	G												
			Remote Manual Actuation	2.2	G												
			Stations														
			Pressure-operated Switches	3.2.1	G												
			Manufacturer's Installation and	3.1	G												
			Maintenance Manuals														
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			Qualifications of Installer	1.5.1	G												
			SD-08 Manufacturer’s Instructions														
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			Piping Layout	3.3.2	G												
			Pump Room	3.3.2	G												
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			Catalog Data	2.1	G												
			Spare Parts	1.6													
			Preliminary Tests	3.8.2													
			Field Tests	3.8	G												
			Manufacturer's Representative	1.7.6	G												
			Field Training	3.11.1	G												
			Army Final Acceptance Test														
			Navy Formal Inspection and														
			Tests														
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		21 30 00	Preliminary Tests	3.8.2													
			Army Final Acceptance Test														
			Navy Formal Inspection and		G												
			Tests														
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			Qualifications of Welders	1.7.2													
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			Preliminary Test Certification	1.7.4													
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		22 00 00	SD-02 Shop Drawings														
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		22 00 00	Fixtures	2.4													
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			WaterSense Label for Flush	2.4.3	S												
			Valve Water Closet														
			Flush Valve Urinals	2.4.4													
			WaterSense Label for Urinal	2.4.4	S												
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			WaterSense Label for Flush Tank	2.4.6	S												
			Water Closet														
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			Service Sinks	2.4.10													
			Drinking-Water Coolers	2.4.11	G												
			Energy Star Label for Electric	2.4.11	S												
			Water Cooler														
			Energy Star Label for Wheelchair	2.4.12	S												
			Electric Water Cooler														
			WaterSense Label for	2.6.2	S												
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			Plastic Bathtub Wall Surrounds	2.4.17													
			Water Heaters	2.10	G												

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		22 00 00	Energy Star Label for Gas		S													
			Storage Water Heater															
			Energy Star Label for Gas	2.10.2	S													
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			Pumps	2.12	G													
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		22 00 70	SD-03 Product Data														
			Pipe and Fittings	2.4	G												
			Pipe Hangers, Inserts, and	2.8	G												
			Supports														
			Valves	2.9	G												
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			Water Heaters	2.16	G												
			Storage Tanks	2.17	G												
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			Water Service Meter	2.20	G												
			Copper-Silver Ionization System	2.21	G												
			Potable Water Monitoring System	2.22	G												
			Vibration-Absorbing Features	3.13													
			Recycled content for cast iron		S												
			pipe														
			Recycled content for steel pipe	2.3	S												
			WaterSense label for shower	2.10.4.6.1	S												
			head														
			Energy Star label for electric	2.10.4.1	S												
			water cooler														
			WaterSense label for urinal	2.10.4.10	S												

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		22 00 70	WaterSense label for water closet	2.10.4.11	S												
			Energy Star label for gas storage		S												
			water heater														
			Energy Star label for gas	2.16.3	S												
			instantaneous water heater														
			Plumbing System	3.16.1													
			SD-06 Test Reports														
			Tests, Flushing and Disinfection	3.16													
			Test of Backflow Prevention	3.16.1.1													
			Assemblies														
			SD-07 Certificates														
			Materials and Equipment	2.3													
			Welding	1.4.2													
			Bolts	2.5													
			Pressure-Seal (Press-Fit) System	3.5.6.3													
			Installation Training														
			Pressure-Seal (Press-Fit) Tools	3.5.6.3													
			Calibration														
			EPA Registration for	2.21													
			Copper-Silver Ionization														
			NSF Certification for	2.21													
			Copper-Silver Ionization														
			SD-10 Operation and Maintenance														
			Data														
			Plumbing System	3.16.1	G												
			Maintenance Data Package	1.4.5													

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		22 05 48.00 20	SD-02 Shop Drawings															
			Inertia Bases	2.7														
			Machinery Bases	2.6														
			Platforms	2.6														
			Rails	2.6														
			Saddles	2.6														
			SD-03 Product Data															
			Isolators	2.3														
			Flexible Connectors	2.8														
			Flexible Duct Connectors	2.9														
			Pipe Guides	2.11														
			Seismic Snubbers	2.10														
			Vertical Stops	3.1.3														
			Thrust Restraints	2.12														
			Inertia Bases	2.7														
			Machinery Bases	2.6														
			Machinery Foundations and	3.1.13														
			Subbases															
			Platforms	2.6														
			Rails	2.6														
			Saddles	2.6														
			Machinery Manufacturer's Sound	1.4.2														
			Data															
			SD-05 Design Data															
			Inertia Bases	2.7														
			Machinery Bases	2.6														

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		22 05 48.00 20	Platforms	2.6													
			Rails	2.6													
			Saddles	2.6													
			Machinery	1.4.3													
			Machinery Over 300 Pounds	1.4.4													
			SD-06 Test Reports														
			Seismic Snubbers	2.10													
			Equipment Vibration Tests	3.2.3.1													
			Equipment Sound Level Tests	3.2.3.2													
			Protected Spring Isolators	2.4													
			SD-08 Manufacturer’s Instructions														
			Vibration and Noise Isolation	3.1.1													
			Components														
			Seismic Protection Components	2.13													
		22 05 83.63	SD-03 Product Data														
			Installation Equipment	2.1	G												
			CIPP Lining Tube	2.2.1	G												
			Epoxy Resin	2.1	G												
			Liner Materials	2.1	G												
			SD-08 Manufacturer’s Instructions														
			CIPP Manufacturer's Written	3.2													
			Installation Instructions														
			SD-11 Closeout Submittals														
			Report Summarizing The Extent	3.2	G												
			Of the Pipe Lining Performed														
			Pre-Lining Inspection	3.2														

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						CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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		22 05 83.63	Post-Lining Inspection	3.2													
			Manufacturer's Warranty	1.4													
			Record Drawings	3.2													
		22 07 19.00 40	SD-02 Shop Drawings														
			Installation Drawings	3.1	G												
			SD-03 Product Data														
			Adhesives	2.3	G												
			Coatings	2.3	G												
			Insulating Cement	2.3	G												
			Insulation Materials	2.3	G												
			Jacketing	2.3	G												
			Tape	2.3	G												
			SD-08 Manufacturer’s Instructions														
			Installation Manual	3.1	G												
			SD-11 Closeout Submittals														
			Record Drawings	3.4													
			Adhesives	2.3	S												
			Coatings	2.3	S												
			Insulation Materials	2.3	S												
			Recycled Materials	1.3.1	S												
		22 13 29	SD-02 Shop Drawings														
			Equipment Installation	3.2	G												
			SD-03 Product Data														
			Materials and Equipment	2.1													
			Framed Instructions	3.4													
			Spare Parts	1.4													

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		22 13 29	SD-06 Test Reports														
			Field Testing and Adjusting	3.5													
			Equipment														
			SD-10 Operation and Maintenance														
			Data														
			Operating and Maintenance	3.7	G												
			Manuals														
		22 13 36	SD-02 Shop Drawings														
			Equipment Installation	3.4													
			SD-03 Product Data														
			Materials and Equipment	2.2													
			Sewage Receiver	2.3													
			Air Compressor	2.4													
			Air Reservoir	2.5													
			Electric Motor	2.6													
			Controls	2.7													
			Spare Parts	1.5													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.8	G												
			Manuals														
		22 14 29.00 40	SD-02 Shop Drawings														
			Connection Diagrams	2.1	G												
			Control Diagrams	2.1	G												
			Installation Drawings	2.1	G												
			SD-03 Product Data														

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		22 14 29.00 40	Manufacturer's Catalog Data	2.1	G													
			Pump Performance Curve	2.1	G													
			Spare Parts List	3.3	G													
			Special Tools	3.3	G													
			Wet-Pit Sump Pumps	2.2.1	G													
			Submersible Pumps	2.2.2	G													
			Accessories	2.2.2	G													
			Floatless Electrode Level	2.2.1.11	G													
			Controls															
			SD-06 Test Reports															
			Hydrostatic Leak	3.2.2	G													
			Static Heads	3.2.2	G													
			Pump Flow Capacity	3.2.2	G													
			SD-07 Certificates															
			Manufacturer's Certification of	2.2.1.6														
			Bearing Life															
			SD-08 Manufacturer’s Instructions															
			Manufacturer's Installation	2.1														
			Instructions															
			Vibration Specifications	2.1														
		22 15 09.00 40	SD-01 Preconstruction Submittals															
			Prequalification Statement	1.4.1	G													
			SD-03 Product Data															
			Demineralized Water	2.1.1	G													
			Drying or Preservation Gas	2.1.2	G													
			Filter Discs	2.1.3	G													

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		22 15 09.00 40	Nitric Acid	2.1.4	G												
			Citric Acid	2.1.5	G												
			Muriatic Acid	2.1.6	G												
			Hydrofluoric Acid	2.1.7	G												
			Normal - Propyl Bromide	2.1.8	G												
			Tape	2.1.9	G												
			Polyethylene Film	2.1.10	G												
			Low Water-Vapor Transmission	2.1.11	G												
			Film														
			Aluminum Foil	2.1.12	G												
			SD-04 Samples														
			Polyethylene Film	2.1.10	G												
			Certification Tags	2.1.13	G												
			Low Water-Vapor Transmission	2.1.11	G												
			Film														
			SD-06 Test Reports														
			Inspection Records	3.1.2	G												
			SD-07 Certificates														
			Cleaning Procedures	1.4.2	G												
		22 15 13.16 40	SD-01 Preconstruction Submittals														
			Proposed Deviations	Part 1	G												
			SD-02 Shop Drawings														
			Detail Drawings	1.3	G												
			SD-03 Product Data														
			Underground Piping	2.2.1	G												
			Aboveground Piping	2.2.2	G												

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		22 15 13.16 40	Air Compressors	2.1.1	G												
			Manual Valves	2.1.2	G												
			Piping Specialties	2.1.4	G												
			Miscellaneous Materials	2.2.3	G												
			Supporting Elements	2.1.3	G												
			SD-06 Test Reports														
			System Pressure Test	3.2.1	G												
			SD-07 Certificates														
			Underground Piping	2.2.1													
			Aboveground Piping	2.2.2													
			Air Compressors	2.1.1													
			Manual Valves	2.1.2													
			Piping Specialties	2.1.4													
			Miscellaneous Materials	2.2.3													
			Supporting Elements	2.1.3													
		22 15 14.00 40	SD-02 Shop Drawings														
			Installation Drawings	2.1	G												
			SD-03 Product Data														
			Equipment and Performance	2.1.1	G												
			Data														
			Underground Piping Materials	2.3.1	G												
			Aboveground Piping Materials	2.3.2	G												
			Piping Specialties	2.2.1	G												
			Supporting Elements	2.4.2	G												
			Air Compressors	2.2.2	G												
			Valves	2.2.3	G												

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		22 15 14.00 40	Accessories	3.1.2.1	G												
			Miscellaneous Materials	2.4.1	G												
			SD-05 Design Data														
			Design Analysis and Calculations	2.1.1	G												
			SD-06 Test Reports														
			Piping System Test Report	3.2.1.4													
			SD-07 Certificates														
			Underground Piping Materials	2.3.1													
			Aboveground Piping Materials	2.3.2													
			Supporting Elements	2.4.2													
			Valves	2.2.3													
			Miscellaneous Materials	2.4.1													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.4													
			Manuals														
		22 15 19.13 20	SD-02 Shop Drawings														
			Air Compressor System	1.4.7													
			SD-03 Product Data														
			Air Compressor	2.2													
			Inlet Air Filters	2.2.10													
			Inlet Line Silencer	2.2.11													
			Air Flow Rate and Pressure	2.3													
			Recorder														
			Carbon Monoxide Monitor	2.4													
			Filter Housing	2.2.9.1													

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		22 15 19.13 20	SD-05 Design Data															
			Intake and Discharge Pipe	1.4.1														
			Calculations															
			SD-06 Test Reports															
			Air Compressor Performance	2.5.1														
			Tests															
			Sound Level and Run-In Tests	2.5.1														
			Performance Tests	3.3.1.1														
			Instrumentation Test	3.3.1.2														
			Sound Level Tests	3.3.1.3														
			Air Compressor System Test	3.3.1														
			SD-07 Certificates															
			Work Plan	1.4.2														
			Factory Test Procedures	2.5.1														
			Factory Testing Certification	1.4.3														
			Qualifications of Field	1.4.4														
			Supervisors															
			Field Test Procedures	3.3.1														
			Training Material	1.4.5														
			Air Compressor System	1.4.7														
			System Installation	1.4.6														
			SD-10 Operation and Maintenance															
			Data															
			Air Compressor System	1.4.7														
			SD-11 Closeout Submittals															
			Posted Operating Instructions	1.11														

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		22 15 19.19 20	SD-02 Shop Drawings														
			Air Compressor System	1.6.1													
			SD-03 Product Data														
			Air Compressor	2.2													
			Inlet Air Filters	2.2.10													
			Line Silencer	2.2.11													
			Air Flow Rate and Pressure	2.3													
			Recorder														
			Carbon Monoxide Monitor	2.4													
			Filter Housing	2.2.9.2													
			SD-06 Test Reports														
			performance tests	2.5.1													
			Sound Level Tests	3.3.1.3													
			Air Compressor Performance	3.3.1.1													
			Tests														
			Instrumentation Test	3.3.1.2													
			Sound Level and Run-in Tests	2.5.1													
			Air Compressor System Test	3.3.1													
			SD-07 Certificates														
			Work Plan	1.4.1													
			Factory Test Procedures	2.5.1													
			Factory Testing Certification	1.4.2													
			Qualifications of Field	1.4.3													
			Supervisors														
			Field Test Procedures	3.3.1													
			Training Material	1.4.4													

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		22 15 19.19 20	Air Compressor System	1.6.1														
			System Installation	1.4.5														
			SD-10 Operation and Maintenance															
			Data															
			Air Compressor System	1.6.1														
			SD-11 Closeout Submittals															
			Posted Operating Instructions	1.11														
		22 15 26.00 20	SD-02 Shop Drawings															
			High Pressure Compressed Air	1.4.2														
			System															
			SD-03 Product Data															
			Air Compressor	2.1														
			Air Dryer	2.2														
			Instrumentation and Controls	2.2.4														
			Air Receivers and Separators	2.3														
			Air Receivers and Separators	2.5														
			Desiccant Air Dryers	2.8														
			Piping and Tubing	2.9.1														
			Fittings	2.10.2														
			Valves	2.10.6														
			Adapters	2.9.7														
			Pressure gages	2.9.8														
			Snubbers	2.9.9														
			Timed Solenoid Drain	2.9.10														
			Traps	2.10.10														
			Filters	2.9.11														

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ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	CONTRACTOR ACTION ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
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		22 15 26.00 20	Strainers	2.9.12													
			Unions	2.9.13													
			O-ring Gaskets	2.9.14													
			Flexible connections	2.10.11													
			Hangers and Supports	2.9.15													
			Valve box	2.12													
			Identification Labels For Piping	2.13													
			SD-06 Test Reports														
			Non-Destructive Examination	3.1.3													
			(NDE) Report For Welding of														
			Piping														
			Leak Tightness Test	3.4.2.2													
			SD-07 Certificates														
			Employer's Record Documents	1.4.5													
			Welding Procedures and	1.4.6													
			Qualifications														
			SD-08 Manufacturer’s Instructions														
			Air receivers and Separators	2.3													
			Air receivers and Separators	2.5													
			SD-10 Operation and Maintenance														
			Data														
			Air Compressor	2.1													
			Air Dryer	2.2													
			SD-11 Closeout Submittals														
			Air Compressor	2.1													
			Air Dryer	2.2													

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		22 15 26.00 20	Compressed Air Systems	1.4													
		22 16 19.26 20	SD-02 Shop Drawings														
			Air Compressor	2.2													
			SD-03 Product Data														
			Air Compressor	2.2													
			Air Intake Devices	2.2.10.2													
			Bypass Line Silencer	2.2.12													
			Air Flow Rate and Pressure	2.3													
			Recorder														
			Carbon Monoxide Monitor	2.4													
			SD-06 Test Reports														
			performance tests	2.5.1													
			Balance Tests	2.5.1													
			Sound Level and Run-In Tests	2.5.1													
			Air Compressor Performance	3.3.1.1													
			Tests														
			Instrumentation Test	3.3.1.2													
			Sound Level Tests	3.3.1.3													
			Air Compressor System Tests	3.3.1													
			SD-07 Certificates														
			Air Compressor System	1.4.6													
			System Installation	1.4.5													
			Work Plan	1.4.1													
			Factory Test Procedures	2.5.1													
			Factory Testing Certification	1.4.2													

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		22 16 19.26 20	Qualifications of Field	1.4.3													
			Supervisors														
			Field Test Procedures	3.3.1													
			Training Material	1.4.4													
			SD-10 Operation and Maintenance														
			Data														
			Air Compressor System	1.4.6													
			SD-11 Closeout Submittals														
			Posted Operating Instructions	1.11													
		22 31 00	SD-02 Shop Drawings														
			Installation	3.2													
			SD-03 Product Data														
			Softening Equipment	2.2													
			Spare Parts	1.4													
			Field Instructions	3.3.2													
			SD-06 Test Reports														
			Softening Equipment	2.2													
			Piping	3.4.2													
			SD-10 Operation and Maintenance														
			Data														
			Operating and Maintenance	3.3.2	G												
			Instructions														
		23 01 30.41	SD-01 Preconstruction Submittals														
			Record of Existing Conditions	3.1.1.1	G												
			Coordination Plan	3.1.1.2	G												
			NADCA Firm	1.4.1	G												

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		23 01 30.41	NADCA Team Assistants	1.4.1	G												
			NADCA Air System Cleaning	1.4.1	G												
			Specialist (ASCS)														
			NADCA Supervisor Qualifications	1.4.1	G												
			Records of Experience in the	1.4.2	G												
			Field of HVAC System Cleaning														
			NADCA Work Execution	1.5.1	G												
			Schedule														
			SD-03 Product Data														
			Safety Data Sheets (SDS)	1.4.3	G												
			SD-06 Test Reports														
			Testing Procedures Summary	3.3.2	G												
			Gravimetric Analysis	3.3.1.3	G												
			Post-Project Report	3.3.2	G												
		23 05 93	SD-01 Preconstruction Submittals														
			Records of Existing Conditions	1.3.3	G												
			Records of Existing Conditions	1.3.3	G												
			Independent TAB Agency and	1.5.1	G												
			Personnel Qualifications														
			TAB Design Review Report	1.5.4.2	G												
			TAB Design Review Report	1.7.2.1	G												
			TAB Firm	1.5.9.1	G												
			TAB Team Assistants	1.2	G												
			TAB Team Engineer	1.2	G												
			TAB Specialist	1.5.9.2	G												
			TAB Team Field Leader	1.2	G												

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		23 05 93	SD-02 Shop Drawings														
			TAB Schematic Drawings and Report Forms	1.3.3	G												
			SD-03 Product Data														
			Equipment and Performance Data	1.3	G												
			TAB Related HVAC Submittals	1.5.1.3	G												
			TAB Related HVAC Submittals	1.5.9.4	G												
			TAB Procedures	1.5.7	G												
			Calibration	1.5.7	G												
			Systems Readiness Check	1.3.3	G												
			TAB Execution	1.5.10	G												
			TAB Verification	1.5.10.3	G												
			SD-06 Test Reports														
			Completed Pre-Final DALT Report		G												
			Certified Final DALT Report		G												
			Prerequisite HVAC Work Checkout List	1.5.4.3	G												
			Prerequisite HVAC Work Checkout List	1.5.4.3	G												
			Prerequisite HVAC Work Checkout List	1.5.4.3	G												
			Prerequisite HVAC Work Checkout List	1.7.2	G												

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		23 05 93	Prerequisite HVAC Work	1.7.2	G												
			Checkout List														
			Prerequisite HVAC Work	1.7.2	G												
			Checkout List														
			Proportional Balancing	3.3.7.1	G												
			Proportional Balancing	3.6	G												
			Season 1	3.3.7.2	G												
			Season 1	3.6	G												
			Season 2	3.3.7.2	G												
			Season 2	3.6	G												
			TAB Design Review Report	1.5.4.2	G												
			TAB Design Review Report	1.7.2.1	G												
			TAB Report for Season 1	1.5.11.2	G												
			TAB Report for Season 2	1.5.11.2	G												
			SD-07 Certificates														
			Independent TAB Agency and	1.5.1	G												
			Personnel Qualifications														
			DALT and TAB Submittal and	1.5.4.2	G												
			Work Schedule														
			DALT and TAB Submittal and	1.7.2	G												
			Work Schedule														
			TAB Pre-Field Engineering	1.5.4.3	G												
			Report														
			TAB Pre-Field Engineering	1.7.2.3	G												
			Report														

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		23 05 93	Instrument Calibration	1.5.6	G												
			Certificates														
			DALT and TAB Procedures	3.6	G												
			Summary														
			Completed Pre-Final DALT Work	3.6	G												
			Checklist														
			Advance Notice of Pre-Final		G												
			DALT Field Work														
			Proportional Balancing	3.3.7.1	G												
			Proportional Balancing	3.6	G												
			Season 1	3.3.7.2	G												
			Season 1	3.6	G												
			Season 2	3.3.7.2	G												
			Season 2	3.6	G												
			TAB Firm	1.5.9.1	G												
			Design Review Report	1.3.3	G												
			Pre-field DALT Preliminary	1.7.2.2	G												
			Notification														
			Advanced Notice for TAB Field	1.7.2	G												
			Work														
			Prerequisite HVAC Work Check	1.5.4.3	G												
			Out List														
			Prerequisite HVAC Work Check	1.7.2	G												
			Out List														
		23 07 00	SD-02 Shop Drawings														
			MICA Plates	3.2.2.4	G												

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		23 07 00	Pipe Insulation Systems	2.3														
			Pipe Insulation Systems	3.2														
			Duct Insulation Systems	3.3														
			Equipment Insulation Systems	3.4														
			Recycled content for insulation	2.3.1	S													
			materials															
			SD-03 Product Data															
			Pipe Insulation Systems	2.3	G													
			Pipe Insulation Systems	3.2	G													
			Duct Insulation Systems	3.3	G													
			Equipment Insulation Systems	3.4	G													
			SD-04 Samples															
			Thermal Insulation	2.2.1.3	G													
			Display Samples	3.1.1	G													
			SD-07 Certificates															
			Indoor air quality for adhesives	2.2.1	S													
			SD-08 Manufacturer’s Instructions															
			Pipe Insulation Systems	2.3	G													
			Pipe Insulation Systems	3.2	G													
			Duct Insulation Systems	3.3	G													
			Equipment Insulation Systems	3.4	G													
		23 08 00.00 20	SD-03 Product Data															
			Test Equipment	2.1	G													
			SD-06 Test Reports															

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		23 08 00.00 20	a. Commisioning Report 1. No														
			later than 14 days after completion														
			of Functional Performance Tests.														
		23 09 00	SD-02 Shop Drawings														
			DDC Contractor Design Drawings	3.3	G												
			Draft As-Built Drawings	3.3	G												
			Final As-Built Drawings	3.3	G												
			SD-03 Product Data														
			Programming Software	1.8.1	G												
			Programming Software	1.8.5	G												
			Controller Application Programs	1.8.2	G												
			Controller Application Programs	1.8.6	G												
			Configuration Software	1.8.3	G												
			Controller Configuration Settings	1.8.4	G												
			Proprietary Multi-Split	1.1.2.3	G												
			Engineering Tool Software														
			Manufacturer's Product Data	2.2	G												
			XIF files	2.2.1	G												
			Draft LNS Database	3.5.3	G												
			Final LNS Database	3.6.4	G												
			Final LNS Database	3.8	G												
			LNS Plug-ins	1.8.7	G												
			Niagara Framework Supervisory	1.8.9	G												
			Gateway Backups														
			Niagara Framework Engineering	1.8.10	G												
			Tool														

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		23 09 00	Niagara Framework Wizards	1.8.8	G													
			SD-05 Design Data															
			Boiler Or Chiller Plant Gateway	1.9														
			Request															
			SD-06 Test Reports															
			Existing Conditions Report	3.1.1														
			Pre-Construction Quality Control	1.10.1	G													
			(QC) Checklist															
			Post-Construction Quality Control	1.10.2	G													
			(QC) Checklist															
			Start-Up Testing Report	3.5.2	G													
			PVT Procedures	3.6.1	G													
			PVT Report	3.6.3	G													
			Control Contractor's Performance	3.7.5	G													
			Verification Testing Plan															
			Equipment Supplier's	3.7.3.1	G													
			Performance Verification Testing															
			Plan															
			Endurance Testing Results	3.7.8.3	G													
			Performance Verification Test	3.7.9	G													
			Report															
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.9	G													
			(O&M) Instructions															
			Training Documentation	3.11.1	G													

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		23 09 00	SD-11 Closeout Submittals														
			Enclosure Keys	2.5	G												
			Password Summary Report	3.2.6.1	G												
			Closeout Quality Control (QC)	1.10.3	G												
			Checklist														
		23 09 13.34 40	SD-02 Shop Drawings														
			Fabrication Drawings	1.2	G												
			Installation Drawings	3.1	G												
			SD-03 Product Data														
			Self-Contained Temperature	2.1	G												
			Control Valves														
			Self-Contained	2.2	G												
			Temperature-Regulator Valves														
			Rate-of-Flow Controller	2.3	G												
			Nonmodulating Float Valve	2.4	G												
			Water Pressure Regulating Valve	2.5	G												
			Water Pressure Relief Valve	2.6	G												
			Pilot-Operated Pressure Relief	2.7	G												
			Valve														
			Relief Valves for Electric Water	2.8	G												
			Heaters														
			Sample Warranty	1.4	G												
			SD-07 Certificates														
			List of Product Installations	1.2	G												
			Certificates of Conformance	1.4	G												
			Manufacturer's Warranty	3.3	G												

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		23 09 13.34 40	SD-06 Test Reports															
			Test Reports	3.2.1	G													
		23 11 20	SD-02 Shop Drawings															
			Gas Piping System	1.5.3	G													
			Gas Piping System	2.2	G													
			Gas Piping System	3.3	G													
			SD-03 Product Data															
			Pipe and Fittings	1.6.1	G													
			Gas Equipment Connectors	1.5.3	G													
			LPG Containers and Accessories	2.10	G													
			Gas Piping System	1.5.3	G													
			Gas Piping System	2.2	G													
			Gas Piping System	3.3	G													
			Pipe Coating Materials	2.1	G													
			Pressure Regulators	2.6	G													
			Risers	2.4	G													
			Transition Fittings	2.2.13	G													
			Valves	2.3	G													
			Warning and Identification Tape	2.2.9	G													
			SD-06 Test Reports															
			Testing	3.19	G													
			Pressure Tests	3.19.1	G													
			Pressure Tests for Liquified	3.19.2	G													
			Petroleum Gas															
			Test with Gas	3.19.3	G													
			SD-07 Certificates															

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		23 11 20	Welders Procedures and	1.5.1	G												
			Qualifications														
			Assigned Number, Letter, or	1.5.1	G												
			Symbol														
			SD-08 Manufacturer’s Instructions														
			PE Pipe and Fittings	1.5.2	G												
			Pipe Coating Materials	2.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Gas Facility System and	1.3.1	G												
			Equipment Operation														
			Gas Facility System Maintenance	1.3.2	G												
			Gas Facility Equipment	1.3.3	G												
			Maintenance														
		23 23 00	SD-02 Shop Drawings														
			Refrigerant Piping System	2.3	G												
			SD-03 Product Data														
			Refrigerant Piping System	2.3													
			Spare Parts	1.5.2													
			Qualifications	1.3.1													
			Refrigerant Piping Tests	3.5													
			Verification of Dimensions	3.1													
			SD-06 Test Reports														
			Refrigerant Piping Tests	3.5													
			SD-07 Certificates														
			Service Organization	2.1													

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TITLE AND LOCATION: MOODY INSTALLATION GUIDE SPECIFICATIONS

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ACTIVITY NO (a)	TRANSMITTAL NO (b)	SPEC SECT (c)	DESCRIPTION ITEM SUBMITTED (d)	PARAGRAPH # (e)	CLASSIFICATION GOVT OR A/E REVWR (f)	CONTRACTOR: SCHEDULE DATES SUBMIT (g)	APPROVAL NEEDED BY (h)	MATERIAL NEEDED BY (i)	CONTRACTOR ACTION ACTION CODE (j)	DATE OF ACTION (k)	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR (l)	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER (m)	DATE RCD FROM OTH REVIEWER (n)	ACTION CODE (o)	DATE OF ACTION (p)	MAILED TO CONTR/ DATE RCD FRM APPR AUTH (q)	REMARKS (r)
		23 23 00	SD-10 Operation and Maintenance														
			Data														
			Maintenance	1.5	G												
			Operation and Maintenance	3.4	G												
			Manuals														
			Demonstrations	3.4	G												
		23 25 00	SD-03 Product Data														
			Water Treatment System	2.3.1.4.1	G												
			Water Analysis	2.1.3	G												
			Spare Parts	1.3													
			Field Instructions	3.4.1													
			Tests	3.3.1	G												
			Training Course	3.4.1	G												
			SD-06 Test Reports														
			Condenser Water QA Tests	3.3.6.1													
			Steam Boiler Water QA Tests	3.3.6.4													
			SD-10 Operation and Maintenance														
			Data														
			Water Treatment System	2.3.1.4.1													
		23 30 00	SD-02 Shop Drawings														
			Detail Drawings	1.4.4	G												
			SD-03 Product Data														
			Metallic Flexible Duct	2.10.1.1													
			Insulated Nonmetallic Flexible	2.10.1.2													
			Duct Runouts														
			Duct Connectors	2.10.1.2													

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		23 30 00	Duct Access Doors	2.10.2	G												
			Fire Dampers	2.10.3													
			Manual Balancing Dampers	2.10.4	G												
			Manual Balancing Dampers	2.10.5	G												
			Automatic Smoke-Fire Dampers	2.10.7													
			Automatic Smoke Dampers	2.10.8													
			Sound Attenuation Equipment	2.10.12													
			Acoustical Duct Liner	2.10.12.3													
			Diffusers	2.10.13.1													
			Registers and Grilles	2.10.13.5													
			Louvers	2.10.14													
			Air Vents, Penthouses, and	2.10.15													
			Goosenecks														
			Centrifugal Fans	2.11.1.1													
			In-Line Centrifugal Fans	2.11.1.2													
			Axial Flow Fans	2.11.1.3													
			Panel Type Power Wall	2.11.1.4													
			Ventilators														
			Centrifugal Type Power Wall	2.11.1.5													
			Ventilators														
			Centrifugal Type Power Roof	2.11.1.6													
			Ventilators														
			Propeller Type Power Roof	2.11.1.7													
			Ventilators														
			Air-Curtain Fans	2.11.1.8													
			Ceiling Exhaust Fans	2.11.1.9													

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		23 30 00	PL-109-58 label for ceiling	2.11.1.9	S												
			exhaust fan product														
			Air Handling Units	2.12	G												
			Room Fan-Coil Units	2.13.1	G												
			Coil Induction Units	2.13.2	G												
			Constant Volume, Single Duct	2.13.3.1	G												
			Terminal Units														
			Variable Volume, Single Duct	2.13.3.2	G												
			Terminal Units														
			Variable Volume, Single Duct,	2.13.3.3	G												
			Fan-Powered Terminal Units														
			Dual Duct Terminal Units	2.13.3.4	G												
			Ceiling Induction Terminal Units	2.13.3.5	G												
			Reheat Units	2.13.3.7	G												
			Unit Ventilators	2.13.4													
			Energy Recovery Devices	2.14	G												
			Hydronic Modular Panels	2.17.1	G												
			Prefabricated Radiant-Heating	2.17.3	G												
			Electric Panels														
			Test Procedures	1.4.5													
			Diagrams	1.2.1.2	G												
			Indoor Air Quality for Duct	2.10.1	S												
			Sealants														
			SD-06 Test Reports														
			Performance Tests	3.13	G												
			Damper Acceptance Test	3.11	G												

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		23 30 00	SD-07 Certificates															
			Bolts	1.4.1														
			Ozone Depleting Substances	1.4.3														
			Technician Certification															
			SD-08 Manufacturer’s Instructions															
			Manufacturer's Installation	3.2														
			Instructions															
			Operation and Maintenance	3.16.2														
			Training															
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.16.1	G													
			Manuals															
			Fire Dampers	2.10.3	G													
			Manual Balancing Dampers	2.10.4	G													
			Manual Balancing Dampers	2.10.5	G													
			Automatic Smoke-Fire Dampers	2.10.7	G													
			Automatic Smoke Dampers	2.10.8	G													
			Centrifugal Fans	2.11.1.1	G													
			In-Line Centrifugal Fans	2.11.1.2	G													
			Axial Flow Fans	2.11.1.3	G													
			Panel Type Power Wall	2.11.1.4	G													
			Ventilators															
			Centrifugal Type Power Wall	2.11.1.5	G													
			Ventilators															

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		23 30 00	Centrifugal Type Power Roof Ventilators	2.11.1.6	G													
			Propeller Type Power Roof Ventilators	2.11.1.7	G													
			Air-Curtain Fans	2.11.1.8	G													
			Ceiling Exhaust Fans	2.11.1.9	G													
			Air Handling Units	2.12	G													
			Room Fan-Coil Units	2.13.1	G													
			Coil Induction Units	2.13.2	G													
			Constant Volume, Single Duct Terminal Units	2.13.3.1	G													
			Variable Volume, Single Duct Terminal Units	2.13.3.2	G													
			Variable Volume, Single Duct, Fan-Powered Terminal Units	2.13.3.3	G													
			Dual Duct Terminal Units	2.13.3.4	G													
			Ceiling Induction Terminal Units	2.13.3.5	G													
			Reheat Units	2.13.3.7	G													
			Unit Ventilators	2.13.4	G													
			Energy Recovery Devices	2.14	G													
			Hydronic Modular Panels	2.17.1	G													
			Prefabricated Radiant-Heating Electric Panels	2.17.3	G													
			SD-11 Closeout Submittals															
			Indoor Air Quality During Construction	3.14	S													

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		23 31 13.00 40	SD-01 Preconstruction Submittals														
			Material, Equipment, and Fixture	Part 2	G												
			Lists														
			Records of Existing Conditions	2.1.1	G												
			SD-02 Shop Drawings														
			Connection Diagrams	2.1	G												
			Offset Fitting Configurations	2.2.1	G												
			SD-03 Product Data														
			Equipment and Performance	2.1.1													
			Data														
			Galvanized Steel Ductwork	2.3.1	G												
			Materials														
			Brazing Materials	2.3.2													
			Mill-Rolled Reinforcing and	2.3.3													
			Supporting Materials														
			Round Sheet Metal Duct Fittings	2.2.1	G												
			Round, High-Pressure,	2.2.2	G												
			Double-Wall Sheet Metal Ducts														
			Turning Vanes	2.2.5	G												
			Sound Attenuators	2.2.7	G												
			Flexible Connectors	2.2.8	G												
			Flexible Duct Materials	2.2.11													
			Power-Operated Dampers	2.2.14	G												
			Fire Dampers and Wall Collars	2.2.15	G												
			Gravity Backdraft and Relief	2.2.13	G												
			Dampers														

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		23 31 13.00 40	Manual Volume Dampers	2.2.12	G												
			SD-05 Design Data														
			Design Analysis and Calculations	2.1.1	G												
			SD-06 Test Reports														
			Ductwork Leakage Tests	3.4.2	G												
			Operational Tests	3.4.1	G												
			SD-07 Certificates														
			Listing of Product Installations	1.3													
			Galvanized Steel Ductwork	2.3.1													
			Materials														
			Brazing Materials	2.3.2													
			Mill-Rolled Reinforcing and	2.3.3													
			Supporting Materials														
			Round Sheet Metal Duct Fittings	2.2.1													
			Round, High-Pressure,	2.2.2													
			Double-Wall Sheet Metal Ducts														
			Turning Vanes	2.2.5													
			Dampers	2.2.6													
			Sound Attenuators	2.2.7													
			Flexible Connectors	2.2.8													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.5.1	G												
			Manuals														
			Power Operated Dampers	2.2.14	G												
			Fire Dampers and Wall Collars	2.2.15	G												

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		23 31 13.00 40	SD-11 Closeout Submittals														
			Record Drawings	3.5.2	G												
		23 33 56	SD-02 Shop Drawings														
			Structural Supports by Contractor	2.5	G												
			SD-03 Product Data														
			Valve Systems	2.1													
			Manufacturer's Field Service	3.3.2													
			SD-05 Design Data														
			Structural Supports by Contractor	2.5													
			SD-06 Test Reports														
			Blast Tests on Prototype Valve	2.7.1													
			Units														
			Factory Air Flow Tests	2.7.2													
			Field Tests	3.2													
			SD-07 Certificates														
			Valve Systems	2.1													
			SD-10 Operation and Maintenance														
			Data														
			Systems Manual	3.3.1													
		23 34 23.00 40	SD-02 Shop Drawings														
			Shop Drawings	2.1.1	G												
			Installation Drawings	3.1	G												
			SD-03 Product Data														
			Housing	2.2.1	G												
			Fan	2.2.2	G												
			Motor	2.2.3	G												

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		23 34 23.00 40	Bases	2.2.4	G												
			Roof Curbs	2.2.5	G												
			Dampers	2.2.6	G												
			Screens	2.2.7	G												
			Sound Baffles	2.2.8	G												
			SD-06 Test Reports														
			Final Test Reports	3.2.3	G												
			SD-11 Closeout Submittals														
			Record Drawings	3.3	G												
		23 35 16.17 10	SD-02 Shop Drawings														
			Detail Drawings	1.4.1	G												
			Exhaust System Installation	3.4	G												
			SD-03 Product Data														
			Related Submittals	1.4.2													
			Ductwork Components	2.4	G												
			Materials and Equipment	2.1													
			Spare Parts	1.6													
			Field Instructions	3.6													
			Final Acceptance Tests	3.7													
			Onsite Training	3.6	G												
			Exhaust System Specialist	1.4.2	G												
			SD-06 Test Reports														
			Final Acceptance Tests	3.7													
			SD-07 Certificates														
			Inspection	3.3	G												

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		23 35 16.17 10	SD-10 Operation and Maintenance														
			Data														
			Exhaust System	1.2													
			Operation and Maintenance	3.6													
			Manuals														
		23 35 19.00 20	SD-02 Shop Drawings														
			Industrial Ventilation and Exhaust	1.2.4	G												
			Systems														
			SD-03 Product Data														
			Fans	2.1	G												
			Dampers	2.7	G												
			Flexible Connectors	2.8.3													
			Flexible Duct	2.8.4	G												
			Gaskets	2.8.5													
			Protective Coating Materials	2.8.6													
			Sealants	2.8.7													
			Access Ports	2.9.1	G												
			Damper Regulators	2.9.2	G												
			Blast Gates	2.9.3	G												
			Vibration Isolators	2.10.5	G												
			Ductwork, Dust [and Fume]	2.11													
			Collection														
			Steel Ducts	2.12	G												
			Fiberglass Ductwork	2.14	G												
			Thermoplastic Ductwork	2.13	G												
			Vehicle Tail Pipe Exhaust System	2.15	G												

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		23 35 19.00 20	Welding Fume Exhaust System	2.16	G												
			Recycled Content of Ductwork	2.11.1	S												
			Steel Components														
			Recycled Content of Protectively	2.12.1	S												
			Coated Steel Ducts														
			Indoor Air Quality for Duct	2.8.7.1	S												
			Sealants														
			SD-06 Test Reports														
			Fan Tests	2.1.1	G												
			Start-Up Tests	1.2.5	G												
			Sound Level Tests	3.2.6	G												
			SD-07 Certificates														
			Welding Procedures	1.4.4	G												
			Welding Test Agenda	3.1.11	G												
			Welding Test Procedures	1.4.4	G												
			Welders' Identification	1.4.1	G												
			Fiberglass Fan Servicer	1.4.2	G												
			Experience Information														
			SD-10 Operation and Maintenance														
			Data														
			Fans	2.1	G												
			Vehicle Tail Pipe Exhaust System	2.15	G												
			Welding Fume Exhaust System	2.16	G												
			Industrial Ventilation and Exhaust	1.2.4	G												
			Systems														
			SD-11 Closeout Submittals														

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		23 35 19.00 20	Posted Operating Instructions	1.5													
		23 36 00.00 40	SD-01 Preconstruction Submittals														
			Records of Existing Conditions	1.2.1													
			SD-02 Shop Drawings														
			Bypass Single-Duct Air Terminal	2.1.2	G												
			Units														
			Dual-Duct Air Terminal Units	2.1.3	G												
			Fan-Powered Air Terminal Units	2.1.4	G												
			Induction Air Terminal Units	2.1.5	G												
			Shutoff Single-Duct Air Terminal	2.1.6	G												
			Units														
			Integral-Diffuser Air Terminal	2.1.7	G												
			Units														
			High-Pressure Dual-Duct Mixing	2.1.8	G												
			Boxes														
			Low-Pressure Dual-Duct Mixing	2.1.9	G												
			Boxes														
			SD-03 Product Data														
			Bypass Single-Duct Air Terminal	2.1.2	G												
			Units														
			Dual-Duct Air Terminal Units	2.1.3	G												
			Fan-Powered Air Terminal Units	2.1.4	G												
			Induction Air Terminal Units	2.1.5	G												
			Shutoff Single-Duct Air Terminal	2.1.6	G												
			Units														

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		23 36 00.00 40	Integral-Diffuser Air Terminal Units	2.1.7	G												
			High-Pressure Dual-Duct Mixing Boxes	2.1.8	G												
			Low-Pressure Dual-Duct Mixing Boxes	2.1.9	G												
			SD-06 Test Reports														
			Test Report	3.2													
			SD-07 Certificates														
			List of Spare Parts	1.2.1													
			SD-10 Operation and Maintenance Data														
			Operation and Maintenance Manuals	3.4.1													
			SD-11 Closeout Submittals														
			Record Drawings	3.4.1													
		23 37 13.00 40	SD-01 Preconstruction Submittals														
			Material, Equipment, and Fixture Lists	2.2.1	G												
			Records of Existing Conditions	2.2.1	G												
			SD-02 Shop Drawings														
			Fabrication Drawings	2.2.1	G												
			Installation Drawings	3.1	G												
			SD-03 Product Data														
			Equipment and Performance Data	2.1	G												

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		23 37 13.00 40	SD-04 Samples														
			Manufacturer's Standard Color	2.2.1	G												
			Chart														
			SD-10 Operation and Maintenance														
			Data														
			Type TS Supply Troffer	2.2.2.28	G												
			Type TSR Combination Supply	2.2.2.30	G												
			and Return Troffer														
		23 41 13.00 40	SD-02 Shop Drawings														
			Installation Drawings	3.1.1													
			SD-03 Product Data														
			Air Filters	2.1	G												
			Filter Gages	2.2	G												
			Manometers	2.2	G												
			SD-06 Test Reports														
			Test Reports	3.2													
			SD-07 Certificates														
			Air Filters	2.1													
			Filter Gages	2.2													
			Manometers	2.2													
		23 52 00	SD-02 Shop Drawings														
			Detail Drawings	1.5													
			SD-03 Product Data														
			Materials and Equipment	2.1.1													
			Energy Star label for residential	2.2.6	S												
			gas fired hot water boiler product														

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		23 52 00	Energy Star label for residential	2.2.6	S												
			oil fired hot water boiler product														
			Spare Parts	1.5													
			Water Treatment System	2.17													
			Boiler Water Treatment	2.17													
			Heating System Tests	3.10													
			Fuel System Tests	3.13													
			Unit Heaters	2.9													
			Welding	1.3													
			Qualifications	3.10													
			Field Instructions	3.12													
			Tests	3.4													
			SD-06 Test Reports														
			Heating System Tests	3.10													
			Fuel System Tests	3.13													
			Water Treatment Testing	3.10.1													
			SD-07 Certificates														
			Bolts	2.12.12.3													
			Continuous Emissions Monitoring	2.12.2													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.12	G												
			Instructions														
			Water Treatment System	2.17	G												
			SD-11 Closeout Submittals														

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		23 52 00	Indoor Air Quality During	3.11.2	S												
			Construction														
		23 54 19	SD-01 Preconstruction Submittals														
			Contractor Qualifications	1.3.1	G												
			SD-02 Shop Drawings														
			Equipment Layouts	1.3.4													
			SD-03 Product Data														
			Self-Contained Furnaces	2.8	G												
			Energy Star Label for Residential	2.8.1	S												
			Gas Fired Furnace Product														
			Energy Star Label for Residential	2.8.2	S												
			Oil-Fired Furnace Product														
			Vent Connections	2.6	G												
			Controls	2.7	G												
			Dampers	2.6.4	G												
			Air Filters	2.3.3	G												
			Humidifiers	2.9	G												
			Duct Furnace	2.10	G												
			Heating and Ventilating Units	2.11	G												
			Heating Only Makeup Air Units	2.11	G												
			System Diagrams	1.3.5	G												
			SD-06 Test Reports														
			Field Acceptance Test Plans and	3.8.1	G												
			Test Reports														
			Field Acceptance Testing	3.8.2	G												
			Test Reports	3.6	G												

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		23 54 19	SD-08 Manufacturer’s Instructions															
			Self-Contained Furnaces - Installation Instructions	3.2	G													
			Vent Connections - Installation Instructions	3.2	G													
			Controls - Installation Instructions	3.2	G													
			Dampers - Installation Instructions	3.2	G													
			Air Filters - Installation Instructions	3.2	G													
			Humidifiers - Installation Instructions	3.2	G													
			Duct Furnace - Installation Instructions	3.2	G													
			Heating and Ventilating Units - Installation Instructions	3.2	G													
			Heating Only Makeup Air Units - Installation Instructions	3.2	G													
			SD-10 Operation and Maintenance Data															
			Self-Contained Furnaces	2.8	G													
			Vent Connections	2.6	G													
			Controls	2.7	G													
			Dampers,	2.6.4	G													
			Humidifiers	2.9	G													
			Duct Furnace	2.10	G													

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		23 54 19	Heating and Ventilating Units	2.11	G												
			Heating Only Makeup Air Units	2.11	G												
			SD-11 Closeout Submittals														
			Field Training	3.9													
			Indoor Air Quality During	3.2.10	S												
			Construction														
		23 57 10.00 10	SD-02 Shop Drawings														
			Heating System	2.18													
			SD-03 Product Data														
			Spare Parts	1.5													
			Welding	3.4													
			Framed Instructions	3.19													
			SD-06 Test Reports														
			Testing and Cleaning	3.18													
			Water Treatment Testing	3.18.4													
			SD-07 Certificates														
			Bolts	2.2.9.3													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.20	G												
			Manuals														
		23 64 00	SD-02 Shop Drawings														
			Drawings	1.5.2	G												
			SD-03 Product Data														
			Absorption Water Chiller	2.5	G												
			Posted Instructions	3.1.3	G												

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 64 00	Verification of Dimensions	1.5.1	G												
			System Performance Tests	3.5	G												
			Demonstrations	3.6													
			Absorption Water Chiller - Field	3.4.1													
			Acceptance Test Plan														
			SD-06 Test Reports														
			Field Acceptance Testing	3.4	G												
			Absorption Water Chiller - Field	3.4.2	G												
			Acceptance Test Report														
			System Performance Tests	3.5	G												
			SD-07 Certificates														
			Absorption Water Chiller	2.5	G												
			SD-08 Manufacturer’s Instructions														
			Water Chiller - Installation	3.1	G												
			Instructions														
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.6													
			Manuals														
			SD-11 Closeout Submittals														
			Indoor Air Quality During	3.3	S												
			Construction														
		23 64 10	SD-03 Product Data														
			Water Chiller	2.5	G												
			Posted Instructions	3.1.3													
			Verification of Dimensions	1.6.1													

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		23 64 10	Factory Tests	2.9													
			System Performance Tests	3.6													
			Demonstrations	3.7													
			Refrigerant	2.6.1													
			Water Chiller - Field Acceptance	3.5.1													
			Test Plan														
			SD-06 Test Reports														
			Field Acceptance Testing	3.5													
			Water Chiller - Field Acceptance	3.5.2													
			Test Report														
			Factory Tests	2.9													
			System Performance Tests	3.6													
			SD-07 Certificates														
			Refrigeration System	3.1.9	G												
			Ozone Depleting Substances	1.3.1													
			Technician Certification														
			SD-08 Manufacturer’s Instructions														
			Water Chiller - Installation	3.1	G												
			Instructions														
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.7	G												
			Manuals														
			SD-11 Closeout Submittals														
			Indoor Air Quality During	3.4	S												
			Construction														

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		23 64 26	SD-03 Product Data															
			Grooved Mechanical	2.2.2.4	G													
			Connections For Steel															
			Grooved Mechanical	2.6.3	G													
			Connections For Copper															
			Calibrated Balancing Valves	2.7.8	G													
			Automatic Flow Control Valves	2.7.9	G													
			Pump Discharge Valve	2.7.10														
			Water Temperature Mixing Valve	2.7.11	G													
			Water Temperature Regulating	2.7.12	G													
			Valves															
			Water Pressure Reducing Valve	2.7.13														
			Pressure Relief Valve	2.7.14														
			Combination Pressure and	2.7.15														
			Temperature Relief Valves															
			Expansion Joints	2.8.9	G													
			Pumps	2.9	G													
			Combination Strainer and Pump	2.8.3														
			Suction Diffuser															
			Expansion Tanks	2.10														
			Air Separator Tanks	2.11														
			Water Treatment Systems	2.12	G													
			SD-06 Test Reports															
			Piping Welds NDE Report	3.1.1.3														
			Pressure Tests Reports	3.5.2	G													

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 64 26	Condenser Water Quality Test	3.5.3	G												
			Reports														
			Condenser Water Quality Test	3.5.3	G												
			Reports														
			One-Year Inspection Report For	3.7	G												
			Cooling Water														
			SD-07 Certificates														
			Employer's Record Documents	3.1.1.1													
			(For Welding)														
			Welding Procedures and	3.1.1.2													
			Qualifications														
			Piping for Steam and	2.4													
			Condensate														
			Piping for High-Pressure	2.5													
			Compressed-Air Systems														
			Fittings	2.4													
			Fittings	2.5													
			Unions	2.4													
			Unions	2.5													
			Flanges	2.4													
			Flanges	2.5													
			Gaskets	2.4													
			Gaskets	2.5													
			Bolting	2.4													
			Bolting	2.5													
			SD-08 Manufacturer’s Instructions														

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		23 64 26	Lesson plan for the Instruction	3.6	G												
			Course														
			SD-10 Operation and Maintenance														
			Data														
			Water Treatment Systems	2.12	G												
			Calibrated Balancing Valves	2.7.8	G												
			Automatic Flow Control Valves	2.7.9	G												
			Pump Discharge Valve	2.7.10	G												
			Water Temperature Mixing Valve	2.7.11	G												
			Water Temperature Regulating	2.7.12	G												
			Valves														
			Water Pressure Reducing Valve	2.7.13	G												
			Pressure Relief Valve	2.7.14	G												
			Combination Pressure and	2.7.15	G												
			Temperature Relief Valves														
			Expansion Joints	2.8.9	G												
			Pumps	2.9	G												
			Combination Strainer and Pump	2.8.3	G												
			Suction Diffuser														
			Expansion Tanks	2.10	G												
			Air Separator Tanks	2.11	G												
		23 65 00	SD-03 Product Data														
			Cooling Towers	2.5	G												
			Posted Instructions	3.2.3	G												
			Demonstrations	3.1	G												
			Verification of Dimensions	1.5.1	G												

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 65 00	Remote Evaporatively-Cooled	2.6													
			Condensers														
			SD-06 Test Reports														
			Packaged Cooling Tower -	3.2	G												
			Installation Instructions														
			Field-Erected Cooling Tower -	3.2	G												
			Installation Instructions														
			Packaged Cooling Tower - Field	3.3.1	G												
			Acceptance Test Plan														
			Field-Erected Cooling Tower -	3.3.1	G												
			Field Acceptance Test Plan														
			Packaged Cooling Tower - Field	3.4	G												
			Acceptance Test Report														
			Field-Erected Cooling Tower -	3.4	G												
			Field Acceptance Test Report														
			SD-07 Certificates														
			Service Organization	2.1													
			Cooling Tower	2.5.1.12													
			Remote Evaporatively-Cooled	2.6													
			Condensers														
			SD-08 Manufacturer’s Instructions														
			Packaged Cooling Tower -	3.2													
			Installation Instructions														
			Field-Erected Cooling Tower -	3.2													
			Installation Instructions														

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 65 00	Remote Evaporatively-Cooled	2.6													
			Condensers														
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.1													
			Manuals														
			Remote Evaporatively-Cooled	2.6													
			Condensers														
		23 72 00.00 10	SD-02 Shop Drawings														
			Installation	3.2													
			SD-03 Product Data														
			Calculations	3.2													
			Welding Procedures and	1.3													
			Qualifications														
			Spare Parts	1.5.5													
			Posted Instructions	3.4													
			Performance Tests	3.7	G												
			SD-06 Test Reports														
			Tests	3.6													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	1.6	G												
			Manuals														
		23 76 00	SD-01 Preconstruction Submittals														
			Letter Of Qualification	1.4.2													

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		23 76 00	Manufacturer's Authorized	1.4.1	G												
			Service Representative														
			SD-02 Shop Drawings														
			Installation Drawings	1.4.2	G												
			SD-03 Product Data														
			Evaporative Coolers	2.7	G												
			Air Washers	2.8	G												
			Water Tanks	2.9	G												
			Thermostats	2.13	G												
			Corrosion Coating	2.14.1	G												
			SD-06 Test Reports														
			Performance Tests	3.3.3	G												
			SD-07 Certificates														
			Test Procedures	1.4.2	G												
			Energy Efficient Products for	2.2.1	S												
			Evaporative Cooler														
			System Diagrams	3.2	G												
			SD-08 Manufacturer’s Instructions														
			Installation	3.2	G												
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.4	G												
			Manuals														
			Operational Training	3.4	G												
		23 80 20.00 10	SD-02 Shop Drawings														
			Detail Drawings	1.3													

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		23 80 20.00 10	Installation	3.2													
			SD-03 Product Data														
			Spare Parts	1.5													
			SD-06 Test Reports														
			Testing, Adjusting, and Balancing	3.4													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.3													
			Instructions														
		23 81 23	SD-03 Product Data														
			Computer Room Air Conditioner	2.1	G												
			Small Computer Room Air	2.2	G												
			Conditioners														
			Space Temperature Control	2.8.3	G												
			System Drawings														
			Filters	2.1.5													
			Refrigerants	1.4	S												
			[Cold][and][Hot] Aisle	2.3	G												
			Containment Systems														
			Rack Mounted Fans	2.4	G												
			Leak Detection	2.5.1.3	G												
			SD-06 Test Reports														
			CRAC Production Schedule and	2.11.2	G												
			Factory Test Schedule														
			Manufacturer's Factory Test	2.11.1	G												
			Plans														

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		23 81 23	Factory Test Reports	2.11.5	G												
			Field Test Schedule	3.3.2	G												
			Manufacturer's Field Test Plans	3.3.1	G												
			Field Test Reports	3.3.6	G												
			SD-07 Certificates														
			Certificate of Specification	2.6	G												
			Compliance														
			Credentials of the Manufacturer's	3.3.3	G												
			Field Test Representative														
			Ozone Depleting Substances	1.5.1													
			Technician Certification														
			Certified List Of Qualified	1.6.3													
			Permanent Service Organizations														
			Seismic Certification	2.1.11	G												
			SD-08 Manufacturer’s Instructions														
			Installation Manual for Each Type	3.1.2													
			of CRAC														
			Installation Manual for Each Type	3.1.2													
			of Aisle Containment System														
			Installation Manual for Each Type	3.1.2													
			of Rack Mounted Fan														
			SD-10 Operation and Maintenance														
			Data														
			Computer Room Air Conditioner	3.1.3	G												
			Operation and Maintenance Data														
			SD-11 Closeout Submittals														

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		23 81 23	Indoor Air Quality During	3.2	S												
			Construction														
		23 82 00.00 20	SD-03 Product Data														
			Unit Heaters	2.1													
			Infrared Heaters	2.2													
			SD-10 Operation and Maintenance														
			Data														
			Unit Heaters	2.1													
			Infrared Heaters	2.2													
		23 82 16.00 40	SD-01 Preconstruction Submittals														
			Record of Existing Conditions	1.3													
			SD-02 Shop Drawings														
			Fabrication Drawings	2.1	G												
			Connection Diagrams	2.1	G												
			Controls Layout	1.3	G												
			Internal Tubing and Wiring	1.3	G												
			Installation Drawings	3.1	G												
			SD-03 Product Data														
			Steam Heating	2.1													
			Hot-Water Heating	2.1	G												
			Chilled-Water Cooling	2.1	G												
			Volatile Refrigerant Cooling	2.1	G												
			SD-05 Design Data														
			Design Analysis and Calculations	1.3													
			SD-06 Test Reports														
			Final Test Reports	3.2													

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		23 82 16.00 40	SD-07 Certificates														
			Certificates of Conformance	1.3													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.3.1													
			Manuals														
			SD-11 Closeout Submittals														
			Record Drawings	3.3.2													
		23 82 19.00 40	SD-02 Shop Drawings														
			Fabrication Drawings	2.2	G												
			Installation Drawings	3.1	G												
			SD-03 Product Data														
			Equipment and Performance	2.2	G												
			Data														
			Coils	2.2	G												
			Casing	2.2	G												
			Enclosure	2.2	G												
			Motors	2.2	G												
			Fan	2.2	G												
			Drain Pans	2.2	G												
			Filters	2.2	G												
			Controls	2.2	G												
			Vibration Isolation	2.2	G												
			SD-04 Samples														
			Manufacturer's Standard Color	2.2	G												
			Chart														

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		23 82 19.00 40	SD-07 Certificates															
			List of Product Installations	1.3														
			Certificates of Conformance	2.2														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.3														
			Manuals															
			SD-11 Closeout Submittals															
			Warranty	3.3														
		23 82 23.00 40	SD-01 Preconstruction Submittals															
			Material, Equipment, and Fixture	2.2	G													
			List															
			List of Product Installations	1.3	G													
			SD-02 Shop Drawings															
			Electrical Diagrams	2.1	G													
			Pneumatic Diagrams	2.1	G													
			SD-03 Product Data															
			Gas Unit Heaters	2.2.1	G													
			Propeller Unit Heaters	2.2.2	G													
			Cabinet Unit Heaters	2.2.3	G													
			Unit Ventilators	2.2.4	G													
			Casing	2.2.1.2	G													
			Heat Exchangers	2.2.1.3	G													
			Burners	2.2.1.4	G													
			Fans	2.2.1.5	G													
			Motors	2.2.1.6	G													

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		23 82 23.00 40	Controls	2.2.1.7	G												
			Vertical Discharge Units	2.2.2.2	G												
			Horizontal Discharge Units	2.2.2.3	G												
			Heating Element	2.2.3.2	G												
			Propellers	2.2.2.6	G												
			Filters	2.2.3.4	G												
			Enclosures	2.2.3.5	G												
			Wall Sleeve	2.2.4.7	G												
			Fresh-Air Intakes	2.2.4.10	G												
			Insulation	2.2.3.6	G												
			Vibration Isolation	2.1	G												
			SD-04 Samples														
			Color Chart	2.2	G												
			SD-05 Design Data														
			Connection Diagrams	2.1	G												
			Control Diagrams	2.1	G												
			SD-07 Certificates														
			Records of Existing Conditions	1.4	G												
			Spare Parts List	2.2													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.3													
			Manuals														
			SD-11 Closeout Submittals														
			Record Drawings	3.3	G												
			Warranty	3.3													

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		23 82 43.00 40	SD-02 Shop Drawings														
			Fabrication Drawings	1.2.1													
			Installation Drawings	1.2.1	G												
			SD-03 Product Data														
			Performance Data	2.1.1	G												
			Duct Heaters	2.1	G												
			Heating Elements	2.2.1	G												
			Enclosures	2.2.1	G												
			Controls	2.2.2	G												
			SD-08 Manufacturer’s Instructions														
			Manufacturer's Instructions	1.2.1													
		23 82 46.00 40	SD-02 Shop Drawings														
			Fabrication Drawings	1.2.1													
			SD-03 Product Data														
			Performance Data	2.1	G												
			Electric Unit Heaters	2.1	G												
			Heating Element	2.2.1	G												
			Controls	2.2.2	G												
			Casings	3.1.1	G												
			Propellers and Motors	2.2.3	G												
			SD-08 Manufacturer’s Instructions														
			Manufacturer's Instructions	1.2.1													
		23 83 00.00 20	SD-02 Shop Drawings														
			Heater Installation Drawing	3.1													
			SD-03 Product Data														

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		23 83 00.00 20	Electric [Unit][and][Cabinet]	2.1													
			Heaters														
			Electric [Baseboard] [Sill]	2.2													
			[Pedestal] Units														
			Electric Infrared Heater	2.3													
			Thermostat	2.1.6													
			Unit Thermostat	2.2.5													
			Infrared Heater Thermostat	2.4													
			SD-10 Operation and Maintenance														
			Data														
			Electric [Unit][and][Cabinet]	2.1													
			Heaters														
			Electric [Baseboard] [Sill]	2.2													
			[Pedestal] Units														
			Electric Infrared Heater	2.3													
		25 08 10	SD-06 Test Reports														
			PVT Plan	3.1.1	G												
			PVT Phase I Report	3.1.2.1	G												
			PVT Phase II Report	3.1.2.2	G												
			SD-07 Certificates														
			Test Instrumentation Calibration	1.4	G												
			Certificates														
		25 10 10	SD-02 Shop Drawings														
			UMCS Contractor Design	3.3.2	G												
			Drawings														
			Draft As-Built Drawings	3.3.3	G												

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		25 10 10	Final As-Built Drawings	3.3.3	G												
			SD-03 Product Data														
			Product Data Sheets	2.1.5	G												
			Computer Software	2.4	G												
			Enclosure Keys	2.6.1	G												
			SD-05 Design Data														
			UMCS IP Network Bandwidth	3.3.1	G												
			Usage Estimate														
			SD-06 Test Reports														
			Pre-Construction QC Checklist	1.7	G												
			Post-Construction QC Checklist	1.7	G												
			Factory Test Procedures	3.1	G												
			Factory Test Report	3.1	G												
			Existing Conditions Report	3.2	G												
			Start-Up and Start-Up Testing	3.7	G												
			Report														
			PVT Phase I Procedures	3.8.1	G												
			PVT Phase I Report	3.8.2	G												
			PVT Phase II Report	3.8.3	G												
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	1.8	G												
			(O&M) Instructions														
			Preventive Maintenance Work	3.9.8.1	G												
			Plan														
			Basic Training Documentation	3.10.1	G												

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		25 10 10	Advanced Training	3.10.1	G												
			Documentation														
			Refresher Training	3.10.1	G												
			Documentation														
			SD-11 Closeout Submittals														
			Closeout QC Checklist	1.7	G												
		26 05 00.00 40	SD-02 Shop Drawings														
			Marking Strips	3.2.11.1	G												
			SD-03 Product Data														
			Conduits and Raceways	2.1.1	G												
			Wire and Cable	2.2.1	G												
			Splices and Connectors	3.2.10	G												
			Switches	2.2.3	G												
			Receptacles	2.2.5	G												
			Outlet Boxes, Pull Boxes and	2.1.3	G												
			Junction Boxes														
			Circuit Breakers	2.1.4.1	G												
			Panelboards	2.1.4	G												
			Dry-Type Distribution	2.1.5	G												
			Transformers														
			Device Plates	2.2.2	G												
			SD-06 Test Reports														
			Continuity Test	3.6	G												
			Phase-Rotation Tests	3.6	G												
			Insulation Resistance Test	3.6	G												
			600-Volt Wiring Test	3.6	G												

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		26 05 00.00 40	Transformer Tests	3.6	G												
			Ground-Fault Receptacle Test	3.6	G												
			Insulation-Resistance Test	3.6	G												
			SD-08 Manufacturer’s Instructions														
			Manufacturer's Instructions	3.1													
		26 05 13.00 40	SD-01 Preconstruction Submittals														
			List of Splices and Terminations	1.3.1	G												
			to be Installed by														
			Splicer/Terminator														
			SD-02 Shop Drawings														
			Pulling Plan	3.2.3	G												
			SD-03 Product Data														
			Multiple-Conductor Shielded	2.2.1	G												
			Cables														
			Multiple-Conductor Nonshielded	2.2.2	G												
			Cables														
			Single-Conductor Shielded	2.2.3	G												
			Cables														
			Single-Conductor Nonshielded	2.2.4	G												
			Cables														
			Portable Cables	2.2.5	G												
			Cable Supports and Fittings	2.2.9	G												
			Polyethylene Cable Tags	2.2.10	G												
			Polyethylene Cable Tags	2.2.10	G												
			Fireproof Tape	2.2.11	G												
			Splices	2.2.7	G												

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TITLE AND LOCATION
MOODY INSTALLATION GUIDE SPECIFICATIONS

CONTRACTOR

ACTIVITY NO (a)	TRANSMITTAL NO (b)	SPEC SECT (c)	DESCRIPTION ITEM SUBMITTED (d)	PARAGRAPH # (e)	CLASSIFICATION GOVT OR A/E REVWR (f)	CONTRACTOR: SCHEDULE DATES SUBMIT (g)	APPROVAL NEEDED BY (h)	MATERIAL NEEDED BY (i)	CONTRACTOR ACTION ACTION CODE (j)	DATE OF ACTION (k)	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR (l)	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER (m)	DATE RCD FROM OTH REVIEWER (n)	ACTION CODE (o)	DATE OF ACTION (p)	MAILED TO CONTR/ DATE RCD FRM APPR AUTH (q)	REMARKS (r)
		26 05 13.00 40	Terminations	2.2.8	G												
			SD-06 Test Reports														
			Field Testing	3.3	G												
			Qualification Test Reports	2.4.1	G												
			Radiographic Tests	3.3	G												
			SD-07 Certificates														
			Splicer/Terminator Certifications	1.5.2	G												
			SD-08 Manufacturer’s Instructions														
			Medium-Voltage Power Cables	3.4	G												
			Terminations	2.2.8	G												
			Splices	2.2.7	G												
		26 05 19.10 10	SD-03 Product Data														
			Wire and Cable	2.1.1	G												
			Conductors	2.1.3.1	G												
			Cable Manufacturing Data	3.1													
			SD-06 Test Reports														
			Test Report(s), Inspection	3.2	G												
			Report(s), and Verification														
			Report(s)														
		26 05 26.00 40	SD-03 Product Data														
			Ground Rods	2.1.1	G												
			Ground Wires	2.1.2	G												
			Connectors and Fasteners	2.1.3	G												
			Test Wells	2.1.4	G												
			Conductive Corrosion Inhibiting	2.1.5	G												
			Compounds														

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		26 05 26.00 40	Ground Buses	2.1.6	G												
			SD-06 Test Reports														
			Bond Resistance Test	3.2.1	G												
			Ground Resistance Tests	3.2.2	G												
			Ground Isolation Test	3.2.3	G												
			Equipment Continuity Test	3.2.4	G												
			SD-07 Certificates														
			Ground Resistance Test	1.3.3	G												
			Equipment														
			Micro-Ohmmeter Test Equipment	1.3.4	G												
			SD-11 Closeout Submittals														
			Record Drawings	3.3													
		26 05 48.00 10	SD-02 Shop Drawings														
			Lighting Fixtures in Buildings	3.2													
			Equipment Requirements	1.3													
			SD-03 Product Data														
			Lighting Fixtures in Buildings	3.2	G												
			Equipment Requirements	1.3	G												
			Contractor Designed Bracing	1.2.4	G												
		26 05 71.00 40	SD-02 Shop Drawings														
			Connection Diagrams	2.1	G												
			Fabrication Drawings	2.1	G												
			Control Devices	3.1	G												
			Protective Devices	3.1	G												
			SD-03 Product Data														
			Fuses	2.2.3	G												

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		26 05 71.00 40	Motor Controllers	2.2.1	G												
			Instrument Transformers	2.3.1	G												
			Enclosures	2.3.2	G												
			Circuit Breakers	2.2.2	G												
			Control Devices	3.1	G												
			Time Switches	2.3.3	G												
			Protective Relays	2.3.4	G												
			Indicating Instruments	2.3.5	G												
			Indicating Lights	2.3.6	G												
			SD-06 Test Reports														
			Dielectric Tests	3.2.1	G												
			Final Test Reports	3.2.1	G												
			SD-07 Certificates														
			Insulating Oil	3.2.1	G												
			SD-08 Manufacturer’s Instructions														
			Control Devices	3.1	G												
			Protective Devices	3.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Manual Motor Controllers	2.2.1.1	G												
			Magnetic Motor Controllers	2.2.1.2	G												
			Combination Motor Controllers	2.2.1.3	G												
			Circuit Breakers	2.2.2	G												
			Time Switches	2.3.3	G												
			Protective Relays	2.3.4	G												
			Indicating Instruments	2.3.5	G												

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		26 08 00	SD-06 Test Reports														
			Acceptance Tests and Inspections	3.1	G												
			SD-07 Certificates														
			Qualifications	1.4.1	G												
			Acceptance Test and Inspections Procedure	1.4.3	G												
		26 09 23.00 40	SD-02 Shop Drawings														
			Lighting System Drawings	2.1	G												
			SD-03 Product Data														
			Installation Instructions	3.1	G												
			Dimming Ballast Controls	2.2.2	G												
			Light Level Sensor	2.2.3	G												
			Dimmer Switch	2.2.4	G												
			Lighting Contactor	2.2.5	G												
			Time Switch	2.2.6	G												
			Photocell Switch	2.2.7	G												
			Occupancy Sensors	2.2.8	G												
			SD-06 Test Reports														
			System Operation Tests	3.3													
			SD-10 Operation and Maintenance Data														
			Lighting Control System, Data Package 5	3.4													
		26 11 13.00 20	SD-02 Shop Drawings														
			Unit Substation Drawings	1.4.2	G												

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		26 11 13.00 20	Transformer Drawings	1.4.3	G												
			SD-03 Product Data														
			Primary Unit Substations	2.2	G												
			Transformer	2.2.3	G												
			SD-05 Design Data														
			Capacity Calculations for Battery	1.4.1	G												
			Charger and Batteries														
			SD-06 Test Reports														
			Calibration Test Reports	1.4.6	G												
			Acceptance Checks and Tests	3.5.1	G												
			Dielectric Tests	3.5.2	G												
			SD-09 Manufacturer’s Field														
			Reports														
			Switchgear Design Tests	2.3.3	G												
			Switchgear Production Tests	2.3.4	G												
			Load Interrupter Switch Design	2.3.5	G												
			Tests														
			Load Interrupter Switch	2.3.6	G												
			Production Tests														
			Transformer Design Tests	2.3.7	G												
			Routine and Other Tests	2.3.8	G												
			SD-10 Operation and Maintenance														
			Data														
			Primary Unit Substations	2.2	G												
			Transformer	2.2.3	G												
			SD-11 Closeout Submittals														

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		26 11 13.00 20	Calibration Schedule	1.4.4	G												
			Formal Request for Settings	1.4.5	G												
			Equipment Test Schedule	2.3.1	G												
		26 11 16	SD-02 Shop Drawings														
			Unit Substation Drawings	1.5.1.1	G												
			Transformer Drawings	1.5.1.2	G												
			SD-03 Product Data														
			Fuse Curves		G												
			Secondary Unit Substation	2.2	G												
			Transformer (Liquid-filled)	2.2.2	G												
			Transformer (Dry-type)	2.2.3	G												
			SD-06 Test Reports														
			Acceptance Checks and Tests	3.6.1	G												
			SD-07 Certificates														
			Paint Coating System	1.5.2	G												
			Transformer Efficiencies	1.5.3	G												
			SD-09 Manufacturer's Field														
			Reports														
			Load Interrupter Switch	2.6.2	G												
			Production Tests														
			Transformer Design Tests	2.6.3	G												
			(Liquid-filled)														
			Transformer Routine and Other	2.6.4	G												
			Tests (Liquid-filled)														
			Design Tests (Dry-type)	2.6.5	G												

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		26 11 16	Routine and Other Tests	2.6.6	G													
			(Dry-type)															
			SD-10 Operation and Maintenance															
			Data															
			Unit Substations	2.2	G													
			SD-11 Closeout Submittals															
			Assembled Operation and	1.6.1	G													
			Maintenance Manuals															
			Equipment Test Schedule	2.6.1	G													
		26 12 19.10	SD-02 Shop Drawings															
			Pad-mounted Transformer	1.5.1	G													
			Drawings															
			SD-03 Product Data															
			Pad-mounted Transformers	2.2	G													
			SD-06 Test Reports															
			Acceptance Checks and Tests	3.7.1	G													
			SD-07 Certificates															
			Transformer Efficiencies	2.2.2.1	G													
			SD-09 Manufacturer’s Field															
			Reports															
			Transformer Test Schedule	2.8.1	G													
			Design Tests	2.8.2	G													
			Routine and Other Tests	2.8.3	G													
			SD-10 Operation and Maintenance															
			Data															
			Transformer(s)	1.6.1	G													

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		26 12 21	SD-02 Shop Drawings															
			Pad-Mounted Transformer Drawings	1.5.1	G													
			SD-03 Product Data															
			Single-Phase Pad-Mounted Transformers (Dead-Front)	2.2	G													
			SD-06 Test Reports															
			Acceptance Checks and Tests	3.7.1	G													
			SD-07 Certificates															
			Transformer Efficiencies	2.2.2.1	G													
			SD-09 Manufacturer's Field Reports															
			Transformer Test Schedule	2.10.1	G													
			Design Tests	2.10.3	G													
			Routine and Other Tests	2.10.4	G													
			SD-10 Operation and Maintenance Data															
			Transformer(s)	1.6.1	G													
		26 18 23.00 40	SD-03 Product Data															
			Surge Arrester	Part 2	G													
			SD-08 Manufacturer's Instructions															
			Installation Instructions	Part 2														
			SD-10 Operation and Maintenance Data															
			Operation and Maintenance Manuals	3.3														

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		26 20 00	SD-02 Shop Drawings														
			Panelboards	2.15	G												
			Transformers	2.19	G												
			Busway	2.4	G												
			Cable Trays	2.5	G												
			Motor Control Centers	2.23	G												
			Wireways	2.33	G												
			Load Centers for Housing Units		G												
			Marking Strips	3.1.12.1	G												
			SD-03 Product Data														
			Receptacles	2.14	G												
			Circuit Breakers	2.15.3	G												
			Circuit Breakers	2.16.2	G												
			Switches	2.12	G												
			Transformers	2.19	G												
			Enclosed Circuit Breakers	2.17	G												
			Motor Controllers	2.21	G												
			Combination Motor Controllers	2.23.2	G												
			Load Centers for Housing Units		G												
			Manual Motor Starters	2.22	G												
			Residential Load Centers	2.16	G												
			Metering		G												
			Meter Base Only		G												
			CATV Outlets	2.26.1	G												
			Secondary Bonding Busbar	2.27.3	G												
			Surge Protective Devices	2.34	G												

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		26 20 00	Cable Trays	2.5	G												
			Cable Tray Design	2.5	G												
			SD-06 Test Reports														
			600-volt Wiring Test	3.5.2	G												
			Grounding System Test	3.5.6	G												
			Transformer Tests	3.5.3	G												
			Ground-fault Receptacle Test	3.5.4	G												
			Arc-fault Receptacle Test	3.5.5	G												
			SD-07 Certificates														
			Fuses	2.13	G												
			SD-09 Manufacturer’s Field														
			Reports														
			Transformer Factory Tests	2.36.1													
			SD-10 Operation and Maintenance														
			Data														
			Electrical Systems	1.5.1	G												
			Metering		G												
		26 22 00.00 10	SD-02 Shop Drawings														
			Shop Drawings	2.5.4.1	G												
			Installation	3.1	G												
			Terminal Blocks	2.5.5.3	G												
			SD-03 Product Data														
			Switchgear	2.5.2.1													
			Power Circuit Breakers	2.5.4													
			Transformers	2.5.10.1													
			Spare Parts	1.4													

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		26 22 00.00 10	Metal-Enclosed Bus	2.6														
			SD-04 Samples															
			Nameplates	2.1	G													
			SD-06 Test Reports															
			Factory Inspection and Tests	2.10														
		26 23 00	SD-02 Shop Drawings															
			a. Switchgear Drawings		G													
			SD-03 Product Data															
			Switchgear	2.2	G													
			SD-06 Test Reports															
			Switchgear Design Tests	2.5.2	G													
			Switchgear Production Tests	2.5.3	G													
			Acceptance Checks and Tests	3.5.1	G													
			SD-10 Operation and Maintenance															
			Data															
			Switchgear Operation and	1.6.1	G													
			Maintenance															
			SD-11 Closeout Submittals															
			Assembled Operation and	1.6.2	G													
			Maintenance Manuals															
			Equipment Test Schedule	2.5.1	G													
			Request for Settings		G													
			Required Settings	3.5	G													
			Service Entrance Available Fault		G													
			Current Label															
		26 23 00.00 40	SD-02 Shop Drawings															

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		26 23 00.00 40	[Switchboard][Switchgear]	2.1.1	G												
			Drawings														
			SD-03 Product Data														
			[Switchboard][Switchgear]	2.2	G												
			Spare Parts List	3.3.3	G												
			SD-06 Test Reports														
			Acceptance Checks and Tests	3.2.1	G												
			SD-07 Certificates														
			Equipment Test Schedule	2.3.1													
			[Switchboard][Switchgear] Design	2.3.2													
			Tests														
			[Switchboard][Switchgear]	2.3.3													
			Production Tests														
			SD-10 Operation and Maintenance														
			Data														
			[Switchboard][Switchgear]	3.3.1													
			Operation and Maintenance														
			SD-11 Closeout Submittals														
			Warranty	1.6													
			Assembled Operation and	3.3.2													
			Maintenance Manuals														
			Request for Settings	3.2													
		26 24 16.00 40	SD-03 Product Data														
			Panelboards	2.1	G												
			SD-06 Test Reports														
			Acceptance Tests	3.2	G												

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		26 24 16.00 40	SD-08 Manufacturer’s Instructions														
			Manufacturer's Instructions	3.3													
		26 27 13.10 30	SD-03 Product Data														
			Power Meters	2.1	G												
			Current	2.1.3	G												
			Potential Transformer	2.1.2	G												
			Communications Module	2.2.2	G												
			Protocol Modules	1.6.1	G												
			Data Recorder	1.6.2	G												
			Modem	1.6.2	G												
			SD-06 Test Reports														
			Acceptance Checks and Tests	3.3.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Power Meters	2.1	G												
			Communications Module	2.2.2	G												
			Protocol Modules	1.6.1	G												
			Data Recorder	1.6.2	G												
			Modem	1.6.2	G												
			SD-11 Closeout Submittals														
			System Function Verification	3.3.2	G												
		26 28 00.00 10	SD-02 Shop Drawings														
			Drawings	2.7.2	G												
			Shop Drawings	2.4.1	G												
			Motor Control Centers	2.9	G												
			Switchboards	2.10	G												

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						CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		26 28 00.00 10	Panelboards	2.11	G												
			SD-03 Product Data														
			Equipment	1.4	G												
			Factory Tests	2.12													
			Required Settings	3.5													
			Request For Settings														
			SD-06 Test Reports														
			Factory Tests	2.12													
			Acceptance Checks And Tests	3.5.1	G												
			SD-07 Certificates														
			Motor Control Centers	2.9													
		26 28 01.00 10	SD-03 Product Data														
			Fault Current Analysis	2.1													
			Protective Device Coordination	2.1													
			Study														
			System Coordinator	1.3.1													
		26 29 01.00 10	SD-02 Shop Drawings														
			Motors	2.2	G												
			SD-03 Product Data														
			Insulated Windings	2.2.5	G												
			Duty Cycle	2.2.2.4	G												
			Motors	2.2	G												
			Government Study	1.4.2													
			Spare Parts	1.2													
			SD-06 Test Reports														
			Starting Capabilities	2.2.2.3													

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		26 29 01.00 10	Factory Tests	2.6													
			SD-07 Certificates														
			Power Factor and Efficiency	2.2.2.7													
			Factory Tests	2.6													
			SD-10 Operation and Maintenance														
			Data														
			Instructions	1.2	G												
		26 29 23	SD-02 Shop Drawings														
			Schematic Diagrams	1.5.1	G												
			Interconnecting Diagrams	1.5.2	G												
			Installation Drawings	1.5.3	G												
			As-Built Drawings	1.5.3	G												
			SD-03 Product Data														
			Adjustable Speed Drives	2.1	G												
			Wires and Cables	2.3													
			Equipment Schedule	1.5.4													
			SD-06 Test Reports														
			ASD Test	3.3.1													
			Performance Verification Tests	3.3.2													
			Endurance Test	3.3.3													
			SD-08 Manufacturer’s Instructions														
			Installation instructions	1.5.5													
			SD-09 Manufacturer’s Field														
			Reports														
			ASD Test Plan	2.5.1	G												
			Standard Products	1.5.6													

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		26 29 23	SD-10 Operation and Maintenance															
			Data															
			Adjustable Speed Drives	2.1														
		26 32 15.00	SD-02 Shop Drawings															
			Engine-Generator Set and		G													
			Auxiliary Equipment															
			Auxiliary Systems	1.4.10	G													
			Detailed Drawings	1.4.9	G													
			Acceptance	3.17	G													
			SD-03 Product Data															
			Harmonic Requirements	2.1.9	G													
			Engine-Generator Set		G													
			Efficiencies															
			Emissions	2.13	G													
			filters	2.7.2	G													
			special tools	2.15	G													
			Remote Alarm Annunciator	2.14.4	G													
			Engine-Generator Parameter															
			Schedule															
			Heat Exchanger	2.8.2														
			Generator	2.16														
			Manufacturer's Catalog	2.5														
			Site Welding	1.4.2														
			Spare Parts	1.7.2														
			Onsite Training	3.12														
			Vibration-Isolation	2.1.8														

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		26 32 15.00	Posted Data and Instructions	3.16	G												
			Instructions	3.6.7.1	G												
			Experience	1.4.7													
			Field Engineer	1.4.8													
			General Installation	3.2													
			Exciter	2.17													
			SD-05 Design Data														
			Performance Criteria	2.16													
			Sound Limitations	2.9	G												
			Integral Main Fuel Storage Tank	2.6.4													
			Day Tank	2.6.5													
			Power Factor	3.6.1.2													
			Heat Exchanger	2.8.2													
			Time-Delay on Alarms	2.20.5													
			Cooling System	2.8													
			Vibration Isolation	2.1.8													
			Battery Charger	2.14.3.2													
			Capacity Calculations for		G												
			Engine-Generator Set														
			Brake Mean Effective Pressure		G												
			(BMEP) Calculations														
			Torsional Vibration Stress		G												
			Analysis Computations														
			Capacity Calculations for		G												
			Batteries														
			Turbocharger Load Calculations		G												

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		26 32 15.00	SD-06 Test Reports														
			Performance Tests	3.6.9													
			Factory Inspection and Tests	2.30													
			Factory Tests	2.30.2													
			Onsite Inspection and Tests	3.6	G												
			Acceptance Checks and Tests	3.9.2	G												
			Functional Acceptance Tests	3.10.2	G												
			Maintenance Procedures	3.12	G												
			Operation and Maintenance	3.12	G												
			Manuals														
			Inspections	3.6.3	G												
			Functional Acceptance Test	3.9.6	G												
			Procedure														
			SD-07 Certificates														
			Cooling System	2.8													
			Vibration Isolation	2.1.8													
			Prototype Test	2.30.2													
			Reliability and Durability	2.1.4													
			Fuel System Certification	1.4.13	G												
			Start-Up Engineer	3.8	G												
			Instructor's Qualification Resume	3.11.1	G												
			Engine Emission Limits	2.1.1.1	G												
			Sound Limitations	2.9													
			Site Visit	3.1													
			Current Balance	2.16.1													
			Materials and Equipment	2.4													

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		26 32 15.00	Factory Inspection and Tests	2.30														
			Engine Tests	3.6.4	G													
			Generator Tests	3.6.5	G													
			Assembled Engine-Generator Set	3.6.6	G													
			Tests															
			SD-10 Operation and Maintenance															
			Data															
			Preliminary Assembled Operation	3.9.5	G													
			and Maintenance Manuals															
			Posted Data and Instructions	3.16	G													
			Training Plan	3.11.2	G													
		26 33 53	SD-02 Shop Drawings															
			UPS Drawings	1.5.1	G													
			UPS Installation	1.5.2	G													
			SD-03 Product Data															
			UPS Module	2.5	G													
			Technical Requirements UPS	2.4														
			System															
			Energy Star Label for Battery		S													
			Charging Systems and															
			AC-DC/AC-AC Power Supply															
			Products															
			Spare Parts	1.4.2	G													
			SD-06 Test Reports															
			Work Plan	1.5.3	G													
			Factory Test Plan	1.5.4	G													

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		26 33 53	Factory Test Report	1.5.5	G												
			SD-09 Manufacturer's Field														
			Reports														
			Initial Inspection and Tests	3.2.2	G												
			Performance Tests	3.2.3	G												
			Performance Test Plan	1.5.6	G												
			Performance Test Report	1.5.7	G												
			SD-10 Operation and Maintenance														
			Data														
			UPS Operation and Maintenance	1.4.1	G												
			SD-11 Closeout Submittals														
			Installation	3.1													
		26 36 23	SD-02 Shop Drawings														
			Automatic Transfer Switch	1.5.2	G												
			Drawings														
			SD-03 Product Data														
			Automatic Transfer Switches	2.1	G												
			By-Pass/Isolation Switch (BP/IS)	2.2	G												
			Remote Annunciator Panel	2.4	G												
			Remote Annunciator and Control	2.5	G												
			System Panel														
			SD-06 Test Reports														
			Acceptance Checks and Tests	3.3.1	G												
			Functional Acceptance Tests	3.3.2	G												
			Factory Testing	2.6	G												
			Factory Test Reports	2.6.2	G												

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		26 36 23	Factory Testing -Medical Facilities	2.7	G												
			SD-07 Certificates														
			Proof of Listing	1.5.1	G												
			SD-10 Operation and Maintenance Data														
			Operation and Maintenance Manual	1.4	G												
		26 41 00	SD-02 Shop Drawings														
			Overall lightning protection system	1.4.1.1	G												
			Each major component	1.4.1.2	G												
			SD-06 Test Reports														
			Lightning Protection and Grounding System Test Plan	1.4.3	G												
			Lightning Protection and Grounding System Test	3.5.1	G												
			SD-07 Certificates														
			Lightning Protection System Installers Documentation	1.2.3	G												
			Component UL Listed and Labeled	1.4.2	G												
			Lightning protection system inspection certificate	1.4.4	G												
			Roof manufacturer's warranty	3.1.1	G												
		26 42 13	SD-01 Preconstruction Submittals														

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		26 42 13	Preconstruction Survey	1.8.2													
			SD-02 Shop Drawings														
			Drawings	2.1.2.7	G												
			Isolation flange kits	2.4.11													
			Anode junction boxes, bonding	2.3.4													
			boxes, and test stations														
			Joint bonds	3.5.4													
			Contractor's Modifications	2.1.2.7	G												
			SD-03 Product Data														
			Qualifications	1.6.2													
			Equipment	1.5.1	G												
			Anodes	1.5.1	G												
			Anode junction boxes, bonding	2.3.4													
			boxes, and test stations														
			Dielectric unions	2.4.13													
			Wires	2.1.2.2													
			Cable and wire	2.4.3													
			Casings, isolation, and seals	3.5.5													
			Shunts	2.3.2													
			Permanent reference electrodes	2.4.7	G												
			Spare Parts	1.5.1													
			SD-06 Test Reports														
			Tests and Measurements	3.6.1	G												
			Contractor's Modifications	2.1.2.7	G												
			SD-10 Operation and Maintenance														
			Data														

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		26 42 13	Cathodic Protection System	3.6	G												
			Cathodic Protection System	3.6	G												
			Training Course	1.5.1	G												
			SD-11 Closeout Submittals														
			Initial Cathodic Protection System	3.6.1.12	G												
			Field Testing														
			One Year Warranty Period	3.6.1.14	G												
			Cathodic Protection System Field														
			Test Report														
			Final Cathodic Protection System	3.6.1.15	G												
			Field Test Report														
		26 42 15	SD-01 Preconstruction Submittals														
			Preconstruction Survey	1.8.2													
			SD-02 Shop Drawings														
			Drawings	2.1.2.1	G												
			Wiring and Schematic Diagram	2.2.3.8													
			Anode junction boxes	2.3.3													
			Anode junction boxes	3.6.1													
			Contractor's Modifications	2.1.2.1	G												
			SD-03 Product Data														
			Qualifications	1.6.2													
			Equipment	1.5.1	G												
			Components	2.3													
			Rectifiers	2.2.3													
			Remote Monitoring Equipment	2.2.1													
			Anodes	1.5.1	G												

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		26 42 15	Permanent reference electrodes	2.4.4	G												
			Permanent reference electrodes	2.4.4	G												
			Anode junction boxes	2.3.3													
			Anode junction boxes	3.6.1													
			Cable and wire	2.5.8													
			Shunts	2.3.2													
			Extra Materials	1.5.2	G												
			Spare Parts	1.5.1													
			SD-05 Design Data														
			Contractor's Modifications	2.1.2.1	G												
			SD-06 Test Reports														
			Anode Connecting Cables	2.4.1.2.4													
			Rectifier Testing	3.6.5													
			SD-10 Operation and Maintenance														
			Data														
			Cathodic Protection System	3.5	G												
			Training Course;	1.5.1	G												
			Contractor's Modifications	2.1.2.1	G												
			SD-11 Closeout Submittals														
			Initial Cathodic Protection System	3.6.6	G												
			Testing														
			One Year Warranty Period	3.6.8	G												
			Cathodic Protection System Field														
			Test Report														
			Final Acceptance Field Testing	3.6.9	G												
		26 42 19.10	SD-02 Shop Drawings														

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		26 42 19.10	Detailed Drawings	1.3.1	G												
			SD-03 Product Data														
			Materials and Equipment	2.1	G												
			Training Course	3.14	G												
			Protective Angle Irons	2.6.2	G												
			Modification of Design	1.3.4	G												
			SD-06 Test Reports														
			Factory Test Data	2.5.4.1													
			System Commissioning	1.9	G												
			SD-07 Certificates														
			Qualifications	1.5.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.13	G												
			Instructions														
		26 51 00	SD-02 Shop Drawings														
			Luminaire Drawings	1.5.1	G												
			Occupancy/Vacancy Sensor	1.5.9	G												
			Coverage Layout														
			Lighting Control System	1.7.2	G												
			One-Line Diagram														
			Sequence of Operation for	2.5.1	G												
			Lighting Control System														
			SD-03 Product Data														
			Luminaires	2.2	G												
			Light Sources	2.3	G												

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		26 51 00	LED Drivers	2.4	G												
			Luminaire Warranty	1.6.1	G												
			Lighting Controls Warranty	1.6.2	G												
			Local Area Controller	2.5.1.1.1	G												
			Lighting Relay Panel	2.5.1.2.1	G												
			Lighting Control Panel	2.5.1.2.2	G												
			Gateway		G												
			Lighting Contactor		G												
			Switches	2.5.2.1	G												
			Digital Switch Timers	2.5.2.2	G												
			Wall Box Dimmers	2.5.2.3	G												
			Scene Wallstations	2.5.2.4	G												
			Occupancy/Vacancy Sensors	2.5.2.5	G												
			Photosensors	2.5.2.6	G												
			Time Clocks	2.5.2.7	G												
			Power Packs	2.5.2.5.6	G												
			Power Hook Luminaire Hangers	2.7.4	G												
			Mini Inverters	2.6.5	G												
			Exit Signs	2.6.1	G												
			Emergency Drivers	2.6.3	G												
			Energy Star Label For	2.2	S												
			Residential Luminaires														
			Linear LED Lamps		G												
			SD-05 Design Data														
			Luminaire Design Data	1.5.2	G												
			Photometric Plan	1.5.8	G												

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		26 51 00	SD-06 Test Reports														
			ANSI/IES LM-79 Test Report	1.5.3	G												
			ANSI/IES LM-80 Test Report	1.5.4	G												
			ANSI/IES TM-21 Test Report	1.5.5	G												
			ANSI/IES TM-30 Test Report	1.5.6	G												
			Occupancy/Vacancy Sensor	3.2.1.1	G												
			Verification Test														
			Photosensor Verification Test	3.2.1.1	G												
			SD-07 Certificates														
			LED Driver and Dimming Switch	1.5.7	G												
			Compatibility Certificate														
			SD-10 Operation and Maintenance														
			Data														
			Lighting System	1.7.1	G												
			Lighting Control System	1.7.2	G												
			Maintenance Staff Training Plan	3.3.2.1	G												
			End-User Training Plan	3.3.2.2	G												
		26 52 00.00 40	SD-02 Shop Drawings														
			Central Emergency Lighting	2.2.3	G												
			Systems														
			SD-03 Product Data														
			Material, Equipment, and Fixture	1.2.1	G												
			Lists														
			Sample Warranty	1.2.1	G												
			Emergency Lighting Egress Units	2.2.1	G												
			Emergency Fluorescent Lighting	2.2.2	G												

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		26 52 00.00 40	Central Emergency Lighting	2.2.3	G												
			Systems														
			Accessories	2.2.3.4	G												
			SD-06 Test Reports														
			System Operational Tests	3.2	G												
			SD-07 Certificates														
			Certificates of Conformance	1.2.1													
			SD-11 Closeout Submittals														
			Warranty	3.3													
		26 53 00.00 40	SD-01 Preconstruction Submittals														
			Material, Equipment, and Fixture	1.2.1	G												
			Lists														
			SD-02 Shop Drawings														
			Exit Lighting Units	1.2.1	G												
			Exit Lighting Units Outline	1.2.1	G												
			Drawings														
			SD-03 Product Data														
			Exit Lighting Units	1.2.1	G												
			Contemporary Fixtures	1.2.1	G												
			Accessories	1.2.1	G												
			SD-06 Test Reports														
			Operational Tests	3.2.1	G												
			SD-07 Certificates														
			Energy Efficiencies	1.2.1	G												
		26 55 53.00 40	SD-02 Shop Drawings														
			Lighting System	2.1.1	G												

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		26 55 53.00 40	Detail Drawings	2.2.11		G												
			SD-03 Product Data															
			Equipment and Materials			G												
			Spare Parts	2.2.11		G												
			SD-06 Test Reports															
			CCTV Assessment Lighting	3.3.1		G												
			Operating Test	3.3.2		G												
			Ground Resistance	3.3.3		G												
			Measurements															
			SD-07 Certificates															
			CCTV Assessment Lighting Test	3.3.1		G												
			Procedures															
			Operating Test Procedures	3.3.2		G												
			SD-10 Operation and Maintenance															
			Data															
			Operations and Maintenance	3.4.1		G												
			Manuals															
			SD-11 Closeout Submittals															
			Record Drawings	3.4.2		G												
		26 56 00	SD-02 Shop Drawings															
			Luminaire Drawings	1.5.1.1		G												
			Pole Drawings	1.5.1.2		G												
			Control System One-Line	1.8.2		G												
			Diagram															
			Sequence of Operation for	2.5.1		G												
			Exterior Lighting Control System															

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		26 56 00	SD-03 Product Data														
			Luminaires	2.2	G												
			Light Sources	2.3	G												
			LED Drivers	2.4	G												
			Luminaire Warranty	1.7.1	G												
			Lighting Controls Warranty	1.7.2	G												
			Pole Warranty	1.7.3	G												
			Dimming Panel		G												
			Motion Sensors		G												
			Photosensors	2.5.2.2	G												
			Time Clock	2.5.2.1	G												
			Lighting Contactor	2.5.2.3	G												
			Poles	2.6	G												
			Brackets	2.6.4													
			Obstruction Marker Luminaires	2.2.2	G												
			SD-04 Samples														
			Luminaire Samples		G												
			SD-05 Design Data														
			Luminaire Design Data	1.5.2	G												
			Photometric Plan	1.5.8	G												
			SD-06 Test Reports														
			ANSI/IES LM-79 Test Report	1.5.3	G												
			ANSI/IES LM-80 Test Report	1.5.4	G												
			ANSI/IES TM-21 Test Report	1.5.5	G												
			Pressure Treated Wood Pole	1.5.7	G												
			Quality														

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		26 56 00	Tests for Fiberglass Poles	1.5.6	G												
			SD-08 Manufacturer's Instructions														
			Poles	2.6													
			SD-10 Operation and Maintenance														
			Data														
			Lighting System	1.8.1	G												
			Exterior Lighting Control System	1.8.2	G												
			Maintenance Staff Training Plan	3.3.1.1	G												
			End-User Training Plan	3.3.1.2	G												
		26 56 20	SD-01 Preconstruction Submittals														
			Protection plan	1.5.5	G												
			Training	3.17.2	G												
			SD-02 Shop Drawings														
			Lighting and visual navigation	2.1	G												
			aids														
			Wave-off system		G												
			Landing signal officer (LSO)		G												
			control panel														
			Approach Lighting Frangible	2.3.1	G												
			Towers														
			Wind Cone Indicator Assembly	2.12	G												
			Connection														
			Posted instructions	3.17.4	G												
			SD-03 Product Data														
			Simulated carrier deck lighting		G												
			system														

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		26 56 20	Pilot relay panel	2.2.1	G												
			Control transfer panel	2.2.2	G												
			Airfield lighting control and monitoring system	2.2.4	G												
			Approach lighting systems	2.3	G												
			Type L-823	2.3.2.3	G												
			Precision approach path indicator system	2.3.4.1	G												
			Chase helicopter approach path indicator system	2.3.4.2													
			Runway edge lights	2.4.1	G												
			Runway threshold and end lights	2.4.2	G												
			Runway centerline lights, tailhook operations		G												
			Runway centerline lights, non-tailhook operations		G												
			Runway touchdown zone lights, tailhook operations	2.4.3	G												
			Taxiway edge lights	2.5.1	G												
			Taxiway centerline lights		G												
			Runway hold position lights	2.5.3	G												
			Guidance signs	2.6.3	G												
			Runway distance remaining signs	2.6.4	G												
			Arresting gear markers	2.6.5	G												
			Obstruction lighting	2.10	G												
			Wheels-up system		G												

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		26 56 20	Wave-off system		G												
			Light bases	2.11	G												
			Wind direction indicator	2.12	G												
			Airfield rotating beacon	2.13.1	G												
			Helipad/heliport beacon														
			Airfield identification/code beacon		G												
			Isolation transformers	2.16	G												
			Encapsulated isolation	2.16.1	G												
			transformers														
			Isolation transformers for		G												
			frangible towers														
			Constant current regulators	2.19	G												
			Constant current regulators	3.11	G												
			Constant current regulators	3.15.7	G												
			Circuit selector switch	2.20	G												
			Control cable	2.21.1.6	G												
			Frangible couplings	2.21.2.7	G												
			Type P-605	2.21.6	G												
			Type P-606	2.21.6	G												
			Materials and equipment	1.5.2	G												
			SD-06 Test Reports														
			Visual inspection	3.14	G												
			Visual inspection	3.14.1	G												
			Photometric testing	3.15	G												
			Airfield guidance signs	3.15.1	G												
			Airfield guidance signs	3.15.4	G												

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		26 56 20	Discharge-type flashing light equipment	3.15.1	G												
			Discharge-type flashing light equipment	3.15.5	G												
			PAPIs	3.15.1	G												
			PAPIs	3.15.6	G												
			Progress testing for series lighting circuits	3.14.5	G												
			Counterpoise system test and inspection	3.14.4	G												
			Operating test	3.14.2	G												
			Distribution conductors, 600-volt class	3.14.3	G												
			Electrical acceptance tests	3.14.6	G												
			Low-voltage continuity tests	3.14.7	G												
			High-voltage insulation resistance tests	3.14.8	G												
			Constant current regulators	2.19	G												
			Constant current regulators	3.11	G												
			Constant current regulators	3.15.7	G												
			SD-07 Certificates														
			Qualifications of contractor	1.5.3	G												
			Qualifications of photometric tester	1.5.4	G												
			Special tools	2.22.1	G												
			Special tools	3.17.2	G												

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		26 56 20	4-Jack positioning jig	3.1.6	G												
			Elevated light level	3.1.6.1	G												
			Crimping tool	3.2.3.2	G												
			Cable penciler	3.2.3.3													
			List of parts	3.18.1	G												
			SD-08 Manufacturer’s Instructions														
			Posted instructions	3.17.4	G												
			SD-10 Operation and Maintenance														
			Data														
			Constant current regulators	2.19	G												
			Constant current regulators	3.11	G												
			Constant current regulators	3.15.7	G												
			Airfield rotating beacon	2.13.1	G												
			Approach lighting systems	2.3	G												
			Wave-off system		G												
			Maintenance and repair	3.18.2	G												
			instructions														
			Posted operations and	3.18.3													
			maintenance instructions														
			SD-11 Closeout Submittals														
			As-built drawings	3.17.3													
		26 60 13.00 40	SD-03 Product Data														
			Low-Voltage Motors	2.1	G												
			SD-06 Test Reports														
			Factory Test Results	2.3	G												
			Field Test Report	3.2	G												

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		26 60 13.00 40	SD-08 Manufacturer’s Instructions														
			Manufacturer's Instructions	3.3.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Operating and Maintenance	3.3.1	G												
			Manual														
			SD-11 Closeout Submittals														
			Warranty	3.3.2	G												
		27 05 28.36 40	SD-02 Shop Drawings														
			Fabrication Drawings	2.2	G												
			Installation Drawings	3.1.2	G												
			SD-03 Product Data														
			Cable Trays	1.2.1	G												
			Supports	1.2.1	G												
			SD-08 Manufacturer’s Instructions														
			Manufacturer's Instructions	3.1.1													
		27 10 00	SD-02 Shop Drawings														
			Telecommunications Drawings	1.6.1.1	G												
			Telecommunications Space	1.6.1.2	G												
			Drawings														
			SD-03 Product Data														
			Telecommunications Cabling	2.3	G												
			Patch Panels	2.4.5	G												
			Telecommunications	2.5	G												
			Outlet/Connector Assemblies														
			Equipment Support Frame	2.4.2	G												

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		27 10 00	Connector Blocks	2.4.3	G													
			Spare Parts	1.10.3	G													
			SD-06 Test Reports															
			Telecommunications Cabling	3.5.1	G													
			Testing															
			SD-07 Certificates															
			Telecommunications Contractor	1.6.2.1	G													
			Key Personnel	1.6.2.2	G													
			Manufacturer Qualifications	1.6.2.3	G													
			Test Plan	1.6.3	G													
			SD-09 Manufacturer’s Field															
			Reports															
			Factory Reel Tests	2.12.1	G													
			SD-10 Operation and Maintenance															
			Data															
			Telecommunications Cabling and	1.10.1	G													
			Pathway System															
			SD-11 Closeout Submittals															
			Record Documentation	1.10.2	G													
		27 21 10.00 40	SD-02 Shop Drawings															
			Fiber Optic System	2.2.9	G													
			Installation	3.1	G													
			SD-03 Product Data															
			Fiber Optic System	2.2.9	G													
			Spare Parts	1.3.1	G													
			Enclosures	2.2.11	G													

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		27 21 10.00 40	Data Transmission Converters	2.2.10	G												
			SD-06 Test Reports														
			Test Procedures and Reports	3.3.1.3													
			Power Attenuation Test	3.2.2.2													
			Analog Video Signal Test	3.2.2.4													
			Digital Video Signal Test	3.2.2.5													
			Optical Time Domain	3.2.2.1													
			Reflectometer Tests														
			SD-07 Certificates														
			Fiber Optic System	2.2.9													
			Optic Cable Assemblies	2.5.1													
			Labeling Format	3.1.8													
			SD-08 Manufacturer’s Instructions														
			Manufacturer's Instructions	3.1													
			Manufacturer's	3.1													
			Recommendations														
			SD-10 Operation and Maintenance														
			Data														
			Operating Instructions	3.3.2.1													
		27 51 16	SD-01 Preconstruction Submittals														
			Qualifications	1.7	G												
			SD-02 Shop Drawings														
			Detail Drawings	2.1.4	G												
			System Layout		G												
			System Design	2.1.5	G												
			SD-03 Product Data														

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		27 51 16	Spare Parts	1.9													
			SD-05 Design Data														
			Design Analysis and Calculations	1.5.7	G												
			SD-06 Test Reports														
			Approved Test Procedures	3.5	G												
			Acceptance Tests	3.5													
			Accreditation	1.6	G												
			SD-07 Certificates														
			Components	2.2													
			SD-10 Operation and Maintenance														
			Data														
			Public Address System	2.1	G												
		28 08 10	SD-05 Design Data														
			Test Plan	3.1	G												
			SD-06 Test Reports														
			Draft Test Report	3.2.2													
			Final Test Report	3.4	G												
			SD-07 Certificates														
			Qualifications	1.4.1													
		28 10 05	SD-02 Shop Drawings														
			ESS Components	1.3.3.1	G												
			Overall System Schematic	1.3.3.2	G												
			SD-03 Product Data														
			Premise Control Unit	2.3.6	G												
			Detection Sensors	2.3.7	G												
			Access Control Unit	2.4.4	G												

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		28 10 05	Access Control Devices	2.4.5	G												
			Cameras	2.5.1	G												
			Camera Lenses	2.5.1.2	G												
			Camera Housing and Mounts	2.5.1.3	G												
			Thermal Imaging System	2.5.2	G												
			Video Recording	2.5.5.3	G												
			Printers	2.6.4	G												
			Communications Interface	2.7	G												
			Devices														
			Radio Frequency Link	2.7.3	G												
			Network Switch	2.7.5	G												
			Video and ESS Transmission	2.7.6	G												
			IPAS	2.9.2	G												
			Uninterruptible Power Supply	2.11.1	G												
			(UPS)														
			Batteries	2.11.2	G												
			Component Enclosure	2.13	G												
			Equipment Rack	2.14	G												
			SD-05 Design Data														
			Backup Battery Capacity	1.5.1	G												
			Calculations														
			Throughput Rates	2.4.2	G												
			CCTV Storage Calculations	1.5.2													
			SD-07 Certificates														
			Contractor Qualifications	1.3.4.1	G												
			Instructor Qualifications	1.3.4.2	G												

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		28 10 05	Data Encryption	2.7.4	G												
			SD-10 Operation and Maintenance														
			Data														
			Training Plan	3.6.1	G												
			Training Content	3.6	G												
			ESS Components	1.3.3.1	G												
			ESS Software	1.6	G												
			SD-11 Closeout Submittals														
			As-Built Drawings	1.7	G												
		28 31 02.00 20	SD-02 Shop Drawings														
			System Floor Plans	1.5.5.1	G												
			System Wiring Diagrams	1.5.5.2	G												
			SD-03 Product Data														
			Digital alarm communicator	2.1	G												
			transmitter (DACT)														
			Digital alarm communicator	2.3	G												
			receiver (DACR)														
			Wiring	2.6	G												
			Battery Power Supply	2.1.6.1	G												
			Printers	2.3.4	G												
			SD-05 Design Data														
			Power Calculations	1.3.2	G												
			SD-06 Test Reports														
			Preliminary Testing	3.2.1	G												
			Final Acceptance Test	3.3	G												
			SD-07 Certificates														

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		28 31 02.00 20	Qualifications of installer	1.5.1	G												
			Qualifications of system	1.5.3	G												
			technician														
			System UL Listing or FM	1.5.6	G												
			Approval														
			SD-10 Operation and Maintenance														
			Data														
			Digital alarm	2.1	G												
			SD-11 Closeout Submittals														
			System As-built Drawings	1.5.5.3													
		28 31 76	SD-01 Preconstruction Submittals														
			Qualified Fire Protection	1.2.2	G												
			Engineer (QFPE)														
			Fire alarm system designer	1.8.2.1	G												
			Supervisor	1.8.2.2	G												
			Technician	1.8.2.3	G												
			Installer	1.8.2.4	G												
			Test Technician	1.8.2.5	G												
			Fire Alarm System Site-Specific	1.6	G												
			Software Acknowledgement														
			SD-02 Shop Drawings														
			Nameplates	1.8.1.3	G												
			Instructions	2.2.4	G												
			Wiring Diagrams	1.8.1.4	G												
			System Layout	1.8.1.5	G												
			Notification Appliances	1.8.1.6	G												

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		28 31 76	Initiating devices	1.8.1.7	G													
			Amplifiers	1.8.1.8	G													
			Battery Power	1.8.1.9	G													
			Voltage Drop Calculations	1.8.1.10	G													
			SD-03 Product Data															
			Fire Alarm and Mass Notification	2.3	G													
			Control Unit (FMCU)															
			Local Operating Console (LOC)	1.3.4	G													
			Amplifiers	1.8.1.8	G													
			Tone Generators	2.5	G													
			Digitalized voice generators	2.5	G													
			LCD Annunciator	2.7.1	G													
			Manual Stations	2.8	G													
			Smoke Detectors	2.9	G													
			Duct Smoke Detectors	2.9.3	G													
			Heat Detectors	2.11	G													
			Carbon monoxide detector	2.14	G													
			Addressable Interface Devices	2.15	G													
			Addressable Control Modules	2.16	G													
			Isolation Modules	2.17	G													
			Notification Appliances	1.8.1.6	G													
			Textual Display Sign Control	2.18.3	G													
			Panel															
			Textual Display Signs	2.18.3	G													
			Batteries	2.20.1	G													
			Battery Chargers	2.20.2	G													

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		28 31 76	Surge Protective Devices	2.21	G												
			Alarm Wiring	2.21	G												
			Back Boxes and Conduit	3.3.4	G												
			Ceiling Bridges	3.2.13	G												
			Terminal Cabinets	3.3.2	G												
			Digital Alarm Communicator	2.24.2	G												
			Transmitter (DACT)														
			Automatic Fire Alarm	2.24	G												
			Transmitters														
			Radio Transmitter and Interface	2.24.1	G												
			Panels														
			Mass Notification Transceiver	2.23.2	G												
			Electromagnetic Door Holders	2.25.4	G												
			Environmental Enclosures or	2.26	G												
			Guards														
			Firefighter Telephone	2.27	G												
			Printer	2.7.3	G												
			Document Storage Cabinet	3.12.3	G												
			SD-05 Design Data														
			Air Sampling Smoke Detection		G												
			System Calculations														
			SD-06 Test Reports														
			Test Procedures	3.8.1	G												
			SD-07 Certificates														
			Verification of Compliant	3.8.2.1	G												
			Installation														

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		28 31 76	Request for Government Final	3.8.2.2	G												
			Test														
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.10	G												
			(O&M) Instructions														
			Instruction of Government	3.11	G												
			Employees														
			SD-11 Closeout Submittals														
			As-Built Drawings	1.8.1.13													
			Spare Parts														
		31 00 00	SD-01 Preconstruction Submittals														
			Shoring	3.5	G												
			Dewatering Work Plan	1.5.3	G												
			SD-03 Product Data														
			Utilization of Excavated Materials	3.9	G												
			Rock Excavation	1.5.1.2													
			Opening of any Excavation or	3.4													
			Borrow Pit														
			Shoulder Construction	3.15													
			SD-06 Test Reports														
			Testing	3.18													
			Borrow Site Testing	2.1													
			SD-07 Certificates														
			Testing	3.18													
		31 05 19.13	SD-04 Samples														

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		31 05 19.13	Geotextiles	2.2.1													
			SD-06 Test Reports														
			Geotextiles	2.2.1													
			Site Verification	2.2.2													
			SD-07 Certificates														
			Geotextiles	2.2.1													
			Needle Punched Geotextile	2.2.1.3													
		31 11 00	SD-01 Preconstruction Submittals														
			Herbicide Application Plan	3.1.1													
			SD-03 Product Data														
			Tree Wound Paint	2.1.1													
			Herbicides	1.3.2	G												
			SD-07 Certificates														
			Qualifications	1.3.2	G												
			SD-11 Closeout Submittals														
			Pest Management Report	3.5.1													
		31 23 00.00 20	SD-01 Preconstruction Submittals														
			Shoring and Sheeting Plan	1.7.1													
			Dewatering work plan	1.7.2													
			SD-06 Test Reports														
			Borrow Site Testing	1.6	G												
			Fill and backfill	3.17.2.1													
			Select material	3.17.2.2													
			Porous fill	3.17.2.3													
			Density tests	3.17.2.4													
		31 31 16.13	SD-01 Preconstruction Submittals														

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		31 31 16.13	Termiticide Application Plan	3.1.5	G												
			SD-03 Product Data														
			Termiticides	2.2.1													
			SD-05 Design Data														
			Mixing Formulation	3.2.2													
			SD-06 Test Reports														
			Soil Moisture	1.6.1													
			Calibration Test	3.2.1													
			SD-07 Certificates														
			Qualifications	1.4.2	G												
			Foundation Exterior	3.1.2													
			Utilities and Vents	3.1.3													
			Crawl and Plenum Air Spaces	3.1.4													
			List of Equipment	3.2.1													
			SD-08 Manufacturer’s Instructions														
			Termiticides	2.2.1													
			SD-11 Closeout Submittals														
			Verification of Measurement	3.3.1													
			Warranty	1.7													
			Pest Management Report	3.4													
		31 31 16.19	SD-02 Shop Drawings														
			Steel Mesh Shop Drawings	3.3.1	G												
			Basaltic Sand Shop Drawings	3.3	G												
			SD-03 Product Data														
			Steel Mesh Materials	2.2.2.1													
			Accessories	2.2.3													

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		31 31 16.19	Steel Mesh System	2.1.1													
			Written Warranty	1.7													
			SD-04 Samples														
			Steel Mesh Materials	2.2.2.1	G												
			SD-06 Test Reports														
			Basaltic Sand	2.2.4	G												
			SD-07 Certificates														
			System Installers	1.4.1.1													
			Steel Mesh Materials	2.2.2.1													
			Written Verification	3.1													
			SD-08 Manufacturer’s Instructions														
			Manufacturer's Installation	3.3.1													
			Instruction Manual														
			Manufacturer's Guidance	3.4.1													
			Manufacturer's Installation	3.3													
			Instructions														
			SD-09 Manufacturer’s Field														
			Reports														
			Site Conditions	3.4.2													
			SD-11 Closeout Submittals														
			Written Warranty	1.7													
		31 32 19.16	SD-03 Product Data														
			Thread	2.1.2													
			Manufacturing Quality Control	2.2													
			Sampling and Testing														
			SD-04 Samples														

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		31 32 19.16	Quality Assurance Samples and	3.1													
			Tests														
			SD-07 Certificates														
			Geotextile	2.1.1													
		32 01 11.51	SD-01 Preconstruction Submittals														
			Schedule of work	1.3	G												
			Rubber and Paint Removal	3.1	G												
			Process Plan														
			Waste Collection, Identification	3.4	G												
			and Disposal Plan														
			SD-03 Product Data														
			Mechanical rubber and paint	1.5													
			removal equipment														
			Chemical rubber and paint	1.6													
			removal equipment														
			Rubber and Paint Removal	2.1	G												
			Detergents or Chemicals														
			SD-06 Test Reports														
			Test Section Results	1.7													
		32 01 13.62	SD-03 Product Data														
			Waybills and Delivery Tickets														
			Cutback Asphalt	2.2.1													
			Emulsified Asphalt	2.2.2													
			Asphalt Cement	2.2.3													
			SD-06 Test Reports														
			Tests	1.4.2													

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		32 01 17.61	SD-01 Preconstruction Submittals														
			Equipment, Tools, And Machines	2.3	G												
			SD-03 Product Data														
			Manufacturer's Instructions	3.3	G												
			Crack Sealant	2.1	G												
			Backer Rod	2.2	G												
			SD-06 Test Reports														
			Laboratory Tests	1.4	G												
		32 01 18.71	SD-03 Product Data														
			Equipment	1.2.1	G												
			Procedures	3.3.1	G												
		32 01 19.61	SD-03 Product Data														
			Sealants	2.1													
			Manufacturer's	3.5.2													
			Recommendations														
			SD-04 Samples														
			Sealants	2.1													
			Blocking Media/Backup Materials	2.3.1													
			Backer Rod	3.3.4.1													
			Bond Breaking Tapes	2.3.2													
			SD-06 Test Reports														
			Sealants	2.1													
			SD-07 Certificates														
			Equipment List	3.1													
			SD-08 Manufacturer’s Instructions														
			Sealants	2.1													

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		32 01 29.61	SD-02 Shop Drawings														
			Shop Drawings	1.3.3	G												
			SD-03 Product Data														
			Concrete Mix Design	1.3.1	G												
			Concrete Mix Design	2.1.4.1	G												
			Rigid Proprietary Repair Products	2.1.10	G												
			Polymeric Proprietary Repair	2.1.11	G												
			Products														
			Pigmented Liquid	2.1.5.1	G												
			Membrane-Forming Compound														
			Pigmented Liquid	2.1.5.1	G												
			Membrane-Forming Compound														
			Aggregate Service Record	2.1.10.6													
			SD-04 Samples														
			Absorbent Curing Material	3.5.1	G												
			Joint Filler	2.1.8	G												
			Joint Sealant	2.1.7	G												
			SD-05 Design Data														
			Concrete Mix Design	1.3.1	G												
			Concrete Mix Design	2.1.4.1	G												
			SD-06 Test Reports														
			Test Results	1.3.1													
			Gradation	1.3.1.2													
			Gradation	2.1.1.4													
			Cement	1.3.1.1													
			Slump	2.1.4.1													

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		32 01 29.61	Air Content	2.1.4.1														
			Compressive Strength	2.1.10.1														
			Mixer Calibration and Efficiency	1.3.2														
			Concrete Uniformity	1.3.2														
			Bond Strength	2.1.10.2														
			Polymeric Proprietary Repair	2.1.11	G													
			Products															
			SD-07 Certificates															
			Cement	1.3.1.1														
			Aggregate	1.3.1.2														
			Admixtures	2.1.3														
			Absorbent curing material	3.5.1														
			Pigmented Liquid	2.1.5.1														
			Membrane-Forming Compound															
			Pigmented Liquid	2.1.5.1														
			Membrane-Forming Compound															
			Joint Filler	2.1.8														
			Joint Sealant	2.1.7														
		32 01 29.62	SD-03 Product Data															
			Weigh Bills		G													
			Equipment	2.1	G													
			SD-05 Design Data															
			Grout Mixture	2.3.2	G													
			SD-06 Test Reports															
			Production Sampling and Testing	3.9														

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		32 01 29.62	Tests, Inspections, and	2.4													
			Verifications														
			SD-07 Certificates														
			Cement	1.3.3													
			Grout Mixture	2.3.2													
		32 05 33	SD-01 Preconstruction Submittals														
			Integrated Pest Management	2.4	G												
			Plan														
			SD-03 Product Data														
			Fertilizer	2.1	G												
			Mulches Topdressing	2.3													
			Organic Mulch Materials	2.3.2													
			SD-07 Certificates														
			Maintenance Inspection Report	3.5.1													
			Plant Quantities	3.5.2	G												
			SD-10 Operation and Maintenance														
			Data														
			Maintenance	1.6													
			SD-11 Closeout Submittals														
			Tree Staking and Guying	3.5.3													
			Removal														
		32 11 20	SD-03 Product Data														
			Plant, Equipment, and Tools	2.3	G												
			Waybills and Delivery Tickets	1.1.3													
			SD-06 Test Reports														
			Initial Tests	2.2.1	G												

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		32 11 20	In-Place Tests	3.13.1	G												
			Test Section Report	1.7.2	G												
		32 11 23	SD-03 Product Data														
			Plant, Equipment, and Tools	2.4	G												
			Waybills and Delivery Tickets	1.1.3													
			SD-06 Test Reports														
			Initial Tests	2.3.1	G												
			In-Place Tests	3.13.1	G												
			Test Section Report	1.7.2	G												
		32 11 23.23	SD-03 Product Data														
			Plants, Equipment, and Tools	1.4.1	G												
			Waybills and Delivery Tickets	1.1.3													
			SD-06 Test Reports														
			Initial Tests	1.5.3.1	G												
			In-Place Tests	1.5.3.2	G												
			Test Section Construction Report	3.6.7													
		32 11 26	SD-03 Product Data														
			Sources of Aggregates	1.4.4													
			Job Mix Formula	2.4.2	G												
			SD-06 Test Reports														
			Sources of Aggregates	1.4.4													
			Bituminous Materials	1.4.6													
			Bituminous Materials	2.2													
			Test Section	1.6.2	G												
			Service Record	1.4.4	G												

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		32 11 26	SD-09 Manufacturer’s Field														
			Reports														
			Batch Tickets	1.4.3													
		32 11 26.19	SD-03 Product Data														
			Plant, Equipment, Machines, and	2.3													
			Tools														
			Mix Design	2.2	G												
			Waybills and Delivery Tickets	1.1.3													
			Notification Of Selected Source	1.5.3													
			Notification Of Selected Source	1.5.4													
			SD-06 Test Reports														
			Sampling and Testing	3.9.1													
		32 11 33.13	SD-03 Product Data														
			Mix Design	2.2	G												
			Aggregate	1.5.3													
			Asphalt Emulsion	2.1.4.3													
			SD-06 Test Reports														
			Aggregate	1.5.3													
			Compressive Strength	3.9.5													
		32 12 13	SD-03 Product Data														
			Waybills and Delivery Tickets	1.1.3													
			Local/Regional Materials														
			SD-06 Test Reports														
			Sampling and Testing	3.7													
		32 12 15.13	SD-01 Preconstruction Submittals														
			Equipment	2.2	G												

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		32 12 15.13	SD-02 Shop Drawings														
			Placement Plan	2.1	G												
			SD-03 Product Data														
			Diamond Grinding Plan	2.2.6	G												
			Mix Design	2.6	G												
			Contractor Quality Control	3.1	G												
			SD-04 Samples														
			Aggregates	2.3													
			Asphalt Binder	2.4													
			Warm-mix Additive	2.6.1													
			SD-06 Test Reports														
			Aggregates	2.3	G												
			QC Monitoring	3.1.3.10													
			Pavement Lots	1.7.3	G												
			SD-07 Certificates														
			Asphalt Binder	2.4	G												
			Testing Laboratory	3.1.2													
			Warm-mix Additive	2.6.1													
			Airfield Asphalt Pavement QC Manager	1.6													
			Airfield Asphalt Pavement Inspector	1.6													
			Airfield Asphalt Pavement Laboratory Technician	1.6													
		32 12 16.16	SD-02 Shop Drawings														
			Placement Plan	2.1	G												

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		32 12 16.16	SD-03 Product Data														
			Diamond Grinding Plan	2.1.6	G												
			Mix Design	2.5	G												
			Contractor Quality Control	3.1	G												
			SD-04 Samples														
			Aggregates	2.2													
			Asphalt Cement Binder	2.3													
			Warm-mix Additive	2.5.1													
			SD-06 Test Reports														
			Aggregates	2.2	G												
			QC Monitoring	3.1.3.9													
			SD-07 Certificates														
			Asphalt Cement Binder	2.3	G												
			Laboratory Accreditation and	1.5.11													
			Validation														
			Warm-mix Additive	2.5.1													
		32 12 17.19	SD-02 Shop Drawings														
			Placement Plan	2.1	G												
			SD-03 Product Data														
			Diamond Grinding Plan	2.1.6	G												
			Mix Design	2.4	G												
			Contractor Quality Control	3.1	G												
			SD-04 Samples														
			Aggregates	2.2													
			Asphalt Binder	2.3													
			SD-06 Test Reports														

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		32 12 17.19	Aggregates	2.2	G												
			QC Monitoring	3.1.3.10													
			Resistance to Fuel	2.4.2	G												
			SD-07 Certificates														
			Asphalt Binder	2.3	G												
			Testing Laboratory	3.1.2													
			Airfield Asphalt Pavement QC	1.5													
			Manager														
			Airfield Asphalt Pavement	1.5													
			Inspector														
			Airfield Asphalt Pavement	1.5													
			Technician														
		32 13 14.13	SD-03 Product Data														
			Diamond Grinding Plan	2.1.7	G												
			Dowels	2.9.1	G												
			Dowel Bar Assemblies	2.9.2	G												
			Equipment	2.11													
			Proposed Techniques	3.1.2	G												
			SD-05 Design Data														
			Preliminary Proposed	2.13.2	G												
			Proportioning														
			Proportioning Studies	2.13.2	G												
			SD-06 Test Reports														
			Batch Plant Manufacturer's	1.4.1	G												
			Inspection Report														

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		32 13 14.13	Slipform Paver Manufacturer's	1.4.1	G												
			Inspection Report														
			Sampling and Testing	2.1.4.1	G												
			Diamond Grinding of PCC	2.1.7	G												
			Surfaces														
			Mixer Performance (Uniformity)	2.11.2.3	G												
			Testing														
			Repair Recommendations Plan	3.9.1	G												
			SD-07 Certificates														
			Contractor Quality Control Staff	1.4.1	G												
			Laboratory Accreditation and	1.4.3													
			Validation														
			Commercial Laboratory	1.4.3.3	G												
			NRMCA Certificate of	2.11													
			Conformance														
		32 13 43	SD-03 Product Data														
			Curing Materials	2.1.5.1													
			SD-04 Samples														
			Test Section	1.6.2													
			SD-05 Design Data														
			Mix Design Report	2.2.1	G												
			SD-06 Test Reports														
			Concrete Density Tests	3.7.2													
			Field Infiltration Tests	3.7.4													
			Surface Smoothness	3.7.5													
			Core Thickness	3.7.3													

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		32 13 43	Plan Grade	3.7.5													
			SD-07 Certificates														
			NRMCA Certificate Of	1.4.1													
			Conformance														
		32 16 19	SD-03 Product Data														
			Concrete	2.1													
			Biodegradable Form Release	2.6.5													
			Agent														
			Biodegradable Form Release	3.2													
			Agent														
			SD-06 Test Reports														
			Field Quality Control	3.8													
		32 17 23	SD-03 Product Data														
			Surface Preparation Equipment	2.1.1.2	G												
			List														
			Application Equipment List	2.1.2	G												
			Exterior Surface Preparation	3.2													
			Safety Data Sheets	1.4.1	G												
			Reflective media for airfields	2.2.3.1	G												
			Reflective media for roads	2.2.3.2	G												
			Waterborne Paint	2.2.1	G												
			Solventborne Paint		G												
			Thermoplastic compound	2.2.2	G												
			Raised Pavement Markers		G												
			Primers and Adhesives														
			SD-06 Test Reports														

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		32 17 23	Reflective Media for Airfields	2.2.3.1	G												
			Reflective Media for Roads	2.2.3.2	G												
			Waterborne Paint	2.2.1	G												
			Solventborne Paint		G												
			High Build Acrylic Coating		G												
			(HBAC)														
			Thermoplastic Compound	2.2.2	G												
			Raised Pavement Markers		G												
			Primers and Adhesives														
			Test Reports														
			SD-07 Certificates														
			Qualifications	1.4.2	G												
			Reflective Media for Airfields	2.2.3.1													
			Reflective Media for Roads	2.2.3.2													
			Waterborne Paint	2.2.1													
			Solventborne Paint														
			Volatile Organic Compound	1.4.1	G												
			Thermoplastic Compound	2.2.2													
			SD-08 Manufacturer’s Instructions														
			Waterborne Paint	2.2.1	G												
			Solventborne Paint		G												
			Thermoplastic Compound	2.2.2	G												
		32 18 16.13	SD-02 Shop Drawings														
			Shop Drawings	1.5.4													
			Finished Grade and Underground	3.1.1													
			Utilities														

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		32 18 16.13	SD-03 Product Data														
			Synthetic Surfacing	2.2													
			Loose Fill Surfacing	2.3													
			Geotextile Fabric	2.4													
			Wood	2.6.2													
			Temperature Limitation	3.2.1													
			Wood By-Products	2.3.3													
			Wood Treatment	2.6.2.2													
			Adhesive	2.2.9													
			Color	2.2.5													
			SD-04 Samples														
			Synthetic Surfacing	2.2													
			Loose Fill Surfacing System	3.3													
			SD-06 Test Reports														
			Percolation Test	3.1.4													
			Recycled Plastic	2.5													
			Synthetic Surfacing	2.2													
			Sand	2.3.1													
			Gravel	2.3.2													
			SD-07 Certificates														
			Manufacturer's Qualification	1.5.1													
			Manufacturer's Representative	1.5.2													
			Installer's Qualification	1.5.3													
			Substitution	3.1.5													
			Protective Surfacing Acceptance	3.5													

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		32 18 16.13	SD-10 Operation and Maintenance															
			Data															
			Maintenance Instructions	1.8														
			SD-11 Closeout Submittals															
			Protective Surfacing Acceptance	3.5														
			Certificate of Insurance	1.5.1														
			Warranty	1.7														
		32 31 13	SD-02 Shop Drawings															
			Fence Assembly	2.1		G												
			Location of Gate, Corner, End,	3.2.2.1		G												
			and Pull Posts															
			Gate Assembly	2.1		G												
			Gate Hardware and Accessories	2.3.6		G												
			Erection/Installation Drawings	Part 3		G												
			SD-03 Product Data															
			Fence Assembly	2.1		G												
			Gate Assembly	2.1		G												
			Gate Hardware and Accessories	2.3.6		G												
			Zinc Coating	2.4.1		G												
			PVC Coating	2.1		G												
			Aluminum Alloy Coating	2.1		G												
			Fabric	2.2.1		G												
			Stretcher Bars	2.2.6		G												
			Concrete	2.4.2		G												
			SD-04 Samples															
			Fabric	2.2.1		G												

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		32 31 13	Posts	2.2.2	G												
			Braces	2.2.3	G												
			Line Posts	2.2.2.1.1	G												
			Sleeves	2.2.5	G												
			Top Rail	2.2.3.1	G												
			Bottom Rail	2.2.3.3	G												
			Tension Wire	2.2.8	G												
			Stretcher Bars	2.2.6	G												
			Gate Posts	2.3.1	G												
			Gate Hardware and Accessories	2.3.6	G												
			Wire Ties	2.2.4	G												
			SD-07 Certificates														
			Certificates of Compliance	1.3.1													
			SD-08 Manufacturer’s Instructions														
			Fence Assembly	2.1													
			Gate Assembly	2.1													
			Hardware Assembly	2.1													
			Accessories	2.1													
			SD-11 Closeout Submittals														
			Recycled Material Content	3.3													
		32 31 13.53	SD-02 Shop Drawings														
			Fence Installation Drawings	3.2.1	G												
			SD-03 Product Data														
			Fabric	2.1.1.1													
			Posts	2.1.3													
			Post Caps	2.1.3.2													

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		32 31 13.53	Chain Link Braces	2.1.4														
			Line Posts	2.1.4														
			Sleeves	3.2.3.2														
			Rails	2.1.4														
			Tension Wire	2.1.3.2														
			Barbed Wire	2.2.1.2														
			Barbed Wire Supporting Arms	2.1.3.2														
			Barbed Tape	2.2.2														
			Latches	2.1.5.3														
			Hinges	2.1.5.3														
			Stops	2.1.5.3														
			Keepers	2.1.5.3														
			Rollers	2.1.5.3														
			Turnstiles	2.1.7														
			Padlocks	2.1.8														
			Wire Ties	2.2.1.1														
			Ornamental Fence Systems	2.1.2														
			Swing Gates	2.1.6.1														
			Slide Gates	2.1.6.2														
			Fence Fabric Reinforcement															
			SD-07 Certificates															
			Chain Link Fence	2.1.3.1														
			Fabric	2.1.1.1														
			Barbed Wire	2.2.1.2														
			Gate Hardware and Accessories	3.2.1														
			Concrete	2.2.3														

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		32 31 13.53	Gate Operator	2.1.9														
			SD-10 Operation and Maintenance															
			Data															
			Electro-Mechanical Locks	2.1.10														
			Gate Operator	2.1.9														
			Operating and maintenance	3.2.8														
			instructions															
		32 32 23.13	SD-02 Shop Drawings															
			Shop Drawings	2.1.3	G													
			SD-03 Product Data															
			Segmental Concrete Units	2.2.1	G													
			SD-04 Samples															
			Segmental Concrete Units	2.2.1	G													
			Geogrid Reinforcement	2.2.3	G													
			SD-05 Design Data															
			Calculations	2.1.2	G													
			Survey And Grade Results	3.3.1	G													
			SD-06 Test Reports															
			Soil Testing	3.4.1	G													
			Reinforcement Testing	3.4.2	G													
			SD-07 Certificates															
			Supplier Qualifications	1.5.2														
			Manufacturer's Representative	1.5.3														
			Geogrid Reinforcement	2.2.3	G													
			Geotextile Reinforcement	2.2.4	G													
		32 84 23	SD-02 Shop Drawings															

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		32 84 23	Sprinkler System	3.2														
			SD-03 Product Data															
			Framed Instructions	3.3														
			Field Training	3.4														
			Sprinkler System	3.2														
			Spare Parts	1.5														
			Design Analysis and Calculations	1.2														
			SD-06 Test Reports															
			Field Tests	3.5														
			SD-07 Certificates															
			Sprinkler System	3.2														
			SD-10 Operation and Maintenance															
			Data															
			Sprinkler System	3.2	G													
		32 84 24	SD-02 Shop Drawings															
			Irrigation Sprinkler System	1.3														
			SD-03 Product Data															
			Piping Materials	2.1														
			Valves	2.3														
			Heads	2.2														
			Backflow Preventers	2.3.6														
			Automatic Controller	2.5														
			Controller Enclosure	2.5.2														
			Solvent Cement	2.1.4														
			Control Wiring	2.6.1														
			Drip Irrigation	2.1.7														

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		32 84 24	Water Hammer Arresters	2.4.4.2													
			Water Meter	2.4.2													
			Rain Shut-Off Device	2.4.5.1													
			Freeze Shut-Off Device	2.4.5.2													
			Soil Moisture Sensor	2.4.5.3													
			Tapping Tee	2.4.1													
			Valve Boxes and Lids	3.1.7.3													
			Drip Head Accessories	2.4.3													
			SD-05 Design Data														
			System Pressure Calculations	1.3													
			Irrigation Requirements	1.3													
			SD-06 Test Reports														
			Tests	1.7.1													
			Backflow Preventers	2.3.6													
			Pressure Test	3.2.1													
			Operation Test	3.2.2													
			SD-07 Certificates														
			Backflow Preventers	2.3.6													
			SD-08 Manufacturer’s Instructions														
			Automatic Controller	2.5													
			Heads	2.2													
			Piping Materials	2.1													
			Backflow Preventers	2.3.6													
			Valves	2.3													
			Solvent Cement	2.1.4													
			Control Wiring	2.6.1													

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		32 84 24	Drip Irrigation	2.1.7														
			Water Hammer Arresters	2.4.4.2														
			Water Meter	2.4.2														
			Rain Shut-Off Device	2.4.5.1														
			Freeze Shut-Off Device	2.4.5.2														
			Soil Moisture Sensor	2.4.5.3														
			SD-10 Operation and Maintenance Data															
			Piping Materials	2.1	G													
			Heads	2.2	G													
			Backflow Preventers	2.3.6	G													
			Valves	2.3	G													
			Automatic Controller	2.5	G													
			Drip Irrigation	2.1.7	G													
			Water Hammer Arresters	2.4.4.2	G													
			Water Meter	2.4.2	G													
			Rain Shut-Off Device	2.4.5.1	G													
			Freeze Shut-Off Device	2.4.5.2	G													
			Soil Moisture Sensor	2.4.5.3	G													
			SD-11 Closeout Submittals															
			Controller Charts	3.2.3														
		32 92 19	SD-03 Product Data															
			Wood Cellulose Fiber Mulch	2.5.3														
			Fertilizer	2.4														
			SD-06 Test Reports															
			Topsoil Composition Tests	2.2.3														

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		32 92 19	SD-07 Certificates														
			Seed	2.1													
			SD-08 Manufacturer’s Instructions														
			Erosion Control Materials	2.7													
		32 92 23	SD-03 Product Data														
			Fertilizer	2.5													
			SD-06 Test Reports														
			Topsoil composition tests	2.3.3													
			SD-07 Certificates														
			sods	2.1													
		32 93 00	SD-01 Preconstruction Submittals														
			State Landscape Contractor's	1.4.3													
			License														
			Time Restrictions and Planting	1.6													
			Conditions														
			SD-03 Product Data														
			Peat	2.3.5													
			Composted Derivatives	2.3.8													
			Rotted Manure	2.3.11													
			Organic Mulch Materials	2.8.2													
			Gypsum	2.3.9													
			Drainage Pipe	2.7													
			Mulch	2.8	G												
			Ground Stakes	2.9.1.2													
			Recycled Plastic Edging	2.10.2													
			Fertilizer	2.5													

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		32 93 00	Weed Control Fabric	2.6	G												
			Root Control Barrier	2.13	G												
			Staking Material	2.9.1													
			Wood Edging	2.10.1													
			Metal Anchors	2.9.7													
			Antidesiccants	2.11													
			Erosion Control Materials	2.12													
			Photographs	1.4.4	G												
			SD-04 Samples														
			Mulch	2.8	G												
			SD-06 Test Reports														
			Topsoil Composition Tests	2.2.4													
			Percolation Test	1.4.5													
			SD-07 Certificates														
			Nursery Certifications	2.1.1													
			SD-10 Operation and Maintenance														
			Data														
			Plastic Identification	1.8													
		33 01 30.16	SD-01 Preconstruction Submittals														
			Traffic Control Plan	3.1.1	G												
			Disposal Plan	1.3.1	G												
			Herbicide Application Plan	3.1.2	G												
			List of Equipment	3.2.1.1													
			Sewage Handling Permit	1.3.2	G												
			SD-03 Product Data														
			Herbicide	2.3.1	G												

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		33 01 30.16	Cleaning Products	2.3.2	G												
			SD-05 Design Data														
			Herbicide Application Records	3.2.1.2													
			SD-06 Test Reports														
			Calibration Test	3.2.1.1													
			SD-07 Certificates														
			Qualifications	1.5.2	G												
			CCTV Technician's Qualifications	1.5.3	G												
			Pre-TV Inspection	3.2.3	G												
			Post-TV Inspection	3.2.4	G												
			Warranty-TV Inspection	3.2.5	G												
			RE-TV Inspection	3.2.6	G												
			SD-11 Closeout Submittals														
			Pest Management Report	3.4.2													
			Verification of Measurement	3.3.1													
			Records of Disposals	3.4.1													
		33 01 30.72	SD-01 Preconstruction Submittals														
			Contractor Quality Control (CQC)	1.5.2	G												
			Plan														
			Sequence Of Liner Installation	3.2.2	G												
			Traffic Control Plan	3.2.1	G												
			Bypass Plan	3.2.2	G												
			Disposal Of Process Water	1.7.1.1	G												
			SD-02 Shop Drawings														
			FFP Repair Method	3.4.4.2	G												
			SD-03 Product Data														

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		33 01 30.72	Hydrophilic Seal	2.2.1	G												
			Lubricant	2.2.2	G												
			Fabric Tube	2.2.3	G												
			CIPP Product Data	2.2.3.3	G												
			Catalyst	2.2.3.3	G												
			Raw Resin Data	2.2.3.3	G												
			Flexible Membrane	2.2.3.3	G												
			SD-05 Design Data														
			Engineering Design Calculations	2.1.1.1.1	G												
			Resin To Tube Ratio	2.2.3.7	G												
			FFP Engineering Design	2.1.1.1.2	G												
			Calculations														
			SD-06 Test Reports														
			IR Analyses	2.2.3.4	G												
			Temperature Logs	3.3.1	G												
			Curing Logs	3.3.1	G												
			CIPP Sample Test Results	3.4.1.1	G												
			FFP Temperature Logs	3.3.2	G												
			FFP Curing Logs	3.3.2	G												
			FFP Sample Test Results	3.4.1.2	G												
			SD-07 Certificates														
			Contractor's Qualifications	1.5.1.1	G												
			Superintendent's Qualifications	1.5.1.3	G												
			Certificate of QC Laboratory	1.5.1.6	G												
			Accreditation														
			Resin Dye	2.2.3.5	G												

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		33 01 30.72	Liner Manufacturer	1.5.1.5	G												
			CIPP Installer's Qualifications	1.5.1.2	G												
			Shipping Documents	1.6.1	G												
			Manufacturing Certificate	2.2.3.5	G												
			SD-08 Manufacturer’s Instructions														
			Manufacturer's Instructions	2.2.3.6	G												
			Manufacturer's Instructions	2.2.4.1	G												
		33 01 50.31	SD-02 Shop Drawings														
			Leak Detection System	2.3	G												
			Electronic Monitoring/Alarm	2.4													
			Panel														
			Computational Pipeline	2.5													
			Monitoring System														
			SD-03 Product Data														
			Leak Detection System	2.3	G												
			Electronic Monitoring/Alarm	2.4													
			Panel														
			Computational Pipeline	2.5													
			Monitoring System														
			SD-06 Test Reports														
			Leak Detection System Test	3.2.1													
			SD-07 Certificates														
			Demonstrations	3.3													
			SD-08 Manufacturer’s Instructions														
			Leak Detection System	2.3													

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		33 01 50.31	SD-10 Operation and Maintenance														
			Data														
			Leak Detection System	2.3	G												
			Electronic Monitoring/Alarm	2.4	G												
			Panel														
			Computational Pipeline	2.5	G												
			Monitoring System														
		33 01 50.55	SD-03 Product Data														
			Cleaning Agents	2.1.1													
			Abrasive for Blasting	2.1.2.1													
			Gasoline-Oil-Resisting Rubber	2.2													
			Gloves and Boots														
			Cotton Coveralls and Hard Hat	2.2													
			Respiratory Protective Equipment	2.2													
			Disinfectant	2.2													
			SD-06 Test Reports														
			Blasting Abrasive	1.5.12.1													
			Tank Contents	1.5.12.1													
			Cleaning Test Panel Results	1.5.12.1													
			Monitoring Results	1.5.12.2	G												
			SD-07 Certificates														
			Qualifications of Marine Chemist	1.5.11.1													
			Qualifications of Certified	1.5.11.2													
			Industrial Hygienist (CIH)														
			Testing Laboratory	1.5.11.3													
			Safety Plan	1.5.11.4													

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		33 01 50.55	Training Certification	1.5.11.4													
			Work Plan	1.5.11.5													
			Hazardous Waste Disposal Plan	1.5.11.6													
			Tank Certification of Safety	1.5.11.7													
			Exhaust	1.7.1													
			Exhaust	1.7.1													
			Respiratory Protective Equipment	2.2													
			Breathing-Air Supply Source	2.2													
			Combustible Gas Indicator	2.2													
			Lead-In-Air Analyzer	2.2													
			Hydrogen-Sulfide (H2S) Indicator	2.2													
			Benzene Indicator	2.2													
			Oxygen Meter	2.2													
			Velometers	2.2													
			Lighting	2.2													
			First Aid Kit	2.2													
			Plan for Pretreatment	3.7.8	G												
			SD-08 Manufacturer’s Instructions														
			Cleaning Agents	2.1.1													
			SD-11 Closeout Submittals														
			Safety Permits	1.5.3													
		33 05 23	SD-01 Preconstruction Submittals														
			Microtunneling Plan	1.4	G												
			Boring and Jacking Plan	1.4	G												
			Statement of Contractor	1.4	G												
			Qualifications														

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		33 05 23	SD-03 Product Data														
			Pipe casing	2.3.1	G												
			Lubricating Fluid	2.3.4	G												
			SD-05 Design Data														
			Design calculations for pipe casing	2.1.1.2	G												
			Access Shaft Construction Plan	1.4	G												
			Access Shaft Construction Plan	3.1.1	G												
			SD-06 Test Reports														
			Monitoring Survey	3.5.1.1	G												
			SD-08 Manufacturer’s Instructions														
			Installation	3.3	G												
			Safety Data Sheets	1.8.1.2	G												
			SD-11 Closeout Submittals														
			Record Drawings	3.6.3	G												
			Daily Work Logs of installation operations	3.6.3	G												
		33 05 23.13	SD-01 Preconstruction Submittals														
			Qualifications	1.3.1	G												
			Horizontal Directional Drilling Plan	1.3.3	G												
			SD-03 Product Data														
			Pipe	2.2.1	G												
			Drilling Fluids	2.2.2	G												
			Additives	2.2.3	G												
			Tracer Wire	2.2.4	G												

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		33 05 23.13	SD-05 Design Data														
			Secondary Containment Plan	3.2.2	G												
			SD-06 Test Reports														
			Soil Test Data	3.1													
			SD-07 Certificates														
			Drill Rod	2.1.1													
			Fusion Technician Qualifications	1.3.4													
			SD-11 Closeout Submittals														
			Record Drawings	3.4													
			Complete Work Logs of Guided	3.4													
			Directional Drill Operations														
		33 11 00	SD-01 Preconstruction Submittals														
			Connections	3.1.1	G												
			SD-03 Product Data														
			Pipe, Fittings, Joints and	2.1.1	G												
			Couplings														
			Ball And Socket Joint	2.1.1.5.3.	G												
			Valves	2.1.2	G												
			Valve Boxes	2.1.2.8	G												
			Fire Hydrants	2.1.4.1	G												
			Pipe Restraint	2.2.1	G												
			Tapping Sleeves	2.2.3	G												
			Corporation Stops	2.2.9.1	G												
			Backflow Preventer	1.5.2.1.1	G												
			Precast Concrete Thrust Blocks	2.2.1.2	G												
			Disinfection Procedures	3.2.4	G												

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		33 11 00	Fusion Joining	2.1.1.5.2													
			SD-06 Test Reports														
			Backflow Preventer Tests	3.3.1.5	G												
			Bacteriological Samples	3.3.1.4	G												
			Post-Construction Fusion Report	3.2.1.7.1	G												
			Hydrostatic Sewer Test	3.2.1.1.6													
			Leakage Test	3.3.1.3													
			Hydrostatic Test	3.3.1.1													
			SD-07 Certificates														
			Pipe, Fittings, Joints and	2.1.1													
			Couplings														
			Lining and Coating	2.1.1.3.4													
			Lining	2.1.1.1.1													
			Lining for Fittings	2.1.1.2.1.3													
			Lining for Ductile Iron Fittings	2.1.1.2.3.1													
			Valves	2.1.2													
			Fire Hydrants	2.1.4.1													
			Backflow Prevention Training	1.5.2.1.1.2													
			Certificate														
			Backflow Tester	1.5.2.1.1.1													
			Backflow Certificate	2.1.6													
			Fusion Technician Qualifications	1.5.2.2	G												
			SD-08 Manufacturer’s Instructions														
			Ductile-Iron Piping	2.1.1.1													
			PVC Piping	2.1.1.2.1.1													
			PVCO Piping	2.1.1.2.1.2													

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		33 11 00	Polyethylene (PE) Pipe	2.1.1.2.3													
			Fiberglass Pipe, Fittings, Joints														
			And Joint Materials														
			PVC Piping For Service Lines	2.1.1.2.2													
			Copper Pipe For Service Lines	2.1.1.4													
			Polyethylene (PE) Piping And	2.1.1.2.4													
			Tubing For Service Lines														
		33 11 23	SD-03 Product Data														
			Valve Box	2.7													
			Pressure Regulator	2.4.3													
			Gas Equipment Connectors	2.6													
			Valves	2.4													
			Warning and Identification Tape	2.9													
			Risers	2.2.3													
			Transition Fittings	2.2.4													
			Gas meter	2.5													
			LPG Containers and Accessories	2.16													
			SD-07 Certificates														
			Welder's Qualifications	1.4.1													
			PE Welder's Qualifications	1.4.2													
			Welder's Identification Symbols	1.4.1													
			SD-08 Manufacturer’s Instructions														
			PE Pipe and Fittings	2.2.2													
		33 16 15	SD-01 Preconstruction Submittals														
			Manufacturer's Qualifications	1.3.1	G												
			SD-02 Shop Drawings														

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		33 16 15	Detail Drawings	1.3.1	G												
			Tank Installation	3.6	G												
			Piping and Valve Installation	3.6	G												
			SD-03 Product Data														
			Manufacturer's Technical	2.1.1	G												
			Literature														
			System Description	2.1	G												
			Foundations	3.1	G												
			Heating System	2.3.5	G												
			Alarm System	2.3.4	G												
			Disinfection	3.9	G												
			Valves	2.2.5	G												
			Pipe, Fittings, Joints and	2.2.3	G												
			Couplings														
			Joint Sealants and Gaskets	2.2.7	G												
			SD-05 Design Data														
			Manufacturer's Design Analysis	1.3.1	G												
			Foundation Design Analysis	1.3.1	G												
			SD-06 Test Reports														
			Tank Installation	3.6	G												
			Testing of Valves and Piping	3.7.2	G												
			Hydrostatic Test	3.6.3	G												
			Leak Test	3.6.3	G												
			SD-07 Certificates														
			Tank Coating System	1.3.3	G												
			Pipe Lining and Coating	3.7.3	G												

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		33 16 15	SD-08 Manufacturer’s Instructions														
			Shipping, Handling, and Storage	1.4	G												
		33 26 00.00 10	SD-02 Shop Drawings														
			Shop Drawings	1.4.1	G												
			SD-03 Product Data														
			Well Screen	2.1	G												
			Filter Pack	2.3	G												
			Cement Grout Mixture Proportion	3.6	G												
			SD-06 Test Reports														
			Tests	3.7													
		33 30 00	SD-01 Preconstruction Submittals														
			Contractor's License	1.3.1	G												
			SD-02 Shop Drawings														
			Installation Drawings	3.1.1	G												
			SD-03 Product Data														
			Precast Concrete Manholes	2.2.7													
			Frames, Covers, and Gratings	2.2.16													
			Gravity Pipe	2.2.1													
			Pressure Pipe	2.2.2													
			Precast Concrete Septic Tanks	2.2.11	G												
			SD-06 Test Reports														
			Precast Concrete Sewer Manhole	3.3.1.2.2	G												
			Test														
			Hydrostatic Sewer Test	3.3.1.1	G												
			Infiltration Tests And Exfiltration	3.3.1.2.1	G												
			Tests														

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		33 30 00	Negative Air Pressure Test	3.3.1.2.2	G												
			Low-Pressure Air Tests	3.3.1.2.3	G												
			Tests For Pressure Lines	3.3.1.3	G												
			Deflection Testing	3.3.1.4													
			Concrete Pipe Test	3.3.1.2.2.'	G												
			SD-07 Certificates														
			Portland Cement	2.2.5													
			Gaskets	2.2.1.2.2													
			Pre-Installation Inspection	3.3.3.1	G												
			Request														
			Post-Installation Inspection	3.3.3.2	G												
		33 31 23.00 10	SD-06 Test Reports														
			Disposal of Waste Water	3.2													
			Final Test Report	3.2													
		33 32 16	SD-02 Shop Drawings														
			Fabrication Drawings	2.1													
			Erection/Installation Drawings	2.1													
			SD-03 Product Data														
			Submersible Sewage	2.2	G												
			Grindernonclog Pumps														
			Pump Performance Curve	2.3	G												
			Pump Motor	2.3	G												
			Pump Control System	2.4	G												
			Wet Well and Valve Vault	2.5.1	G												
			Flexible Flanged Coupling	2.6.5	G												
			Station Piping	2.6	G												

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		33 32 16	Valves	2.7	G													
			Spare Parts Data	3.3.1	G													
			Access Hatch Covers	2.5.2														
			SD-05 Design Data															
			Buoyancy Calculations	2.5.1.1	G													
			Buoyancy Calculations	2.5.1.2	G													
			Pump Test	3.2.1	G													
			Pressure Sensor Test	3.2.1	G													
			Float Test	3.2.1	G													
			SD-07 Certificates															
			Submersible Sewage	2.2	G													
			Grindernonclog Pumps															
			Recycled Material Content	2.5.1.2	G													
			Manhole Chamber	2.1	G													
			Access Hatch Covers	2.5.2														
			Gate Valves	2.7.1	G													
			Check Valves	2.7.3	G													
			Blowers	2.5.3.1	G													
			Dehumidifier	2.5.3.2	G													
			Pump Motor	2.3	G													
			SD-08 Manufacturer’s Instructions															
			Manhole Chamber	2.1	G													
			Access Hatch Covers	2.5.2														
			Pump Control System	2.4	G													
			Gate Valves	2.7.1	G													
			Check Valves	2.7.3	G													

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		33 32 16	Blowers	2.5.3.1	G												
			Dehumidifier	2.5.3.2	G												
			Pump Motor	2.3	G												
			Special Tools	3.3.1	G												
			Posted Instructions	3.3.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Operation And Maintenance	3.3.1													
			Manuals														
			SD-11 Closeout Submittals														
			Warranty	1.5	G												
		33 34 56.00 10	SD-02 Shop Drawings														
			Approved Detail Drawings	2.2	G												
			Dosing Tank	2.2.4													
			SD-05 Design Data														
			Buoyancy Calculations for	2.2.4.1.1													
			Fiberglass Basins														
			Buoyancy Calculations For	2.2.4.2													
			Precast Concrete Structures														
			SD-06 Test Reports														
			Rapid Inflow Test	3.2.2.2													
		33 40 00	SD-06 Test Reports														
			Leakage Test	3.9.1.1	G												
			SD-07 Certificates														
			Hydrostatic Test on Watertight	2.7.1	G												
			Joints														

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		33 40 00	Frame and Cover or Gratings	2.6.6	G												
			SD-08 Manufacturer’s Instructions														
			Placing Pipe and Box Culvert	3.3	G												
			SD-11 Closeout Submittals														
			Post-Installation Inspection	3.9.2.1.3	G												
			Report														
			LID Verification Report	3.9.2.2	G												
		33 46 13	SD-04 Samples														
			Materials	2.1													
			SD-07 Certificates														
			Materials	2.1													
		33 46 16	SD-04 Samples														
			Geotextile	2.2													
			Pipe and Pipe Fittings	2.1													
			SD-06 Test Reports														
			Geotextile JP-8 Fuel Resistance	2.5.1													
			Test														
			SD-07 Certificates														
			Geotextile	2.2													
			Pipe and Pipe Fittings	2.1													
		33 47 13	SD-02 Shop Drawings														
			Liner System	1.4.1	G												
			SD-03 Product Data														
			Liner	2.1	G												
			Seaming Adhesive	2.2.1													
			Penetration Assemblies	2.2.3	G												

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		33 47 13	Filter Fabric	1.3	G												
			Sealants	2.2.2													
			SD-07 Certificates														
			Liner	2.1	G												
			Filter Fabric	1.3													
			SD-08 Manufacturer’s Instructions														
			Liner	2.1	G												
			Seaming Adhesive	2.2.1													
			Sealants	2.2.2													
			SD-11 Closeout Submittals														
			Manufacturer's Warranty	1.5.1	G												
			Installation Warranty	1.5.2	G												
		33 51 13.00 30	SD-03 Product Data														
			Pressure Regulator	2.3.3	G												
			Valves	2.3													
			Risers	2.2.2													
			Transition Fittings	2.2.3													
			Gas Meter	2.4	G												
			SD-07 Certificates														
			Welder's Qualifications	1.4.1													
			Welder's Identification Symbols	1.4.1													
		33 51 15	SD-02 Shop Drawings														
			Pipe, Fittings, and Associated	2.2													
			Materials														
			SD-03 Product Data														
			Materials and Equipment	2.2	G												

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		33 51 15	Materials and Equipment	2.2	G												
			Spare Parts	1.6	G												
			Pipe and Accessory Coatings	2.2	G												
			SD-05 Design Data														
			Connections to Existing Lines	1.4.2.2	G												
			Connections to Existing Lines	3.15	G												
			Connection and Abandonment	1.4.2.2	G												
			Plan														
			Connection and Abandonment	3.15.2	G												
			Plan														
			SD-06 Test Reports														
			Pressure and Leak Tests	3.17.2													
			SD-07 Certificates														
			Welder's training and	1.4.1.1													
			qualifications														
			Jointing of Plastic Piping	1.4.1.2													
			Utility Work	3.15.1													
			SD-08 Manufacturer’s Instructions														
			EFV Design and Installation	2.5.4													
			Guide														
			SD-10 Operation and Maintenance														
			Data														
			Gas Distribution System and	3.19.1	G												
			Equipment Operation														
			Gas Distribution System	3.19.2	G												
			Maintenance														

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		33 51 15	Gas Distribution Equipment	3.19.3	G												
			Maintenance														
		33 51 39	SD-01 Preconstruction Submittals														
			Investigation-derived Waste	1.5.3	G												
			Management Plan														
			Installation Plan	1.5.6	G												
			Health and Safety Plan	1.5.4	G												
			Sampling and Analysis Plan	1.5.5	G												
			Well Construction Permit	1.5.9													
			Treatment Facility Permit	1.5.7													
			Qualifications	1.5.1	G												
			SD-02 Shop Drawings														
			Survey Maps and Notes	3.3.8.1	G												
			Well Construction Drawings	1.5.2	G												
			SD-03 Product Data														
			Riser Pipe	1.1	G												
			Cement	1.1	G												
			Centralizers	1.1	G												
			Surface Protective Covers	1.1	G												
			Well Vaults	1.1	G												
			Locking Caps	1.1	G												
			Oil Filters	1.1	G												
			Sampling Equipment	1.1	G												
			Chemical Specifications on Drill	1.1	G												
			Lubricants and Tracers														
			Well Casing	2.2.1	G												

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		33 51 39	Well Screen	2.2.2	G												
			Filter Pack	1.1	G												
			Neat Cement Grout	2.2.4.2	G												
			Bentonite	2.2.4.1	G												
			SD-06 Test Reports														
			Drilling Fluid Additive	3.2.1	G												
			Well Development Record	3.3.7.1	G												
			Filter Pack Material Test Results	2.2.3	G												
			Sieve Analyses of Sampled	3.3.5	G												
			Material														
			Water Source Analytical Test	3.1.1	G												
			Results														
			SD-07 Certificates														
			Permits	1.7													
			Installation Survey Report	3.3.8													
			Well Development Report	1.5.8													
			Borehole Analysis Report	3.3.5													
			Shipment Manifests	1.5.10													
			Delivery Certificates	1.5.11													
			Correspondence	1.7													
			Photographs	3.3.9													
			Treatment and Disposal	1.5.12													
			Certificates														
			SD-11 Closeout Submittals														
			Installation Diagram	3.5.2.2	G												

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		33 51 39	Well	3.5.4													
			Decommissioning/Abandonment														
			Record														
			Geophysical Logs	3.5.3													
			Borehole Logs	3.5.2.1	G												
		33 51 43	SD-01 Preconstruction Submittals														
			Instrumentation Specialist	1.7	G												
			Instrumentation and Monitoring	1.7.3	G												
			Plan														
			Permit Documentation	3.3.1	G												
			Backups, Archiving, And Disaster	1.10.3	G												
			Recovery Plan														
			Seismologist/Vibration Consultant	1.8	G												
			Vibration Monitoring Plan	1.8.3	G												
			Preconstruction Condition Survey	3.12.1	G												
			Drilling Program Plan	3.3.5	G												
			Grounding And Lightning	2.13.10	G												
			Protection Plan														
			Quick Reference Guide	3.5.3.2	G												
			Web Interface	3.5.3.1	G												
			SD-02 Shop Drawings														
			Instrument Modification Report	3.10	G												
			SD-03 Product Data														
			Factory Test Reports	2.2.2	G												
			Riser Pipe	2.3.1.2	G												
			Filter Pack Material	2.3.1.5	G												

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		33 51 43	Proprietary Data Determination	1.10.1	G												
			Request														
			Raw Data	3.6.2	G												
			SD-05 Design Data														
			Method Statements	1.7.3	G												
			Grout Mix Design	2.3.2.2	G												
			SD-06 Test Reports														
			Pre-Installation Acceptance Tests	3.1	G												
			Vibration Test Program And	3.12.3	G												
			Report														
			Vibration Complaint Report	1.8.3	G												
			Monitoring Data Reports	3.5.2	G												
			Deficiency Correction Report	3.12.7	G												
			Instrument Alert Assessment	3.7.2	G												
			Action Threshold Exceedance	3.7.2	G												
			Report														
			Daily Vibration Monitoring	3.12.5	G												
			Reports														
			Postconstruction Condition	3.12.2	G												
			Survey														
			Installation Record	3.3.3	G												
			SD-07 Certificates														
			Seismologist/Vibration Consultant	1.8.2	G												
			Qualifications														
			Instrumentation Specialist	1.7.2	G												
			Qualifications														

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		33 51 43	SD-08 Manufacturer's Instructions														
			Factory Test Reports	2.2.2	G												
			SD-10 Operation and Maintenance														
			Data														
			Installation	3.3.2	G												
			Instrument Modification Report	3.10	G												
			Operations Manual	3.4.5.4	G												
			SD-11 Closeout Submittals														
			Instrument Removal List	3.11	G												
			As-Built Drawings	3.4.5.5	G												
			ADAS Final Report	2.13.14	G												
		33 52 10	SD-02 Shop Drawings														
			Grounding and Bonding	2.1.2													
			Pipe Supports	2.5.9													
			SD-03 Product Data														
			Insulating Flange Kits	2.3.2	G												
			Flange Protectors	2.3.3	G												
			Fuel Piping Flange Bolts, Nuts,	2.3.4	G												
			and Washers														
			Carbon Steel Pipe	2.4.1	G												
			Stainless Steel Pipe	2.4.2	G												
			Flexible Non-Metallic Pipe	2.4.3	G												
			Double Wall Carbon Steel Piping	2.4.4	G												
			Steel Reinforced Flexible Pipe	2.4.5	G												
			Copper Piping	2.4.6	G												
			Joint Compound	2.5.4	G												

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		33 52 10	Flexible Connector	2.5.5	G												
			Strainer	2.5.6	G												
			Thermometers	2.5.7	G												
			Pressure Gauge	2.5.8	G												
			Flexible Ball Joint	2.5.11	G												
			Bellows Expansion Joint	2.5.12	G												
			Flow Meter	2.5.13	G												
			Ball Valves	2.6.1	G												
			Plug (Double Block and Bleed)	2.6.2	G												
			Valves														
			Swing Type Check Valves	2.6.3	G												
			Wafer Type Check Valve	2.6.4	G												
			Globe Valve	2.6.5	G												
			Thermal Relief Valve	2.6.6	G												
			Pressure\Vacuum Relief Valve	2.6.7	G												
			Foot Valve	2.6.8	G												
			Tank Overfill Prevention Valve	2.6.9	G												
			(Gravity Fill)														
			Tank Overfill Prevention Valve	2.6.10	G												
			(Pumped Fuel Receipt)														
			Anti-Siphon Valves	2.6.11	G												
			Submersible Pump	2.7.1	G												
			ANSI Type Centrifugal Pump	2.7.2	G												
			Sliding Vane Rotary Pump	2.7.3	G												
			Self-Priming Centrifugal Pump	2.7.4	G												
			Pump Control Panel	2.7.5	G												

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		33 52 10	FRP Containment Sump	2.8	G													
			Pipeline Markers	2.9.8	G													
			SD-06 Test Reports															
			Exterior Coating Holiday Test	3.3.2.1														
			Preliminary Pneumatic Test	3.3.2.2														
			Final Pneumatic Test	3.3.2.3														
			Hydrostatic Test	3.3.2.4														
			Exterior Containment Piping	3.3.2.5														
			Tests															
			SD-07 Certificates															
			Contractor Qualifications	1.4.1	G													
			Licensed Personnel	1.4.2.1														
			Stage II Vapor Recovery System	1.4.2.2														
			Pipeline Inventory	1.4.3.1	G													
			Demonstrations	3.5														
			SD-08 Manufacturer's Instructions															
			Flexible Ball Joint	2.5.11														
			Bellows Expansion Joint	2.5.12														
			SD-10 Operation and Maintenance															
			Data															
			Insulating Flange Kits	2.3.2	G													
			Flange Protectors	2.3.3	G													
			Strainer	2.5.6	G													
			Thermometers	2.5.7	G													
			Flexible Ball Joint	2.5.11	G													
			Bellows Expansion Joint	2.5.12	G													

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		33 52 10	Flow Meter	2.5.13	G												
			Ball Valves	2.6.1	G												
			Plug (Double Block and Bleed)	2.6.2	G												
			Valves														
			Swing Type Check Valves	2.6.3	G												
			Wafer Type Check Valve	2.6.4	G												
			Globe Valve	2.6.5	G												
			Thermal Relief Valve	2.6.6	G												
			Pressure\Vacuum Relief Valve	2.6.7	G												
			Foot Valve	2.6.8	G												
			Tank Overfill Prevention Valve	2.6.9	G												
			(Gravity Fill)														
			Tank Overfill Prevention Valve	2.6.10	G												
			(Pumped Fuel Receipt)														
			Anti-Siphon Valves	2.6.11	G												
			Submersible Pump	2.7.1	G												
			ANSI Type Centrifugal Pump	2.7.2	G												
			Sliding Vane Rotary Pump	2.7.3	G												
			Self-Priming Centrifugal Pump	2.7.4	G												
			Pump Control Panel	2.7.5	G												
		33 56 53	SD-02 Shop Drawings														
			Installation	3.2	G												
			SD-06 Test Reports														
			Test	2.5.1													
			Procedure for Welding Vessels	2.3.7													
			and Manifolds														

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		33 56 53	SD-07 Certificates														
			Cleaning	2.6													
		33 57 55	SD-02 Shop Drawings														
			Grounding and Bonding	2.3.1	G												
			Tightness Monitoring System	2.6.4	G												
			Truck Fillstand Overfill Protection	2.6.5	G												
			and Ground Verification Unit														
			Venturi Tubes	2.6.7	G												
			Meters	2.8	G												
			Jockey Pump	2.10.5	G												
			Packaged Truck Offload System	2.11	G												
			High Point Vent and Low Point	2.19	G												
			Drain Pits														
			Water Draw-Off System	2.26	G												
			Operating Tank Vent	2.28	G												
			SD-03 Product Data														
			Pressure Gages	2.4	G												
			Differential Pressure Gauge	2.5	G												
			Automatic Pump Controls	2.6	G												
			Tightness Monitoring System	2.6.4	G												
			Truck Fillstand Overfill Protection	2.6.5	G												
			and Ground Verification Unit														
			Flow Switches	2.6.6	G												
			Venturi Tubes	2.6.7	G												
			Differential Pressure Transmitter	2.6.8	G												
			Pressure Sensor	2.6.9	G												

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		33 57 55	Relaxation Tank	2.7	G												
			Meters	2.8	G												
			Submersible Pump	2.10.1	G												
			ANSI Type Centrifugal Pump	2.10.2	G												
			Sliding Vane Rotary Pump	2.10.3	G												
			Self-Priming Centrifugal Pump	2.10.4	G												
			Jockey Pump	2.10.5	G												
			Packaged Truck Offload System	2.11	G												
			Deaerator Tank	2.12	G												
			Truck Fillstand Hose	2.14.1	G												
			Truck Fillstand Swivel Joints	2.14.2	G												
			Tank Truck Bottom Loading Arm	2.15	G												
			Top Loading Arm	2.16	G												
			Filter/Separator	2.18	G												
			High Point Vent and Low Point	2.19	G												
			Drain Pits														
			FRP Containment Sump	2.20	G												
			Liquid Level Gauge	2.21	G												
			Operating Tank Level Indicator	2.22	G												
			Operating Tank Level Switches	2.23	G												
			Operating Tank Level Switches	2.24	G												
			Operating Tank Level Switches	2.25	G												
			Water Draw-Off System	2.26	G												
			Operating Tank Vent	2.28	G												
			Product Dispensing Unit	2.29.1	G												
			SD-06 Test Reports														

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						CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION GOVT OR A/E REVWR	SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
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		33 57 55	Tightness Monitoring System	2.6.4	G												
			Coating Testing	3.2.1	G												
			SD-07 Certificates														
			System Supplier	1.5	G												
			Tightness Monitoring System	2.6.4	G												
			SD-10 Operation and Maintenance														
			Data														
			Automatic Pump Controls	2.6	G												
			Tightness Monitoring System	2.6.4	G												
			Truck Fillstand Overfill Protection	2.6.5	G												
			and Ground Verification Unit														
			Relaxation Tank	2.7	G												
			Meters	2.8	G												
			Submersible Pump	2.10.1	G												
			ANSI Type Centrifugal Pump	2.10.2	G												
			Sliding Vane Rotary Pump	2.10.3	G												
			Self-Priming Centrifugal Pump	2.10.4	G												
			Jockey Pump	2.10.5	G												
			Packaged Truck Offload System	2.11	G												
			Deaerator Tank	2.12	G												
			Filter/Separator	2.18	G												
			Operating Tank Level Indicator	2.22	G												
			Water Draw-off System	2.26	G												
			Operating Tank Vent	2.28	G												
			Product Dispensing Unit	2.29.1	G												
		33 60 02	SD-02 Shop Drawings														

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		33 60 02	Materials and Equipment	2.1													
			SD-03 Product Data														
			Materials and Equipment	2.1	G												
			Procedures and Welders	1.4													
			SD-04 Samples														
			Insulation Systems	2.8													
			SD-10 Operation and Maintenance														
			Data														
			Distribution System	3.2.2.1	G												
		33 61 13	SD-02 Shop Drawings														
			Heat Distribution System	3.5	G												
			SD-03 Product Data														
			Expansion Loops and Bends	2.7	G												
			Cathodic Protection Installation	3.5.7	G												
			Interruption of Existing Service	3.1.2	G												
			Work Plan	1.5.1	G												
			Quality Assurance Plan	1.5.1													
			UHDS Manufacturer's	3.5.4													
			Representative Reports														
			Connecting to Existing Work	3.1.4	G												
			SD-06 Test Reports														
			Thermal Performance Testing	3.9	G												
			Operational Test	3.6.2.3	G												
			Tests	3.6	G												
			Test of WSL Systems for Steam	2.3.9	G												
			Service														

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		33 61 13	Test of WSL Systems for	2.3.10	G												
			Condensate Return Service														
			SD-07 Certificates														
			Manufacturer	1.5.1	G												
			Manufacturer's Representative	1.5.2	G												
			UHDS Design	1.3.2	G												
			Certificate of Compliance	3.5.4	G												
			Testing Firm	1.5.4													
			Welding	3.4													
			SD-10 Operation and Maintenance														
			Data														
			Heat Distribution System	3.5	G												
		33 61 13.13	SD-02 Shop Drawings														
			Fabrication and Assembly	2.1													
			Drawings														
			SD-03 Product Data														
			Support of the Equipment	2.1													
			Markers For Underground Piping	3.6.9													
			SD-07 Certificates														
			Welding	1.4													
			Written Certification	2.1													
			SD-10 Operation and Maintenance														
			Data														
			Maintenance	3.10	G												
		33 61 13.19	SD-02 Shop Drawings														
			Detail Drawings	1.3.1	G												

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		33 61 13.19	SD-03 Product Data														
			Support of the Equipment	2.1													
			Piping and Fittings	2.5													
			Valves	2.6													
			Insulating Flanges	2.5.4.1													
			Insulation	2.12.2													
			Sump Pumps and Drainers	2.13													
			Expansion Joints	2.15													
			SD-04 Samples														
			Insulated Sections	1.3.2	G												
			SD-10 Operation and Maintenance														
			Data														
			Valve Manholes and Accessories	3.7	G												
			Data Package 2	3.7.1	G												
		33 61 14	SD-02 Shop Drawings														
			Factory-prefabricated	2.1													
			preinsulated water piping system														
			field joints	3.2													
			SD-03 Product Data														
			Pipe, fittings, and end	2.1													
			connections														
			Factory-prefabricated	2.1													
			preinsulated water piping system														
			Plastic reinforced thermosetting	2.2.3													
			resin (RTR) piping														
			SD-07 Certificates														

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		33 61 14	Certification of welders'	1.4.1													
			qualifications														
			SD-08 Manufacturer’s Instructions														
			factory-prefabricated preinsulated	2.1													
			water piping system														
		33 63 13	SD-02 Shop Drawings														
			Heat Distribution System design	1.4.4	G												
			SD-03 Product Data														
			Pipe	2.4.1	G												
			Insulation	2.3	G												
			Fittings	2.4.2	G												
			Cathodic protection	1.4.1	G												
			Anchors	1.3.3	G												
			Expansion joints	2.5	G												
			Coatings	1.2.9	G												
			Conduit	2.1.6	G												
			Field Connection of Casing	2.1.12	G												
			Sections														
			SD-05 Design Data														
			Pipe-stress and system	1.2.7	G												
			expansion calculations														
			Cathodic protection system	1.2.8	G												
			calculations														
			Manufacturer's data sheets	1.2.9	G												
			SD-06 Test Reports														
			WSL system tests	2.2.8.1	G												

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		33 63 13	SD-07 Certificates														
			Work plan	1.2.10	G												
			Quality assurance	1.2.11	G												
			Thermal performance testing	1.2.12	G												
			UHDS manufacturer certification	1.2.4	G												
			UHDS design	1.3.2	G												
			Certificate of compliance	1.2.13	G												
			Testing firm qualification	1.2.14	G												
			Welds	1.2.15	G												
			SD-10 Operation and Maintenance														
			Data														
			Heat distribution system	1.2.17	G												
			SD-11 Closeout Submittals														
			Daily written report	1.2.16													
		33 63 14	SD-02 Shop Drawings														
			Cooling tanks	2.4.6													
			Manholes	2.5.1													
			buried piping system	2.5													
			SD-03 Product Data														
			Pipe and fittings	2.1.1													
			Valves	2.3													
			Strainers	2.4.2													
			Pipe hangers and supports	2.4.1													
			Traps	2.4.3													
			Gages	2.4.6													

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		33 63 14	Federal Agency Approved	2.5													
			Brochure														
			Thermometers	2.4.6													
			SD-05 Design Data														
			buried piping system	2.5													
			SD-07 Certificates														
			Certification of welder's	1.4.1													
			qualifications														
		33 63 16	SD-02 Shop Drawings														
			Piping system	1.2	G												
			Pipe hangers and supports	2.4.1	G												
			Manholes	2.6	G												
			Shallow concrete trench	2.8	G												
			SD-03 Product Data														
			Pipe	2.1													
			Valves	2.3	G												
			Strainers	2.4.2	G												
			Pipe hangers and supports	2.4.1													
			Traps	2.4.3													
			Gages	2.4.4													
			Steam flow meters	2.4.8	G												
			Expansion joints	2.4.9	G												
			Manhole drainers	2.5	G												
			Sealant	2.8													
			SD-07 Certificates														

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		33 63 16	Certification of welder's	1.4.1														
			qualifications															
			SD-10 Operation and Maintenance															
			Data															
			Manhole drainers	2.5	G													
			Steam flow meters	2.4.8	G													
		33 63 23	SD-03 Product Data															
			Piping	2.1														
			Valves	2.3														
			Strainers	2.4.2														
			Pipe hangers and supports	2.4.1														
			Traps	2.4.3														
			Gages	2.4.4														
			Steam flow meters	2.4.8														
			Expansion joints	2.4.10														
			Manhole drainers	2.6														
			SD-07 Certificates															
			Certification of welder's	1.4.1														
			qualifications															
			SD-10 Operation and Maintenance															
			Data															
			Manhole drainers	2.6	G													
			Steam flow meters	2.4.8	G													
		33 71 01	SD-03 Product Data															
			Conductors	2.6	G													
			Insulators	2.5	G													

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		33 71 01	Concrete Poles	2.2.3	G												
			Steel Poles	2.2.2	G												
			Wood Poles	2.2.1													
			Nameplates	2.24	G												
			Pole Top Switch	3.1.10	G												
			Recloser	2.17	G												
			Sectionalizer	2.18	G												
			Cutouts	2.13	G												
			Transformer	2.15	G												
			Metering Equipment	2.19	G												
			Meters	2.19.3	G												
			Surge Arresters	2.12	G												
			Capacitors	2.20	G												
			Voltage Regulator	2.21	G												
			Guy Strand	2.8													
			Anchors	2.10													
			SD-05 Design Data														
			Concrete Poles	2.2.3	G												
			Steel Poles	2.2.2	G												
			Power-Installed Screw	3.1.4.2	G												
			Foundations														
			SD-06 Test Reports														
			Wood Crossarm Inspection	1.5.4													
			Report														
			Field Test Plan	1.5.4.1	G												
			Field Quality Control	3.6	G												

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		33 71 01	Ground Resistance Test Reports	1.5.3	G												
			Medium-Voltage Preassembled	3.6.3	G												
			Cable Test														
			Sag and Tension Test	3.6.4	G												
			Low-Voltage Cable Test	3.6.5	G												
			Acceptance Checks and Tests	3.6.7													
			SD-07 Certificates														
			Concrete Poles	2.2.3	G												
			Steel Poles	2.2.2	G												
			Wood Poles	2.2.1	G												
			Wood Crossarms	2.3.1	G												
			Transformer Efficiencies	2.15.1	G												
			SD-09 Manufacturer’s Field														
			Reports														
			Operation and Maintenance	1.6	G												
			Manuals														
			Operation and Maintenance	1.6.1	G												
			Manuals														
			Transformer Test Schedule	2.25.1	G												
			Routine and Other Tests	2.25.2	G												
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	1.6	G												
			Manuals														
			Operation and Maintenance	1.6.1	G												
			Manuals														

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		33 71 01.00 40	SD-02 Shop Drawings														
			Connection Diagrams	1.3.1	G												
			Fabrication Drawings	1.3.1	G												
			Installation Drawings	1.3.1	G												
			SD-03 Product Data														
			Conductors	2.4.1	G												
			Insulators	2.3.5	G												
			Concrete Poles	2.3.3	G												
			Steel Poles	2.3.2	G												
			Wood Poles	2.3.1.1	G												
			Nameplates	2.3.10	G												
			Pole Top Switch	3.1.10	G												
			Recloser	2.2.8	G												
			Sectionalizer	2.2.9	G												
			Cutouts	2.3.8	G												
			Transformer	2.3.9	G												
			Metering Equipment	2.2.10	G												
			Meters	2.2.10.3	G												
			Surge Arresters	2.3.7	G												
			Guy Strand	2.2.2	G												
			Anchors	2.2.4	G												
			SD-05 Design Data														
			Concrete Pole Design	2.3.3	G												
			Steel Pole Design	2.3.2	G												
			Power-Installed Screw	3.1.4.2	G												
			Foundations														

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		33 71 01.00 40	SD-06 Test Reports														
			Wood Crossarm Inspection	1.6.4	G												
			Report														
			Field Test Plan	1.6.4.1	G												
			Field Quality Control	3.2	G												
			Ground Resistance Test Reports	1.6.3	G												
			SD-07 Certificates														
			Wood Crossarms	2.3.4.1	G												
			Transformer Losses	2.3.9.1	G												
			SD-09 Manufacturer’s Field														
			Reports														
			Routine and Other Tests	2.5.2	G												
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	1.5.1	G												
			Manuals														
			SD-11 Closeout Submittals														
			Transformer Test Schedule	2.5.1	G												
		33 71 02	SD-02 Shop Drawings														
			Aluminum Conductors	2.2.1	G												
			Precast Underground Structures	1.6.1	G												
			SD-03 Product Data														
			Medium Voltage Cable	2.5	G												
			Medium Voltage Cable Joints	2.7	G												
			Medium Voltage Cable	2.6	G												
			Terminations														

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ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	CONTRACTOR ACTION ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		33 71 02	Live End Caps	2.9	G												
			Precast Concrete Structures	2.14.2.1	G												
			Sealing Material	2.14.2.4													
			Pulling-In Irons	3.5.3													
			Manhole Frames and Covers	2.14.3	G												
			Handhole Frames and Covers	2.14.4	G												
			Frames and Covers for Airfield	2.14.5	G												
			Facilities														
			Ductile Iron Frames and Covers	2.14.6	G												
			for Airfield Facilities														
			Composite/Fiberglass Handholes	2.14.8	G												
			Cable Supports	2.15	G												
			Protective Devices and	2.19	G												
			Coordination														
			SD-06 Test Reports														
			Medium Voltage Cable	2.20.2	G												
			Qualification and Production Tests														
			Field Acceptance Checks and	3.20.1	G												
			Tests														
			Arc-proofing Test	2.20.1	G												
			Cable Installation Plan and	3.3	G												
			Procedure														
			SD-07 Certificates														
			Cable splicer/terminator	1.6.2	G												
			Cable Installer Qualifications	1.6.3	G												
			Certificate of Conformance	1.6.4	G												

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ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	CONTRACTOR ACTION ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
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		33 73 00.00 40	SD-01 Preconstruction Submittals														
			Transformer Test Schedule	2.5.1	G												
			SD-02 Shop Drawings														
			Connection Diagrams	2.1.1	G												
			Fabrication Drawings	2.1.1	G												
			Installation Drawings	3.1	G												
			Equipment Foundation Drawings	2.1.1	G												
			SD-03 Product Data														
			Power Transformers	2.1.1	G												
			Manufacturer's Instructions	2.1.1	G												
			SD-06 Test Reports														
			Factory Test Reports	2.5	G												
			Factory Test Reports	2.5.2	G												
			Acceptance Tests	3.2.1	G												
			SD-07 Certificates														
			Certificates of Compliance	1.4.3	G												
			SD-11 Closeout Submittals														
			Final Test Reports	3.3.1	G												
			Operation And Maintenance	3.3.2	G												
			Manuals														
			Warranty	1.7	G												
		33 75 00.00 40	SD-01 Preconstruction Submittals														
			Switchgear Assemblies	1.3	G												
			SD-02 Shop Drawings														
			Switchgear Assemblies	1.3	G												
			Buses	2.2.3	G												

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ACTIVITY NO (a)	TRANSMITTAL NO (b)	SPEC SECT (c)	DESCRIPTION ITEM SUBMITTED (d)	PARAGRAPH # (e)	CLASSIFICATION GOVT OR A/E REVWR (f)	CONTRACTOR: SCHEDULE DATES SUBMIT (g)	APPROVAL NEEDED BY (h)	MATERIAL NEEDED BY (i)	CONTRACTOR ACTION ACTION CODE (j)	DATE OF ACTION (k)	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR (l)	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER (m)	DATE RCD FROM OTH REVIEWER (n)	ACTION CODE (o)	DATE OF ACTION (p)	MAILED TO CONTR/ DATE RCD FRM APPR AUTH (q)	REMARKS (r)
		33 75 00.00 40	Switchgear Components	2.3	G												
			Automatic/Manual Transfer	2.3.6	G												
			Switch														
			Space Heaters	2.3.10	G												
			Enclosures	2.2.3	G												
			Weatherproof Enclosures	2.2.3	G												
			Installation Drawings	3.1	G												
			SD-03 Product Data														
			Equipment and Performance	2.1	G												
			Data														
			Equipment Foundation Data	2.1	G												
			Switchgear Assemblies	1.3	G												
			Enclosures	2.2.3	G												
			Buses	2.2.3	G												
			Switchgear Components	2.3	G												
			Weatherproof Enclosures	2.2.3	G												
			Automatic/Manual Transfer	2.3.6	G												
			Switch														
			Space Heaters	2.3.10	G												
			SD-06 Test Reports														
			Electrical Acceptance Tests	3.2	G												
			High-Voltage Tests	3.2	G												
			Current Test	3.3.2	G												
			Insulation-Resistance Test	3.2	G												
			Insulation-Resistance Test	3.2	G												
			Weatherproof Test	3.2	G												

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		33 75 00.00 40	Electrical Current and Voltage	3.2	G												
			Tests														
			Ratio and Polarity Tests	3.3.2	G												
			High-Voltage (Hi-Pot) Withstand	3.2	G												
			Test														
			Final Test Data	3.2	G												
			SD-07 Certificates														
			Certificates	1.4.2	G												
			SD-08 Manufacturer’s Instructions														
			Switchgear Assemblies	1.3	G												
			SD-10 Operation and Maintenance														
			Data														
			Switchgear Assemblies	1.3	G												
			Transfer Switches	2.3.4	G												
			Space Heaters	2.3.10	G												
		33 77 19.00 40	SD-02 Shop Drawings														
			Assembly Drawings	2.1	G												
			SD-03 Product Data														
			Medium Voltage Switches	2.1	G												
			Medium Voltage Switches	3.3	G												
			SD-06 Test Reports														
			Factory Test Report	2.3.1	G												
			Acceptance Test Report	3.2.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Medium Voltage Switches	2.1													

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		33 77 19.00 40	Medium Voltage Switches	3.3													
		33 77 36.00 40	SD-02 Shop Drawings														
			Fabrication Drawings	2.1	G												
			Installation Drawings	3.1	G												
			SD-03 Product Data														
			Distribution Fuse Cutouts	2.1	G												
			SD-07 Certificates														
			Testing Certificates	2.1													
			SD-08 Manufacturer’s Instructions														
			Fuse Cutouts	2.2.2													
			Manufacturer's Installation	3.1													
			Instructions														
		33 82 00	SD-02 Shop Drawings														
			Telecommunications Outside	1.6.1.1	G												
			Plant														
			Telecommunications Entrance	1.6.1.2	G												
			Facility Drawings														
			SD-03 Product Data														
			Wire and Cable	2.8	G												
			Cable Splices, and Connectors	2.5	G												
			Closures	2.3	G												
			Building Protector Assemblies	2.2.1	G												
			Protector Modules	2.2.2	G												
			Cross-Connect Terminal	2.4	G												
			Cabinets														
			Spare Parts	1.8.2	G												

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		33 82 00	SD-06 Test Reports														
			Pre-installation Tests	3.5.1	G												
			Acceptance Tests	3.5.2	G												
			Outside Plant Test Plan	1.6.3	G												
			SD-07 Certificates														
			Telecommunications Contractor	1.6.2.1	G												
			Key Personnel	1.6.2.2	G												
			Manufacturer's Qualifications	1.6.2.3	G												
			SD-08 Manufacturer’s Instructions														
			Building Protector Assembly	2.2.1	G												
			Installation														
			Cable Tensions	3.1.8.1	G												
			Fiber Optic Splices	3.1.10.2	G												
			SD-09 Manufacturer’s Field														
			Reports														
			Factory Reel Test Data	2.16.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Telecommunications Outside	1.6.1.1	G												
			Plant (OSP)														
			SD-11 Closeout Submittals														
			Record Documentation	1.8.1	G												
		41 22 13.14	SD-02 Shop Drawings														
			Overhead Electric Traveling	1.6.4	G												
			Crane														

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ACTIVITY NO (a)	TRANSMITTAL NO (b)	SPEC SECT (c)	DESCRIPTION ITEM SUBMITTED (d)	PARAGRAPH # (e)	CLASSIFICATION GOVT OR A/E REVWR (f)	CONTRACTOR: SCHEDULE DATES SUBMIT (g)	APPROVAL NEEDED BY (h)	MATERIAL NEEDED BY (i)	CONTRACTOR ACTION ACTION CODE (j)	DATE OF ACTION (k)	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR (l)	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER (m)	DATE RCD FROM OTH REVIEWER (n)	ACTION CODE (o)	DATE OF ACTION (p)	MAILED TO CONTR/ DATE RCD FRM APPR AUTH (q)	REMARKS (r)
		41 22 13.14	Complete Schematic Wiring	3.3.2	G												
			Diagram														
			Control System and Network	1.6.4	G												
			Drawings														
			SD-03 Product Data														
			Gear Reducers	2.3.7.1	G												
			Hoist Brakes	2.3.10	G												
			Travel Brakes	2.3.9	G												
			Couplings	2.3.11	G												
			Load Blocks and Hooks	2.3.3	G												
			Wheels	2.3.8	G												
			Hoists	2.3.1	G												
			Sheaves	2.3.5	G												
			Commercial Hoist and Trolley	2.3.1	G												
			Units														
			End Trucks	2.2.5	G												
			Bridge Rails	2.2.3	G												
			End Stops	2.2.7	G												
			Bumpers	2.2.7	G												
			Operator's Cab	2.2.9	G												
			Variable Frequency Drives	2.4.1	G												
			Motors	2.4.1	G												
			Runway Conductor System	2.4.8.1	G												
			Runway Conductor System	2.4.8.1	G												
			Bridge Conductor System	2.4.8.2	G												
			Bridge Conductor System	2.4.8.2	G												

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		41 22 13.14	Limit Switches	2.4.6	G												
			Radio Control System	2.4.7.2	G												
			Pendant Pushbutton Station	2.4.7.1	G												
			Pendant Conductor System	2.4.7.1.1	G												
			Cab Control Station	2.4.7.3	G												
			Controls	2.4.2	G												
			Control Parameter Settings	3.3.2	G												
			Capacity Overload Protective	2.4.9	G												
			Device														
			Load Indicating Device	2.4.9	G												
			Painting System	2.5	G												
			Control System and Network	2.4.16.1	G												
			SD-05 Design Data														
			Load and Sizing Calculations	1.6.5	G												
			SD-06 Test Reports														
			Hook Proof Test	1.6.2.3	G												
			Hook Non-destructive Test (NDT)	1.6.2.2.1	G												
			Post-erection Inspection	3.4.1	G												
			Operational Tests	3.4.2	G												
			Hook Tram Measurement	3.4.4	G												
			Load Tests	3.4.5	G												
			SD-07 Certificates														
			Wire Ropes	1.6.3	G												
			Crane Runway System	1.6.3	G												
			Hazardous Material	1.6.3	G												
			Loss of Power Test	1.6.3	G												

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		41 22 13.14	Coupling Alignment Verification Record	1.6.3	G													
			Overload Test	1.6.3	G													
			Overload Test	1.6.3	G													
			Brake Adjustment Record	1.6.3	G													
			Compliance with Listed Standards	1.6.3	G													
			Contractor Hazardous Environment	1.6.3	G													
			Public Domain Software	1.6.3	G													
			Software and Services	1.6.3	G													
			SD-10 Operation and Maintenance Data															
			Operation and Maintenance Manuals	3.6	G													
			SD-11 Closeout Submittals															
			Disabled Ports, Connectors, and Interfaces	2.4.16.2	G													
			Network-Capable Control Devices	2.4.16	G													
			Control System Access Control	2.4.16.3	G													
			Control System Account Management	2.4.16.4	G													
			Patch Management and Updates	2.4.16.9	G													
			Malware Detection and Protection	2.4.16.10	G													

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		41 22 13.14	Wireless Technology Provisions	2.4.16.12	G												
			Control System Inventory	2.4.16.13	G												
			Evaluation Status of Hardware and Software	2.4.16.2	G												
		41 22 13.15	SD-02 Shop Drawings														
			Overhead Electric Crane System	1.6.3	G												
			Complete Schematic Wiring Diagram	3.3.2	G												
			Control System and Network Drawings	1.6.3	G												
			SD-03 Product Data														
			Gear Reducers	2.3.5.1	G												
			Hoist Brakes	2.3.2.1	G												
			Travel Brakes	2.3.4	G												
			Couplings	2.3.7	G												
			Load Block and Hook	2.3.2.2	G												
			Hoist and Trolley Units	2.3.2	G												
			Bridge End Trucks	2.2.3	G												
			Crane Bridge Girder	2.2.2	G												
			End Stops	2.2.4	G												
			Bumpers	2.2.4	G												
			Crane Runway System	1.6.5	G												
			Motors	2.4.1	G												
			Enclosures	2.4.10	G												
			Circuit Breakers	2.4.3	G												
			Disconnect Switch	2.4.3	G												

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TITLE AND LOCATION MOODY INSTALLATION GUIDE SPECIFICATIONS						CONTRACTOR											
						CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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		41 22 13.15	Contactors and Relays	2.4.5	G												
			Fuses	2.4.3	G												
			Variable Frequency Drives	2.4.1	G												
			Limit Switches	2.4.6	G												
			Resistors	2.4.4	G												
			Radio Control System	2.4.7.1.2	G												
			Pendant Push-Button Station	2.4.7.1	G												
			Pendant Conductor System	2.4.7.1.1	G												
			Crane Controllers	2.4	G												
			Control Parameter Settings	2.4.2	G												
			Pilot Devices	2.4.13	G												
			Warning Devices	2.4.11	G												
			Floodlights	2.4.12	G												
			Runway Conductor System	2.4.8.1	G												
			Bridge Conductor System	2.4.8.2	G												
			Overload Protection	2.4.9	G												
			Load Indicating Device	2.4.9	G												
			Painting System	2.5	G												
			Control System and Network	2.4.16.1	G												
			SD-05 Design Data														
			Load and Sizing Calculations	1.6.4	G												
			SD-06 Test Reports														
			Hook Proof Test	1.6.2.3	G												
			Hook Non-Destructive Test	1.6.2.2.1	G												
			(NDT)														
			Post-Erection Inspection	3.4.1	G												

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		41 22 13.15	Operational Tests	3.4.2	G												
			Hook Tram Measurement	3.4.4	G												
			Load Tests	3.4.5	G												
			SD-07 Certificates														
			Wire Rope	1.6.5	G												
			Load Chain	1.6.5	G												
			Crane Runway System	1.6.5	G												
			Hazardous Material	1.6.5	G												
			Loss of Power Test	1.6.5	G												
			Coupling Alignment Verification	1.6.5	G												
			Record														
			Overload Test	1.6.5	G												
			Overload Test	1.6.5	G												
			Brake Adjustment Record	1.6.5	G												
			Compliance with Listed	1.6.5	G												
			Standards														
			Contractor Hazardous	1.6.5	G												
			Environment														
			Hoist Manufacturer Hazardous	1.6.5	G												
			Environment														
			Public Domain Software	1.6.5	G												
			Software and Services	1.6.5	G												
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.6	G												
			Manuals														

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ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	CONTRACTOR ACTION ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
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		41 22 13.15	SD-11 Closeout Submittals														
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			Network-Capable Control Devices	2.4.16	G												
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			Control System Account Management	2.4.16.4	G												
			Patch Management and Updates	2.4.16.9	G												
			Malware Detection and Protection	2.4.16.10	G												
			Wireless Technology Provisions	2.4.16.12	G												
			Control System Inventory	2.4.16.13	G												
			Evaluation Status of Hardware and Software	2.4.16.2	G												
		41 22 13.16	SD-02 Shop Drawings														
			Overhead Electric Traveling (OET) Crane(s)	1.5.5	G												
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			Crane Runway System	1.5.5	G												
			Complete Schematic Wiring Diagram	1.5.5	G												
			SD-03 Product Data														
			OET Design Criteria	1.5.5	G												
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		41 22 13.16	Load and Sizing Calculations	1.3.1	G												
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		41 22 13.55	Complete Schematic Wiring	3.3.2	G												
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			Hoist Brakes	2.3.2.1	G												
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			Motors	2.4.1	G												
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			Radio Control System	2.4.7.1.2	G												
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		41 22 13.55	Crane Controllers	2.4	G												
			Control Parameter Settings	2.4.2	G												
			Pilot Devices	2.4.13	G												
			Warning Devices	2.4.11	G												
			Floodlights	2.4.12	G												
			Runway Conductor System	2.4.8.1	G												
			Bridge Conductor System	2.4.8.2	G												
			Overload Protection	2.4.9	G												
			Painting System	2.5	G												
			Control System and Network	2.4.15.1	G												
			SD-05 Design Data														
			Load and Sizing Calculations	1.6.4	G												
			SD-06 Test Reports														
			Hook Proof Test	1.6.2.1	G												
			Hook Non-Destructive Test	1.6.2.2.1	G												
			(NDT)														
			Post-Erection Inspection	3.4.1	G												
			Operational Tests	3.4.2	G												
			Hook Tram Measurement	3.4.4	G												
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			Wire Rope	1.6.5	G												
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		41 22 13.55	Overload Test	1.6.5	G												
			Brake Adjustment Record	1.6.5	G												
			Contractor Hazardous Environment	1.6.5	G												
			Public Domain Software	1.6.5	G												
			Software and Services	1.6.5	G												
			SD-10 Operation and Maintenance Data														
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			Network-Capable Control Devices	2.4.15	G												
			Disabled Ports, Connectors, and Interfaces	2.4.15.2	G												
			Evaluation Status of Hardware and Software	2.4.15.2	G												
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			Control System Account Management	2.4.15.4	G												
			Patch Management and Updates	2.4.15.9	G												
			Malware Detection and Protection	2.4.15.10	G												
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SECTION 21 12 00

STANDPIPE SYSTEMS
05/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C651	(2014) Standard for Disinfecting Water Mains

ASTM INTERNATIONAL (ASTM)

ASTM C1036	(2021) Standard Specification for Flat Glass

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	(2022; ERTA 1 2021) Standard for the Installation of Sprinkler Systems
NFPA 14	(2019; TIA 19-1) Standard for the Installation of Standpipes and Hose Systems
NFPA 24	(2022) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 72	(2022) National Fire Alarm and Signaling Code

UNDERWRITERS LABORATORIES (UL)

UL Fire Prot Dir (2012) Fire Protection Equipment Directory

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

Design and provide new] standpipe and fire sprinkler systems as shown.

1.4 SYSTEM DESCRIPTION

System design and manufacturer's products shall be in accordance with the required and advisory provisions of NFPA 14 except as modified herein. Standpipe system shall be designed by hydraulic calculations.Provide sprinkler portion of system under Section 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION. Each system shall include materials, accessories, and equipment inside and outside the building necessary to provide each system complete and ready for use. Devices and equipment shall be UL Fire Prot Dir listed or FM APP GUIDE approved for fire protection service. In the publications referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" shall be interpreted to mean the enity provided by the CO/COR.

1.4.1 Residual Pressure

The minimum residual pressure at the outlet of the most remote 64 mm hose connection shall be 65 psig while the system is discharging at the required design flow rates.

1.4.2 Friction Losses

Calculate losses in piping in accordance with the Hazen-Williams formula with 'C' value of 120 for steel piping, 150 for copper tubing, and 140 for cement-lined ductile-iron piping.

1.4.3 Water Supply

Base hydraulic calculations on a static pressure available at a residual pressure and flow obtained from the Base>>Post at the junction with the existing water distribution piping system. Base hydraulic calculations on operation of fire pumps provided in Section 21 30 00 FIRE PUMPS.

1.4.4 Standpipe System Drawings

Prepare in accordance with the requirements for "Plans and Specifications" as specified in NFPA 14. Each drawing shall be 34 by 22 inches. Plans shall be drawn to a scale not less than 1/8 inch scale Do not commence work until the design of each system and the various components have been approved. Show data essential for proper installation of each system. Show details, plan view, elevations, and sections of the systems supply and piping. Show piping schematic of systems supply, devices, valves, pipe, and fittings. Submit drawings signed by a registered fire protection engineer. Show:

a. Room, space or area layout and include pipe supports and hangers.

b. Field wiring diagrams showing locations of devices and points of connection and terminals used for all electrical field connections in the system, with wiring color code scheme.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

The fire protection engineer will review any approve all submittals in this section requiring Government approval.

SD-02 Shop Drawings

Standpipe System; G

SD-03 Product Data

Aboveground Pipe and Fittings; G

Mechanical Couplings; G

Pipe Hangers and Supports; G

Valves, including Gate, Check, and Hose; G

Fire Department Connections; G

Alarm Valves; G

Water Motor Alarms; G

Pressure Switch; G]

Waterflow Detector; G

Fire hose Cabinets; G

Valve Tamper Switch; G

Backflow Preventer; G

Buried Pipe and Fittings; G

Data which describes more than one type of item shall be clearly marked to indicate which type the Contractor intends to provide. Submit one original for each item and clear, legible, first-generation photocopies for the remainder of the specified copies. Incomplete or illegible photocopies will not be accepted. Partial submittals will not be accepted.

SD-06 Test Reports

Preliminary Tests; G

Acceptance Tests; G

Submit for all inspections and tests specified under paragraph entitled "Field Quality Control."

SD-07 Certificates

Qualifications of Installer; G

Submit installers qualifications as required under paragraph entitled "Qualifications of Installer."

SD-10 Operation and Maintenance Data

Alarm Valves, Data Package 3; G

Backflow Preventer, Data Package 3; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Furnish one complete package prior to the time that final acceptance tests are performed, and furnish the remaining before the contract is completed. Inscribe the following identification on the cover: the words OPERATION AND MAINTENANCE MANUAL, the location of the building, the name of the Contractor, system manufacturer and the contract number. The instructions shall be legible and easily read, with large sheets of drawings folded in. The package shall include: schematic drawings showing piping; circuit drawings; installation instructions; maintenance instructions; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts list.

SD-11 Closeout Submittals

System As-Built Drawings; G

1.6 QUALITY ASSURANCE

1.6.1 Qualifications of Installer

Prior to commencing work, submit data showing that the Contractor has successfully installed fire extinguishing standpipe systems of the same type and design as specified herein, or that he has a firm contractual agreement with a subcontractor having the required experience. Include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems. Indicate the type and design of each system, and certify that the system has performed satisfactorily for a period of at least 18 months.

Qualifications of System Technician: Installation drawings, shop drawing and as-built drawings shall be prepared, by or under the supervision of, an individual who is experienced with the types of works specified herein, and is currently certified by the National Institute for Certification in Engineering Technologies (NICET) as an engineering technician with minimum Level-III certification in Automatic Sprinkler System program. Contractor shall submit data for approval showing the name and certification of all involved individuals with such qualifications at or prior to submittal of drawings.

1.6.2 System As-Built Drawings

Upon completion, and before final acceptance of the work, submit a complete set of as-built drawings of each system. Submit 34 by 22 inch reproducible as-built drawings on mylar film with title block similar to full size contract drawings. Furnish as-built(record) working drawings in addition to the as-built drawings required by Division 1, "General Requirements."

1.7 DELIVERY, STORAGE AND HANDLING

Protect stored equipment from weather, humidity and temperature variations, dirt, dust, and other contaminants.

PART 2 PRODUCTS

2.1 ABOVEGROUND PIPING SYSTEMS

Provide fittings for changes in direction of piping and for connections. Make changes in piping sizes through tapered reducing pipe fittings; bushings will not be permitted. Perform welding in the shop; field welding will not be permitted. Conceal piping in areas with suspended ceiling.

2.1.1 Pipe and Fittings

NFPA 14, except as modified herein. Steel piping shall be Schedule 40 for sizes less than 8 inches, and Schedule 30 or 40 for sizes 8 inches and larger. Fittings shall be welded, threaded, or grooved-end type. Plain-end fittings with mechanical couplings and fittings which use steel gripping devices to bite into the pipe when pressure is applied will not be permitted. Rubber gasketed grooved-end pipe and fittings with mechanical couplings shall be permitted in pipe sizes 1.5 inches and larger. Fittings shall be UL Fire Prot Dir listed or FM APP GUIDE approved for use in dry wet pipe sprinkler systems. Fittings, mechanical couplings, and rubber gaskets shall be supplied by the same manufacturer. Steel piping with wall thickness less than Schedule 30 shall not be threaded. Side outlet tees using rubber gasketed fittings shall not be permitted. Pipe and fittings shall be metal.

2.1.2 Pipe Hangers and Supports

Provide in accordance with NFPA 14.

2.1.3 Valves

NFPA 14. Provide valves of types approved for fire service. Hose and gate valves shall open by counterclockwise rotation. Provide isolation and check valves as required by NFPA 14. Isolation valves shall be OS&Y type. Check valves shall be flanged clear opening swing-check type with flanged inspection and access cover plate for sizes 4 inches and larger.

2.1.3.1 Hose Valves

Provide bronze pressure regulating type hose valve with 2 1/2 inch National Standard male hose threads, and 2 1/2 inch NH female by 1 1/2 inch IPT male reducer with cap and chain. Equip valve with a device to regulate pressure at the outlet to a pressure not exceeding 100 psi under both flow and no-flow conditions.

2.1.4 Identification Signs

NFPA 14. Attach properly lettered and approved metal signs to each valve and alarm device.

2.1.5 Waterflow Test Connection

Provide test connections approximately 6 feet above the floor for each standpipe system or portion of each standpipe system equipped with an alarm device; locate downstream and adjacent to each alarm actuating device. Provide test connection piping to a location where the discharge will be readily visible and where water may be discharged without property damage. Discharge to janitor sinks or similar fixtures shall not be permitted. Provide discharge orifice equivalent to 1/2 inch sprinkler orifice. The penetration of the exterior wall shall be no greater than 2 feet above finished grade.

2.1.6 Main Drains

Provide separate drain piping to discharge at safe points outside each building or to sight cones attached to drains of adequate size to readily receive the full flow from each drain under maximum pressure. Provide auxiliary drains as required by NFPA 13 and NFPA 14.

2.1.7 Pipe Sleeves

Provide where piping passes entirely through walls, floors, roofs and partitions. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, floors, roofs and partitions. Provide one inch minimum clearance between exterior of piping and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of pipe sleeves or core-drilled holes with UL listed fill, void, or cavity material.

2.1.7.1 Sleeves in Masonry and Concrete Walls, Floors, and Roofs

Provide hot-dip galvanized steel, ductile-iron, or cast-iron sleeves. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth. Extend sleeves in floor slabs 3 inches above finished floors.

2.1.7.2 Sleeves in Partitions

Provide 26 gage galvanized steel sheet.

2.1.8 Escutcheon Plates

Provide one piece or split hinge type metal plates for piping passing through walls, floors, and ceilings in both exposed and concealed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces. Securely anchor plates in place.

2.1.9 Fire Department Connections

Provide connections approximately 3 feet above finish grade, of the approved two-way type with 2.5 inch National Standard female hose threads with plug, chain, and identifying fire department connection escutcheon plate.

2.1.10 Alarm Valves

Provide variable pressure type alarm valve complete with retarding chamber, alarm test valve, alarm shutoff valve, drain valve, pressure gages, accessories, and appurtenances for the proper operation of the system. The alarm shut-off valve in the piping between the alarm valve and the alarm pressure switch shall be a UL listed electrically supervised quarter-turn valve. Connection of switch shall be under Section 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE.

2.1.11 Water Motor Alarms

Provide alarms of the approved weatherproof and guarded type, to sound locally on the flow of water in each corresponding standpipe. Mount alarms on the outside of the outer walls of each building. Provide separate drain piping directly to exterior of building.

2.1.12 Pressure Switch

Provide switch with circuit opener or closer SPDT contacts for the automatic transmittal of an alarm over the facility fire alarm system. Connect into the building fire alarm system. Alarm actuating device shall have mechanical diaphragm controlled retard device adjustable from 10 to 60 seconds and shall instantly recycle.

2.1.13 Waterflow Detector

Provide vane-type waterflow detector. Provide detector with adjustable retard feature to prevent false alarms caused by momentary water surges. Connect into the building fire alarm system. Alarm actuating device shall have mechanical diaphragm controlled retard device adjustable from 10 to 60 seconds and shall instantly recycle. Provide detector at the base of each standpipe riser above main check valve in accordance with manufacturers instructions.

2.1.14 Fire Hose Cabinets

Provide recessed -mounted cabinets where indicated. Cabinets shall be prime grade, cold-rolled, reannealed, process-leveled, furniture steel. Fabricate cabinet from 20 gage steel and door and trim from 18 gage steel. Provide fully welded joints ground smooth. On each jamb, provide at least two anchors or reinforcements spaced approximately 24 inches apart for building in or attaching the cabinets to adjacent construction. Doors shall be flush hollow metal type with fully welded joints ground smooth and full glazed opening. Provide door with continuous hinge, latch and pull. Hinge door for 180 degree opening. Glass shall conform to ASTM C1036 and shall be Type II (flat wired glass), Class 1 (clear), Form 1 (wired, polished both sides), Quality q 8 (glazing quality), diamond or square wire mesh, 1/4 inch thick. Factory finish cabinet inside and out with one coat of enamel applied over a primer. Interior finish color shall be white. Exterior finish color shall match wall color. Fabricate cabinet with sufficient interior space to store one fire extinguisher.

2.1.15 Valve Tamper Switch

Provide valve tamper switch(es) to monitor the open position of valve(s) controlling water supply to the standpipe system. Switch contacts shall transfer from the normal (valve open) position to the off-normal (valve closed) position during the first two revolutions of the hand wheel or when the stem of the valve has moved not more than one-fifth of the distance from its normal position. Switch shall be tamper resistant. Removal of the cover shall cause switch to operate into the off-normal position.

2.1.16 Fire Pumps

Provide as specified in Section 21 30 00 FIRE PUMPS.

2.1.17 Backflow Preventer

Provide double check valve assembly backflow preventer with OS&Y gate valve on both ends. Each check valve shall have a drain. Backflow prevention assemblies shall have current "Certificate of Approval from the Foundation for Cross-Connection Control and Hydraulic Research, FCCCHR List. Listing of the specific make, model, design, and size in the FCCCHR List shall be acceptable as the required documentation."

2.2 BURIED PIPING SYSTEMS

2.2.1 Buried Pipe and Fittings

NFPA 24, outside coated, cement lined, ductile iron pipe and fittings for piping under the building and to a point 5 feet outside the building walls. Anchor the joints in accordance with NFPA 24 using pipe clamps and steel rods. Minimum pipe size shall be 6 inches. Minimum depth of cover shall be 4 feet. Piping more than 5 feet outside the building walls shall be provided under Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

2.2.2 Buried Utility Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.3 ELECTRICAL WORK

Provide electrical work associated with this section under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, except for fire alarm wiring. Provide fire alarm wiring and connection to fire alarm systems under this section in accordance with NFPA 70 and NFPA 72.

2.3.1 Wiring

Provide fire alarm wiring and connections to fire alarm systems, under this section and conforming to NFPA 70, and NFPA 72. Wire for 120 volt circuits shall be No. 12 AWG minimum solid conductor. Wire for low voltage DC circuits shall be No. 16 AWG minimum solid conductor. All wiring shall be color coded. Wiring, conduit and devices exposed to water or weather shall be weatherproof. Wiring, conduit and devices located in hazardous atmospheres, as defined by NFPA 70 , shall be explosion proof. All conduit shall be minimum 3/4 inch size. Identify circuit conductors within each enclosure where a tap, splice or termination is made. Identify conductors by plastic coated self sticking printed markers or by heat-shrink type sleeves. Attach the markers in a manner that will not permit accidental detachment.

PART 3 EXECUTION

3.1 EXCAVATION, BACKFILLING, AND COMPACTING

Provide under this section as specified in Section 31 00 00 EARTHWORK.

3.2 CONNECTIONS TO EXISTING WATER SUPPLY SYSTEMS

Connections to existing water supply system are specified in Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

3.3 STANDPIPE SYSTEM INSTALLATION

Equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the NFPA standards referenced herein. Install piping straight and true to bear evenly on hangers and supports. Conceal piping to the maximum extent possible. Piping shall be inspected, tested and approved before being concealed. Provide fittings for changes in direction of piping and for all connections Make changes in piping sizes through standard reducing pipe fittings; do not use bushings. Cut pipe accurately and work into place without springing or forcing. Ream pipe ends and free pipe and fittings from burrs. Clean with solvent to remove all varnish and cutting oil prior to assemble. Make screw joints with PTFE tape applied to male thread only.

3.4 DISINFECTION

Disinfect new water piping from the point of connection at the water main and existing water piping affected by the Contractor's operation in accordance with AWWA C651. Exercise caution when mixing chlorine disinfectant solutions. Fill piping systems with solution containing minimum of 50 parts per million of free available chlorine and allow solution to stand for a minimum of 24 hours. Flush solution from systems with clean water until maximum residual chlorine content is not greater than 0.2 parts per million. Obtain at least two consecutive satisfactory bacteriological samples from new water piping, analyze by a certified laboratory, and submit results prior to new water piping being placed into service.

3.5 FIELD PAINTING

Field painting of fire extinguishing standpipe system shall be specified in Section 09 90 00 PAINTS AND COATINGS. Field painting requirements for "Fire Extinguishing Sprinkler Systems" shall apply.

3.5.1 Piping Labels

Provide permanent labels in mechanical rooms, spaced at 20 foot maximum intervals along pipe, indicating "STANDPIPE."

3.6 ELECTRICAL WORK

Provide electrical work associated with this section under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, except for fire alarm wiring. Provide fire alarm wiring and connection to fire alarm systems under this section in accordance with NFPA 70 and NFPA 72.

3.6.1 Wiring

Provide fire alarm wiring and connections to fire alarm systems, under this section in accordance with NFPA 70, and NFPA 72. Provide wiring in rigid metal conduit or intermediate metal conduit, except electrical metallic tubing may be used in dry locations not enclosed in concrete or where not subject to mechanical damage. Do not run low voltage DC circuits in the same conduit with AC circuits.

3.7 FLUSHING

Flush the piping system with potable water in accordance with NFPA 14. Continue flushing operation until water is clear, but for not less than 10 minutes.

3.8 FIELD QUALITY CONTROL

Prior to initial operation, inspect equipment and piping systems for compliance with drawings, specifications, and manufacturer's submittals. Perform tests in the presence of the Contracting Officer to determine conformance with the specified requirements.

3.8.1 Preliminary Tests

Each piping system shall be hydrostatically tested at 200 psig in accordance with NFPA 14 and NFPA 24 and shall show no leakage or reduction in gauge pressure after 2 hours. The Contractor shall conduct complete preliminary tests, which shall encompass all aspects of system operation. Individually test alarms, and all other components and accessories to demonstrate proper functioning. Test water flow alarms by flowing water. When tests have been completed and all necessary corrections made, submit to the Contracting Officer a signed and dated certificate, similar to that specified in NFPA 13, attesting to the satisfactory completion of all testing and stating that the system is in operating condition. Also include a written request for a formal inspection and test.

3.8.2 Formal Inspection and Tests (Acceptance Tests)

The ,, Naval Facilities Engineering Command, Fire Protection Engineer, will witness formal tests and approve all systems before they are accepted. The system shall be considered ready for such testing only after all necessary preliminary tests have been made and all deficiencies found have been corrected to the satisfaction of the Contracting Officer and written certification to this effect is received by the Division Fire Protection Engineer. Submit the request for formal inspection at least 15 working days prior to the date the inspection is to take place. Experienced technicians regularly employed by the Contractor in the installation of both the mechanical and electrical portions of such systems shall be present during the inspection and shall conduct the testing. All instruments, personnel, appliances and equipment for testing shall be furnished by the Contractor. Contracting Officer and Base Fire Department All necessary tests encompassing all aspects of system operation shall be made including the following, and any deficiency found shall be corrected and the system retested at no cost to the Government.

3.8.2.1 Flow Test

Perform flow tests of each standpipe riser in accordance with NFPA 14. Affix 0-300 psi pressure gauges to lowest hose valve and next-to-highest hose valve. Connect lined, 2 1/2 inch diameter fire hose with underwriter's playpipe to highest hose valve and flow at least 250 gpm for 5 minutes from standpipe to a safe location outside the building. For dry pipe system, supply system through 2 1/2 inch fire hose connected to the nearest fire hydrant. Furnish hose, nozzles and fittings required for this test.

3.8.2.2 Alarm Testing

a. Each pressure switch, waterflow detector, and water motor gong shall be activated by flow of water.

b. Each valve tamper switch shall be activated by partially closing the associated control valve.

c. Alarm annunciation at the fire alarm control panel shall be verified.

d. Circuit supervision shall be demonstrated.

3.8.3 Additional Tests

When deficiencies, defects or malfunctions develop during the tests required, all further testing of the system shall be suspended until proper adjustments, corrections or revisions have been made to assure proper performance of the system. If these revisions require more than a nominal delay, the Contracting Officer shall be notified when the additional work has been completed, to arrange a new inspection and test of the system. All tests required shall be repeated prior to final acceptance, unless directed otherwise.

-- End of Section --

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SECTION 21 13 13

WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION
08/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.3 (2021) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.4 (2021) Gray Iron Threaded Fittings; Classes 125 and 250

ASME B16.18 (2021) Cast Copper Alloy Solder Joint Pressure Fittings

ASME B16.21 (2021) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.22 (2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.26 (2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1013 (2021) Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies

ASSE 1015 (2021) Performance Requirements for Double Check Backflow Prevention Assemblies

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4 (2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water

AWWA C110/A21.10 (2012) Ductile-Iron and Gray-Iron Fittings for Water

AWWA C111/A21.11 (2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

AWWA C203 (2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel

	and Tape - Hot-Applied
AWWA M14	(2015) Manual: Recommended Practice for Backflow Prevention and Cross-Connection Control

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A135/A135M	(2021) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INTELLIGENCE COMMUNITY STANDARD (ICS)

ICS 705-1	(2010) Physical and Technical Security Standard for Sensitive Compartmented Information Facilities

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	(2022; ERTA 1 2021) Standard for the Installation of Sprinkler Systems

NFPA 13R	(2022) Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies
NFPA 24	(2022) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 101	(2021) Life Safety Code
NFPA 291	(2022) Recommended Practice for Fire Flow Testing and Marking of Hydrants
NFPA 1963	(2019) Standard for Fire Hose Connections

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(2012) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Automatic Sprinkler System Layout

UNDERWRITERS LABORATORIES (UL)

UL 193	(2016) UL Standard for Safety Alarm Valves for Fire-Protection Service
UL 199	(2020) UL Standard for Safety Automatic Sprinklers for Fire-Protection Service
UL 262	(2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service
UL 312	(2022) UL Standard for Safety Check Valves for Fire-Protection Service
UL 405	(2013; Bul. 2020) UL Standard for Safety Fire Department Connection Devices
UL 668	(2004; Reprint Oct 2021) UL Standard for Safety Hose Valves for Fire-Protection Service
UL 789	(2004; Reprint May 2017) UL Standard for Safety Indicator Posts for Fire-Protection Service
UL 1626	(2008; Bul. 2018) UL Standard for Safety Residential Sprinklers for Fire-Protection Service
UL 1767	(3013; Bul. 2015) UL Standard for Safety Early-Suppression Fast-Response Sprinklers
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 SYSTEM DESCRIPTION

Provide wet pipe sprinkler system(s) in all areas of the building . Except as modified herein, the system must meet the requirements of NFPA 13 or NFPA 13R. Pipe sizes which are not indicated on the Contract drawings must be determined by hydraulic calculations.

1.2.1 Hydraulic Design

1.2.1.1 Basis for Calculations

Perform a fire hydrant flow test prior to shop drawing submittal in accordance with NFPA 291. Results must include hydrant elevations relative to the building and hydrant number/identifiers for the tested hydrants, including which were flowed, which had a gauge. This information must be presented in a tabular form if multiple hydrants were flowed. The results must be included with the hydraulic calculations. Hydraulic calculations must be based on flow test noted in this paragraph, unless Fire Protection Engineer and approved by Contracting Officer. Hydraulic calculations must be based upon the Hazen-Williams formula with a "C" value noted in NFPA 13 for piping, and 100 for existing underground piping. Hydraulic calculations must be based on operation of the fire pump(s) provided in Section 21 30 00 FIRE PUMPS. .

1.2.1.2 Hydraulic Calculations

a. Water supply curves and system requirements must be plotted on semi-logarithmic graph (N^1.85) paper so as to present a summary of the complete hydraulic calculation.

b. Provide a summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, minimum discharge pressures and minimum flows. Elevations of hydraulic reference points (nodes) must be indicated.

c. Documentation must identify each pipe individually and the nodes connected thereto. Indicate the diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient for each pipe.

d. Where the sprinkler system is supplied by interconnected risers, the sprinkler system must be hydraulically calculated using the hydraulically most demanding single riser. The calculations must not assume the simultaneous use of more than one riser.

e. All calculations must include the backflow preventer manufacturer's stated friction loss at the design flow or 8 psi for double check backflow preventer, whichever is greater.

f. All calculations must be performed back to the actual location of the flow test, taking into account the direction of flow in the service main at the test location.

g. For gridded systems, calculations must show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. A flow diagram indicating the quantity and direction of flows must be included.

1.2.1.3 Design Criteria

Hydraulically design the system to discharge a minimum density [of [_____] gpm/square foot over the hydraulically most demanding [_____] square feet of floor area][as indicated on the drawings]. Hydraulic calculations must be in accordance with the Area/Density Method of NFPA 13. Add an allowance for exterior hose streams of [_____] gpm to the sprinkler system demand [at the fire hydrant shown on the drawings closest to the point where the water service enters the building] [at the point of connection to the existing water system].[An allowance for interior hose stations of [_____] gpm must be added to the sprinkler system demand.]

1.2.2 Sprinkler Coverage

Sprinklers must be uniformly spaced on branch lines. Provide coverage throughout 100 percent of the building. This includes, but is not limited to, telephone rooms, electrical equipment rooms (regardless of the fire resistance rating of the enclosure), boiler rooms, switchgear rooms, transformer rooms, attached electrical vaults and other electrical and mechanical spaces. Coverage per sprinkler must be in accordance with NFPA 13. Provide sprinklers below all obstructions in accordance with NFPA 13. Exceptions are as follows:

a. Sprinklers may be omitted from small rooms which are exempted for specific occupancies in accordance with NFPA 101.

b. Facilities that are designed in accordance with NFPA 13R.

1.2.3 Qualified Fire Protection Engineer (QFPE)

An individual who is a licensed professional engineer (P.E.) who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience. Services of the QFPE must include:

a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification. Working (shop) drawings and calculations must be prepared by, or prepared under the immediate supervision of, the QFPE. The QFPE must affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting the shop drawings to the DFPE.

b. Provide a letter documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting all outstanding comments.

c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).

d. Witnessing pre-Government and final Government functional performance testing and performing a final installation review.

e. Signing applicable certificates under SD-07.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for

Contractor Quality Control approval. Partial submittals and submittals not fully complying with NFPA 13 and this specification section must be returned disapproved without review. SD-02, SD-03 and SD-05 must be submitted simultaneously.

Shop drawings (SD-02), product data (SD-03) and calculations (SD-05) must be prepared by the designer and combined and submitted as one complete package. The QFPE must review the SD-02/SD-03/SD-05 submittal package for completeness and compliance with the Contract provisions prior to submission to the Government. The QFPE must provide a Letter of Confirmation that they have reviewed the submittal package for compliance with the contract provisions. This letter must include their professional engineer stamp and signature. Partial submittals and submittals not reviewed by the QFPE must be returned disapproved without review.

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualified Fire Protection Engineer (QFPE); G

Sprinkler System Designer; G

Sprinkler System Installer; G

SD-02 Shop Drawings

Shop Drawing; G

SD-03 Product Data

Pipe; G

Fittings; G

Valves, including gate, check, butterfly, and globe; G

Alarm Valves; G

Relief Valves; G

Sprinklers; G

Pipe Hangers and Supports; G

Sprinkler Alarm Switch; G

Valve Supervisory (Tamper) Switch; G

Fire Department Connection; G

Backflow Prevention Assembly; G

Air Vent; G

Hose Valve; G

Seismic Bracing; G

Nameplates; G

SD-05 Design Data

Seismic Bracing; G

Load calculations for sizing of seismic bracing

Hydraulic Calculations; G

SD-06 Test Reports

Test Procedures; G

SD-07 Certificates

Verification of Compliant Installation; G

Request for Government Final Test; G

SD-10 Operation and Maintenance Data

Operating and Maintenance (O&M) Instructions; G

Spare Parts Data; G

SD-11 Closeout Submittals

As-built drawings

1.4 QUALITY ASSURANCE

1.4.1 Preconstruction Submittals

Within 36 days of contract award but no less than 14 days prior to commencing work on site, the prime Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications will be returned Disapproved Without Review.

1.4.1.1 Shop Drawing

4 copies of the shop drawings, no later than 28 days prior to the start of system installation. Working drawings conforming to the requirements prescribed in NFPA 13 and must be no smaller than ANSI D. Each set of drawings must include the following:

a. A descriptive index with drawings listed in sequence by number. A legend sheet identifying device symbols, nomenclature, and conventions used in the package.

b. Floor plans drawn to a scale not less than 1/8-inch equals 1-foot clearly showing locations of devices, equipment, risers, and other details required to clearly describe the proposed arrangement.

c. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross mains and branch lines to finished floor and roof or ceiling. A detail must show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.

d. Longitudinal and transverse building sections showing typical branch line and cross main pipe routing, elevation of each typical sprinkler above finished floor and elevation of "cloud" or false ceilings in relation to the building ceilings.

e. Plan and elevation views which establish that the equipment will fit the allotted spaces with clearance for installation and maintenance.

f. Riser layout drawings drawn to a scale of not less than 1/2-inch equals 1-foot to show details of each system component, clearances between each other and from other equipment and construction in the room.

g. Details of each type of riser assembly, pipe hanger, sway bracing for earthquake protection, and restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring. The dimension from the edge of vertical piping to the nearest adjacent wall(s) must be indicated on the drawings when vertical piping is located in stairs or other portions of the means of egress.

h. Details of each type of pipe hanger and related components.

i. Include fire pump curve with shop drawings and hydraulic calculations.

1.4.1.2 Product Data

4 copies of annotated catalog data to show the specific model, type, and size of each item. Catalog cuts must also indicate the NRTL listing. The data must be highlighted to show model, size, options, and other pertinent information, that are intended for consideration. Data must be adequate to demonstrate compliance with all contract requirements. Product data for all equipment must be combined into a single submittal.

1.4.1.3 Hydraulic Calculations

Calculations must be as outlined in NFPA 13 except that calculations must be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Include fire pump curve with submittal.

1.4.1.4 Operating and Maintenance (O&M) Instructions

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA as supplemented and modified by this specification section.

Provide six manuals and one pdf version on electronic media. The manuals must include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

Submit spare parts data for each different item of material and equipment specified. The data must include a complete list of parts and supplies, and a list of parts recommended by the manufacturer to be replaced after 1-year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied.

1.4.2 Qualifications

1.4.2.1 Sprinkler System Designer

The sprinkler system designer must be certified as a Level IV Technician by National Institute for Certification in Engineering Technologies (NICET) in the Water-Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7.

1.4.2.2 Sprinkler System Installer

The sprinkler system installer must be regularly engaged in the installation of the type and complexity of system specified in the contract documents, and must have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.4.3 Regulatory Requirements

Equipment and material must be listed or approved. Listed or approved, as used in this Section, means listed, labeled or approved by a Nationally Recognized Testing Laboratory (NRTL) such as UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of an item or equipment described must not be construed as waiving this requirement. All listings or approvals by testing laboratories must be from an existing ANSI or UL published standard. The recommended practices stated in the manufacturer's literature or documentation are mandatory requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and temperature variations, dirt and dust, or other contaminants. All pipes must be either capped or plugged until installed.

1.6 EXTRA MATERIALS

Spare sprinklers and wrench(es) must be provided as spare parts in accordance with NFPA 13.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials, equipment, and devices listed for fire protection service when so required by NFPA 13 or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for a classification of material. Material and equipment must be standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid.

2.1.2 Nameplates

Major components of equipment must have the manufacturer's name, address, type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new name plate permanently affixed to the item or equipment. Nameplates must be etched metal or plastic, permanently attached by screws to control units, panels or adjacent walls.

2.1.3 Identification and Marking

Pipe and fitting markings must include name or identifying symbol of manufacturer and nominal size. Pipe must be marked with ASTM designation. Valves and equipment markings must have name or identifying symbol of manufacturer, specific model number, nominal size, name of device, arrow indicating direction of flow, and position of installation (horizontal or vertical), except if valve can be installed in either position. Markings must be included on the body casting or on an etched or stamped metal nameplate permanently on the valve or cover plate.

2.1.4 Pressure Ratings

Valves, fittings, couplings, alarm switches, and similar devices must be rated for the maximum working pressures that can be experienced in the system, but in no case less than 175 psi.

2.2 UNDERGROUND PIPING COMPONENTS

2.2.1 Pipe

Pipe must comply with NFPA 24. Minimum pipe size is 6 inches. Piping more than 5 feet outside the building walls must comply with Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING. A continuous section of welded stainless steel fire water service piping from a point outside the building perimeter to a flanged fitting at least 1-foot above the finished floor within the building is acceptable.

2.2.2 Fittings and Gaskets

Fittings must be ductile-iron conforming to AWWA C110/A21.10 with cement mortar lining conforming to AWWA C104/A21.4. Gaskets must be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile-iron pipe joints must conform to AWWA C111/A21.11.

2.2.3 Gate Valve and Indicator Posts

Installation must comply with NFPA 24. Gate valves for use with indicator post must conform to UL 262. Indicator posts must conform to UL 789. Provide each indicator post with one coat of primer and two coats of red enamel paint.

2.2.4 Valve Boxes

Except where indicator posts are provided, for each buried valve, provide a cast-iron, ductile-iron, or plastic valve box of a suitable size. Plastic boxes must be constructed of acrylonitrile-butadiene-styrene (ABS) or inorganic fiber-reinforced black polyolefin. Provide cast-iron, ductile-iron, or plastic cover for valve box with the word "WATER" cast on the cover. The minimum box shaft diameter must be 5.25 inches. Coat cast-iron and ductile-iron boxes with bituminous paint applied to a minimum dry-film thickness of 10 mils.

2.2.5 Buried Utility Warning and Identification Tape

Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape must be detectable by an electronic detection instrument. Provide tape, 3 inches minimum width, color coded for the utility involved with warning and identification imprinted in bold block letters continuously and repeatedly over the entire tape length. Warning and identification must read "CAUTION BURIED WATER PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2.3 ABOVEGROUND PIPING COMPONENTS

2.3.1 Steel Piping Components

2.3.1.1 Steel Pipe

Except as modified herein, steel pipe must be black as permitted by NFPA 13 and conform to the applicable provisions of ASTM A53/A53M, ASTM A135/A135M or ASTM A153/A153M.

Steel pipe must be Schedule 40 only. Steel piping with wall thickness less than Schedule 40 must not be threaded. Grooved pipe must be cut-grooved.

2.3.1.2 Fittings

Fittings must be welded, threaded, or grooved-end type. Threaded fittings must be cast-iron conforming to ASME B16.4, malleable-iron conforming to ASME B16.3 or ductile-iron conforming to ASTM A536. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe, steel press fittings and field welded fittings are not permitted. Fittings, mechanical couplings, and rubber gaskets must be supplied by the same manufacturer. Threaded fittings must use Teflon tape or manufacturer's approved joint compound. Saddle tees using rubber gasketed fittings are permitted only when connecting to existing piping for additions or modifications. Saddle tees must use a connection method that completely wraps around the pipe. Reducing couplings are not permitted except as allowed by NFPA 13.

2.3.1.3 Grooved Mechanical Joints and Fittings

Joints and fittings must be designed for not less than 175 psi service and the product of the same manufacturer. Field welded fittings must not be used. Fitting and coupling housing must be malleable-iron conforming to ASTM A47/A47M, Grade 32510; ductile-iron conforming to ASTM A536, Grade 65-45-12. Rubber gasketed grooved-end pipe and fittings with mechanical couplings are permitted in pipe sizes 2 inches and larger. Gasket must be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts must be heat-treated steel conforming to ASTM A183 and must be cadmium-plated or zinc-electroplated.

2.3.1.4 Flanges

Flanges must conform to NFPA 13 and ASME B16.1. Gaskets must be non-asbestos compressed material in accordance with ASME B16.21, 1/16-inch thick, and full face or self-centering flat ring type.

2.3.2 Copper Tube Components

2.3.2.1 Copper Tube

Copper tube must conform to ASTM B88, Types L and M.

2.3.2.2 Copper Fittings and Joints

Cast copper alloy solder-joint pressure fittings must conform to ASME B16.18 and wrought copper and bronze solder-joint pressure fittings must conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy fittings for flared copper tube must conform to ASME B16.26 and ASTM B62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

2.3.3 Flexible Sprinkler Hose

The use of flexible hose is not permitted.

2.3.4 Pipe Hangers and Supports

Provide galvanized pipe hangers, supports and seismic bracingand supports in accordance with NFPA 13..

2.3.5 Valves

Provide valves of types approved for fire service. Valves must open by counterclockwise rotation.

2.3.5.1 Control Valve

Manually operated sprinkler control/gate valve must be outside stem and yoke (OS&Y) type and must be listed.

2.3.5.2 Check Valves

Check valves must comply with UL 312. Check valves 4 inches and larger must be of the swing type, have a clear waterway and meet the requirements of MSS SP-71, for Type 3 or 4. Inspection plate must be provided on valves larger than 6 inches.

2.3.5.3 Hose Valve

Valve must comply with UL 668.

2.3.6 AlarmRiser Check Valves

Provide variable pressure type alarm check valve, standard trim piping, pressure gauges, bypass, retarding chamber, testing valves, and main drain, and other components as required for a fully operational system. Alarm valves must comply with UL 193.

2.4 ALARM INITIATING AND SUPERVISORY DEVICES

2.4.1 Sprinkler Alarm Switch

Vane or pressure-type flow switch(es). . Vane type alarm actuating devices must have mechanical diaphragm controlled retard device adjustable from 10 to 60 seconds and must instantly recycle.

2.4.2 Valve Supervisory (Tamper) Switch

Switch must be integral to the control valve or suitable for mounting to the type of control valve to be supervised open. The switch must be tamper resistant and contain SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.5 BACKFLOW PREVENTION ASSEMBLY

Reduced-pressure principleDouble-check valve assembly backflow preventer complying with ASSE 1013, ASSE 1015 and AWWA M14. Each check valve must have a drain. Backflow prevention assemblies must have current "Certificate of Approval from the Foundation for Cross-Connection Control and Hydraulic Research, FCCCHR List" and be listed for fire protection use. Listing of the specific make, model, design, and size in the FCCCHR List is acceptable as the required documentation.

2.5.1 Backflow Preventer Test Connection

Test connection must consist of a series of listed hose valves with 2 1/2-inch National Standard male hose threads with cap and chain.

2.6 FIRE DEPARTMENT CONNECTION

Fire department connection must be projecting type with cast-brass body, matching wall escutcheon lettered "Auto Spkr" with a chromium-plated finish. The connection must have individual self-closing clappers, caps with drip drains and chains. Female inlets must have 2 1/2-inch diameter American National Fire Hose Connection Screw Threads (NH) per NFPA 1963 . Comply with UL 405.

2.7 SPRINKLERS

Sprinklers must comply with UL 199 and NFPA 13. Sprinklers with internal O-rings are not acceptable. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters must have temperature classification in accordance with NFPA 13. Extended coverage sprinklers are permitted for loading docks, residential occupancies and high-piled storage applications only.

2.7.1 Pendent Sprinkler

Pendent sprinkler must be quick-response type with nominal K-factor of [5.6][8.0][11.2][_____]. Pendent sprinklers must have a polished chrome finish. Assembly must include an integral escutcheon.

2.7.2 Upright Sprinkler

Upright sprinkler must be chrome-plated quick-response typeand have a nominal K-factor of [5.6][8.0][11.2][_____].

2.7.3 Sidewall Sprinkler

Sidewall sprinkler must be the quick-response type. Sidewall sprinkler must have a nominal K-factor of [5.6][8.0][11.2][_____]. Sidewall sprinkler must have a polished-chrome finish.

2.7.4 Residential Sprinkler

Residential sprinkler must be pendent and sidewall type with nominal K-factor of [4.2][5.6]. Residential sprinkler must have a polished-chrome finish. Sprinkler must comply with UL 1626.

2.7.5 Corrosion-Resistant Sprinkler

Corrosion-resistant sprinkler must be the upright or pendent type installed in locations as indicated. Corrosion-resistant coatings must be factory-applied by the sprinkler manufacturer.

2.7.6 Dry Sprinkler Assembly

Dry sprinkler assembly must be of the pendent sidewall or 45-degree type as indicated. Assembly must include an integral escutcheon. Maximum length must not exceed maximum indicated in its listing. Sprinkler must have a polished chrome finish.

2.7.7 Control Mode Specific Application Sprinkler

Control mode specific application sprinkler must be of the pendent type as indicated. Sprinkler must be specifically listed for high-piled storage only. Sprinkler must have a polished chrome finish.

2.7.8 ESFR Sprinkler

ESFR sprinkler must be pendent and comply with UL 1767. Nominal K-factor must be [_____].

2.7.9 Intermediate Level Rack Sprinkler

Intermediate level rack sprinkler must be of the pendent type with nominal K-factor of [5.6][8.0]. The sprinkler must be equipped with a deflector plate to shield the fusible element from water discharged above it.

2.8 ACCESSORIES

2.8.1 Sprinkler Cabinet

Provide spare sprinklers in accordance with NFPA 13 and must be placed in a suitable metal or plastic cabinet of sufficient size to accommodate all the spare sprinklers and wrenches in designated locations. Spare sprinklers must be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed as required by NFPA 13. At least one wrench of each type required must be provided.

2.8.2 Pendent Sprinkler Escutcheon

Escutcheon must be one-piece metallic type with a depth of less than 3/4-inch and suitable for installation on pendent sprinklers. The escutcheon must have a factory finish that matches the pendent sprinkler.

2.8.3 Pipe Escutcheon

Provide split hinge metal plates for piping entering walls, floors, and ceilings in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.8.4 Sprinkler Guard

Listed guard must be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards must be provided on sprinklers located within 7 feet of the floor or as indicated.

2.8.5 Relief Valve

Relief valves must be listed and installed at the riser in accordance with NFPA 13.

2.8.6 Air Vent

Air vents must be of the automatic type and piped to drain to the building exterior.

2.8.7 Identification Sign

Valve identification sign must be minimum 6 inches wide by 2 inches high with enamel baked finish on minimum 18 gage steel or 0.024-inch aluminum with red letters on a white background or white letters on red background. Wording of sign must include, but not be limited to "main drain", "auxiliary drain", "inspector's test", "alarm test", "alarm line", and similar wording as required to identify operational components. Where there is more than one sprinkler system, signage must include specific details as to the respective system.

PART 3 EXECUTION

3.1 VERIFYING ACTUAL FIELD CONDITIONS

Before commencing work, examine all adjoining work on which the contractor's work that is dependent for perfect workmanship according to the intent of this specification section, and report to the Contracting Officer's Representative a condition that prevents performance of first class work. No "waiver of responsibility" for incomplete, inadequate or defective adjoining work will be considered unless notice has been filed before submittal of a proposal.

3.2 INSTALLATION

The installation must be in accordance with the applicable provisions of NFPA 13, NFPA 24 and publications referenced therein. Locate sprinklers in a consistent pattern with ceiling grid, lights, and air supply diffusers. Install sprinkler system over and under ducts, piping and platforms when such equipment can negatively affect or disrupt the sprinkler discharge pattern and coverage.

a. Piping offsets, fittings, and other accessories required must be furnished to provide a complete installation and to eliminate interference with other construction.

b. Wherever the contractor's work interconnects with work of other trades the Contractor must coordinate with other Contractors to insure all Contractors have the information necessary so that they may properly install all necessary connections and equipment. Identify all work items needing access (dampers and similar equipment) that are concealed above hung ceilings by permanent color coded pins/tabs in the ceiling directly below the item.

c. Provide required supports and hangers for piping, conduit, and equipment so that loading will not exceed allowable loadings of structure. Submittal of a bid must be a deemed representation that the contractor submitting such bid has ascertained allowable loadings and has included in his estimates the costs associated in furnishing required supports.

3.2.1 Waste Removal

At the conclusion of each day's work, clean up and stockpile on site all waste, debris, and trash which may have accumulated during the day as a result of work by the contractor and of his presence on the job. Sidewalks and streets adjoining the property must be kept broom clean and free of waste, debris, trash and obstructions caused by work of the contractor, which will affect the condition and safety of streets, walks, utilities, and property.

3.3 UNDERGROUND PIPING INSTALLATION

The fire protection water main must be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover must be 3 feet or the frost line, whichever is deeper. The supply line must terminate inside the building with a flanged piece, the bottom of which must be set not less than 1-foot above the finished floor. A blind flange must be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block must be provided at the elbow where the pipe turns up toward the floor. In addition, joints must be anchored in accordance with NFPA 24. Buried steel components must be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 5 feet outside the building walls must meet the requirements of Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

3.4 ABOVEGROUND PIPING INSTALLATION

The methods of fabrication and installation of the aboveground piping must fully comply with the requirements and recommended practices of NFPA 13 and this specification section.

3.4.1 Protection of Piping Against Earthquake Damage

Seismic restraint is required.

3.4.2 Piping in Exposed Areas

Install exposed piping without diminishing exit access widths, corridors or equipment access. Exposed horizontal piping, including drain piping, must be installed to provide maximum headroom.

3.4.3 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping must be concealed above ceilings. Piping must be inspected, hydrostatically tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas must be concealed.

3.4.4 Pendent Sprinklers

a. Drop nipples to pendent sprinklers must consist of minimum 1-inch pipe with a reducing coupling into which the sprinkler must be threaded.

b. Where sprinklers are installed below suspended or dropped ceilings, drop nipples must be cut such that sprinkler ceiling plates or escutcheons are of a uniform depth throughout the finished space. The outlet of the reducing coupling must not extend below the underside of the ceiling.

c. Recessed pendent sprinklers must be installed such that the distance from the sprinkler deflector to the underside of the ceiling must not exceed the manufacturer's listed range and must be of uniform depth throughout the finished area.

d. Pendent sprinklers in suspended ceilings must be located in the center of the tile (plus or minus 2 inches).

e. Dry pendent sprinkler assemblies must be such that sprinkler ceiling plates or escutcheons are of the uniform depth throughout the finished space.

f. Dry pendent sprinklers must be of the required length to permit the sprinkler to be threaded directly into a branch line tee.

g. Where the maximum static or flowing pressure, whichever is greater at the sprinkler, applied other than through the fire department connection, exceeds 100 psi and a branch line above the ceiling supplies sprinklers in a pendent position below the ceiling, the cumulative horizontal length of an unsupported armover to a sprinkler or sprinkler drop must not exceed 12 inches for steel pipe and 6 inches for copper tube.

3.4.5 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers must contain no fittings between the branch line tee and the reducing coupling at the sprinkler.

3.4.6 Pipe Joints

Pipe joints must conform to NFPA 13, except as modified herein. Not more than four threads must show after joint is made up. Welded joints will be permitted, only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site. Flanged joints must be provided where indicated or required by NFPA 13. Grooved pipe and fittings must be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings, fittings and grooving tools must be products of the same manufacturer. For copper tubing, pipe and groove dimensions must comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field must be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe must be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances.

3.4.7 Reducers

Reductions in pipe sizes must be made with one-piece tapered reducing fittings. When standard fittings of the required size are not manufactured, single bushings of the face or hex type will be permitted. Where used, face bushings must be installed with the outer face flush with the face of the fitting opening being reduced. Bushings cannot be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 1/2-inch.

3.4.8 Pipe Penetrations

a. Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors must be core-drilled and provided with pipe sleeves. Each sleeve must be Schedule 40 galvanized steel, ductile-iron or cast-iron pipe and extend through its respective wall or floor and be cut flush with each wall surface. Sleeves must provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe must be firmly packed with mineral wool insulation.

b. Where pipes and sleeves penetrate fire walls, fire partitions, or floors, pipes/sleeves must be firestopped in accordance with Section 07 84 00 FIRESTOPPING.

c. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe must be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

d. All penetrations through the boundary of rooms/areas identified as secure space area must meet ICS 705-1.

3.4.9 Escutcheons

Escutcheons must be provided for pipe penetration in finished areas of ceilings, floors and walls. Escutcheons must be securely fastened to the pipe at surfaces through which piping passes.

3.4.10 Inspector's Test Connection

Unless otherwise indicated, the test connection must consist of 1-inch pipe connected at the riser as a combination test and drain valve; a test valve located approximately 7 feet above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test". All test connection piping must be inside of the building and penetrate the exterior wall at the location of the discharge orifice only. The discharge orifice must be located outside the building wall no more than 2 feet above finished grade, directed so as not to cause damage to adjacent construction or landscaping during full flow discharge, or to the sanitary sewer. Discharge to the exterior must not interfere with exiting from the facility. Water discharge or runoff must not cross the path of egress from the building. Do not discharge to the roof. Discharge to floor drains, janitor sinks or similar fixtures is not permitted.

Provide concrete splash blocks at all drain and inspector's test connection discharge locations if not discharging to a concrete surface. Splash blocks must be large enough to mitigate erosion and not become dislodged during a full flow of the drain. Ensure all discharged water drains away from the facility and does not cause property damage.

3.4.11 Backflow Preventer

Locate within the building or in a heated enclosure in locations subject to freezing. For heated enclosures, provide a low temperature supervisory alarm connected to the facility fire alarm system. Heat trace is not permitted to be used.

Install backflow preventers so that the bottom of the assembly is a minimum of 6 inches above the finished floor/grade. Install horizontal backflow preventers so that the bottom of the assembly is no greater than 24 inches above the finished floor/grade. Install vertical backflow preventers so that the upper operating handwheel is no more than 6 feet above the finished floor/grade. Clearance around control valve handles must be minimum 6 inches above grade/finished floor and away from walls.

3.4.11.1 Test Connection

Provide downstream of the backflow prevention assembly UL 668 hose valves with 2.5-inch National Standard male hose threads with cap and chain. Provide one valve for each 250 gpm of system demand or fraction thereof. Provide a permanent sign in accordance with paragraph entitled "Identification Signs" which reads, "Test Valve". Indicate location of test header. If an exterior connection, provide a control valve inside a heated mechanical room to prevent freezing.

3.4.12 Drains

a. Main drain piping must be provided to discharge at a safe point outside the building, no more than 2 feet above finished grade. Provide a concrete splash block at drain outlet. Discharge to the exterior must not interfere with exiting from the facility. Water discharge or runoff must not cross the path of egress from the building.

b. Auxiliary drains must be provided as required by NFPA 13. Auxiliary drains are permitted to discharge to a floor drain if the drain is sized to accommodate full flow (min 40 gpm). Discharge to service sinks or similar plumbing fixtures is not permitted.

3.4.13 Installation of Fire Department Connection

Connection must be mounted on the exterior wall approximately 3 feet above finished gradeadjacent to and on the sprinkler system side of the backflow preventer. The piping between the connection and the check valve must be provided with an automatic drip in accordance with NFPA 13 and piped to drain to the outside or a floor drain within the same room.

3.4.14 Identification Signs

Signs must be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Main drain test results must be etched into main drain identification sign. Hydraulic design data must be etched into the nameplates and permanently affixed to each sprinkler riser as specified in NFPA 13. Provide labeling on the surfaces of all feed and cross mains to show the pipe function (e.g., "Sprinkler System", "Fire Department Connection", "Standpipe") and normal valve position (e.g. "Normally Open", "Normally Closed"). For pipe sizes 4-inch and larger provide white painted stenciled letters and arrows, a minimum of 2 inches in height and visible from at least two sides when viewed from the floor. For pipe sizes less than 4-inch, provide white painted stenciled letters and arrows, a minimum of 0.75-inch in height and visible from the floor. Provide properly lettered and approved metal sign to elevator flow switch stating the circuits' voltage, and identify the switch as an "Elevator Power Shunt Flow Switch".

3.5 ELECTRICAL

Except as modified herein, electric equipment and wiring must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Alarm signal wiring connected to the building fire alarm control system must be by the fire alarm installer.

3.6 PAINTING

Color code mark piping redas specified in Section 09 90 00 PAINTS AND COATINGS.

3.7 FIELD QUALITY CONTROL

3.7.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level III or IV Fire Sprinkler Technician, and the representative of the installing company, and reviewed by the QFPE 60 days prior to performing system tests. Detailed test procedures must list all components of the installed system. Test procedures must include sequence of testing, time estimate for each test, and sample test data forms. The test data forms must be in a check-off format (pass/fail with space to add applicable test data; similar to the forms in NFPA 13). The test procedures and accompanying test data forms must be used for the pre-Government testing and the Government final testing.

a. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.7.2 Pre-Government Testing

3.7.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that equipment is functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" and "System Acceptance" as noted in NFPA 13. The Contractor and QFPE must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 13 and the test reports noted below.

a. NFPA 13 Aboveground Material and Test Certificate

b. NFPA 13 Underground Material and Test Certificate

3.7.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the Designated Fire Protection Engineer (DFPE) and the Contracting Officers (CO). Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Government final testing will not be performed until after the connections to the building fire alarm system and the installation fire alarm reporting system have been completed and tested to confirm communications are fully functional. Submit request for test at least 15 calendar days prior to the requested test date.

3.7.3 Correction of Deficiencies

If equipment was found to be defective or non-compliant with contract requirements, perform corrective actions and repeat the tests. Tests must be conducted and repeated if necessary until the system has been demonstrated to comply with all contract requirements.

3.7.4 Government Final Tests

The tests must be performed in accordance with the approved test procedures in the presence of the DFPE. Furnish instruments and personnel required for the tests. The following must be provided at the job site for Government Final Testing:

a. The manufacturer's technical representative.

b. The contractor's Qualified Fire Protection Engineer (QFPE).

c. Marked-up red line drawings of the system as actually installed.

Government Final Tests will be witnessed by the Base Fire Depsartment, Contracting Officer, Qualified Fire Protection Engineer (QFPE). At this time, all required tests noted in the paragraph "Minimum System Tests" must be repeated at their discretion.

3.8 MINIMUM SYSTEM TESTS

The system, including the underground water mains, and the aboveground piping and system components, must be tested to ensure that equipment and components function as intended. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure must be tested in accordance with NFPA 13 and NFPA 24.

3.8.1 Underground Piping

3.8.1.1 Flushing

Underground piping must be flushed at a minimum of 10 fps in accordance with NFPA 24.

3.8.1.2 Hydrostatic Test

New underground piping must be hydrostatically tested in accordance with NFPA 24.

3.8.2 Aboveground Piping

3.8.2.1 Hydrostatic Test

Aboveground piping must be hydrostatically tested in accordance with NFPA 13. There must be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure must be read from a gauge located at the low elevation point of the system or portion being tested.

3.8.2.2 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly must be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. The Contractor must provide all equipment and instruments necessary to conduct a complete forward flow test, including 2.5-inch diameter hoses, playpipe nozzles or flow diffusers, calibrated pressure gauges, and pitot tube gauge. The Contractor must provide all necessary supports to safely secure hoses and nozzles during the test. At the system demand flow, the pressure readings and pressure drop (friction loss) across the assembly must be recorded. A metal placard must be provided on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate determined during the preliminary testing. The pressure drop must be compared to the manufacturer's data and the readings observed during the final inspections and tests.

3.8.3 Main Drain Flow Test

Following flushing of the underground piping, a main drain test must be made to verify the adequacy of the water supply. Static and residual pressures must be recorded on the certificate specified in paragraph SUBMITTALS.

3.9 SYSTEM ACCEPTANCE

Following acceptance of the system, as-built drawings and O&M manuals must be delivered to the Contracting Officer for review and acceptance. Submit six sets of detailed as-built drawings. The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final acceptance test of the system. At least one set of as-built (marked-up) drawings must be provided at the time of, or prior to the final acceptance test.

a. Provide one set of full size paper as-built drawings and schematics. The drawings must be prepared electronically and sized no less than the contract drawings. Furnish one set of CDs or DVDs containing software back-up and CAD based drawings in latest version of AutoCAD, DXF and portable document formats of as-built drawings and schematics.

b. Provide operating and maintenance (O&M) instructions.

3.10 ONSITE TRAINING

Conduct a training course for the responding fire department and operating and maintenance personnel as designated by the Contracting Officer. Training must be performed on two separate days (to accommodate different shifts of Fire Department personnel) for a period of 4 hours of normal working time and must start after the system is functionally complete and after the final acceptance test. The on-site training must cover all of the items contained in the approved Operating and Maintenance Instructions.

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SECTION 21 13 25

HIGH-EXPANSION FOAM SYSTEM, FIRE PROTECTION
02/19, CHG 1: 02/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this section to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A449	(2014; R 2020) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM F436	(2011) Hardened Steel Washers

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61508	(2010) Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 11	(2021) Standard for Low-, Medium- and High- Expansion Foam
NFPA 13	(2022; ERTA 1 2021) Standard for the Installation of Sprinkler Systems
NFPA 20	(2022;TIA 21-1; TIA 21-2) Standard for the Installation of Stationary Pumps for Fire Protection
NFPA 24	(2022) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 72	(2022) National Fire Alarm and Signaling Code
NFPA 101	(2021) Life Safety Code
NFPA 170	(2021) Standard for Fire Safety and Emergency Symbols
NFPA 704	(2022) Standard System for the Identification of the Hazards of Materials for Emergency Response

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(2012) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Automatic Sprinkler System Layout

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 11	(2020) Surface Preparation Standard No. 11 - Power Tool Cleaning to Bare Metal

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 864	(2014; Reprint May 2020) UL Standard for Safety Control Units and Accessories for Fire Alarm Systems

1.2 SUMMARY

Design and provide a new automatic low-level high-expansion foam fire extinguishing system, including optical flame detection, control, and releasing system, as indicated on the drawings and in accordance with applicable codes and standards. The system(s) shall provide a uniform distribution of high-expansion foam solution for complete coverage over the protected area as indicated on drawings. The system(s) shall be balanced to operate both independently and with simultaneous operation of the overhead sprinkler system specified in Section 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION .

The electronic detection, control, and release system shall include wiring, raceways and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described.

The design, equipment, materials, installation, and workmanship shall comply with the NFPA 11, NFPA 13, NFPA 70, and NFPA 72, except as modified herein. Each system shall include all materials, accessories and equipment necessary so that it is complete and ready for use. Design and install each system to give full consideration to blind spaces, piping, electrical equipment, ductwork, and all other construction and equipment to provide complete coverage in accordance with the drawings to be submitted. Devices and equipment shall be listed by a Nationally Recognized Testing Laboratory unless otherwise specified. In the publications referred to herein, reference to the "authority having jurisdiction" shall be Air Force Civil Engineer Center Operations Directorate (AFCEC/CO) . Begin work at the point indicated.

Furnish piping offsets, fittings, and any other accessories as required to provide a complete installation and to eliminate interference with other construction. Design any portions of the system that are not indicated on the drawings, including locating and sizing piping and equipment when this information is not indicated on the drawings or is not specified herein. The design of the system shall be based on hydraulic calculations, and the other provisions specified herein.

The Contractor is responsible for the installation, testing, and acceptance testing of the High-Expansion Foam systems as required by this specification section and the plans. The contractor is also responsible for portions of the design per this specification section and the plans.

1.3 GENERAL DESIGN REQUIREMENTS

1.3.1 Definitions

Fire Area. A "fire area" is the aggregate floor area enclosed and bounded by fire walls, fire barriers, exterior walls or horizontal assemblies of a Facility. Areas of the Facility not provided with surrounding walls shall be included in the Fire Area if such areas are included within the horizontal projection of the roof or floor above.

Review Stamp. A "review stamp" certifies that the fire protection specialist has reviewed the documents and finds that it meets all contractual requirements. A "review stamp" is not a professional engineer stamp or seal.

1.3.2 Performance Requirements

Foam application shall be from foam generators by aeration specified herein and as indicated on the drawings.

Cover 90 percent of the aircraft's projected silhouette on the floor with high-expansion foam within 60 seconds upon system actuation (e.g. manual foam releasing station). For fixed winged aircraft, the areas under engines extending beyond the wing edge and under the rear elevators are not considered part of the silhouette. For rotary winged aircraft, the rotor sweep is considered part of the silhouette.

Additionally, cover the aircraft servicing area and adjacent floor areas not cut-off from the hangar bay (e.g. self-closing or automatically closing doors/shutters) with high-expansion foam to a depth of 3.2 ft. within four minutes.

Where more than one high expansion (Hi-Ex) foam system is present within a fire area, design the releasing system to only release the Hi-Ex foam system associated with the fire event. Such as where a hangar bay is subdivided by a non-rated wall into two bays with independent Hi-Ex foam systems or where a large hangar bay is provided with multiple Hi-Ex foam systems, zone the initiation devices to only release the Hi-Ex foam system associated with the fire event. However, design the fire flow and concentrate supply to allow for sufficient simultaneous operation of all Hi-Ex Foam Systems within the fire area.

1.3.3 Rate of Foam Discharge

The rate of discharge shall be as shown on the drawings.

1.3.4 Foam Concentrate Proportioning System

Foam proportioning shall be by a foam inductor taking suction from an atmospheric high-expansion foam concentrate storage tank located directly beneath/adjacent the inductor.

Provide a foam concentrate pumping system, with an atmospheric foam concentrate storage tank. Provide In-Line Balanced Pressure Proportioner Assembly (ILBP) that is listed.

1.3.5 Concentrate and Water Supply

System shall apply foam solution over the protected area for a minimum of 15 minutes while simultaneously discharging water through the overhead wet pipe sprinkler system specified inSection 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION . Reduction of the discharge duration based on a discharge rate higher than the specified minimum is not permitted.

A concentrate storage tank with a supply of concentrate to support a 15 minute discharge at the hydraulically calculated waterflow rate and 130 percent of the nominal concentrate injection rate shall be provided.

1.3.6 Activation

System activation shall be controlled by an addressable foam system control panel listed for releasing service.

The following will release the low-level high-expansion foam systems:

a. Manual foam releasing stations located as shown on drawings. Provide manual foam releasing stations within each zone for the release of that zone.

a. Manual foam releasing stations located as shown on drawings. Zoned manual foam release stations are not permitted. Program the foam release stations to simultaneously release the foam/water discharge from all zones viewable from the foam release station.

b. The operation of one water flow switch simultaneous with one optical flame detector, or two simultaneous optical flame detectors. Actuation of the fire sprinkler system shall not activate the high-expansion foam system, unless an optical flame detector alarms simultaneously. The first automatic initiating device shall activate the general fire alarm, blue beacons, and report to the fire department. The second automatic initiating device shall activate the foam system, and report to the fire department.

b. The simultaneous operation of two optical flame detector in the hangar bay is required to automatically release the high-expansion foam. Actuation of the fire sprinkler system shall not activate the high-expansion foam system. The first optical flame detector shall activate the general fire alarm, the blue beacons, and report to the fire department. The second optical flame detector shall activate the foam system, and report to the fire department.

1.3.7 Hydraulic Calculations

Design of low-level high-expansion foam systems shall be by hydraulic calculations for uniform distribution of HIGH-EXPANSION FOAM solution over the protected area as defined on the drawings and shall conform to the NFPA standards listed above and to the requirements specified herein.

For systems supplied from a non-potable fire service water distribution system, hydraulic calculations shall begin at the fire water tank or reservoir.

For systems supplied from the potable water distribution hydraulic calculations shall begin at the point of connection to the existing distribution system piping.

Base hydraulic calculations on the operation of the minimum number of pumps running necessary to supply the high-expansion generators and the sprinkler design area. Pumps are specified under Section 21 30 00 FIRE PUMPS.

Hydraulically design the system as follows:

a. Calculations shall include pressure discharge graphs or tables showing pressure discharge relationship for foam generators. Design shall be such that operating pressure of foam solution nozzles is maintained between (the foam generator's manufacturer's minimum operating pressure plus 5 psig and the foam generators' maximum pressure minus10 psig during system discharge. Hydraulic calculations shall include the manufacturer’s minimum pressure drop across flow control valve for the features indicated. Include "Demand Calculations" and "Supply Calculations".

b. Provide a combined hydraulic demand calculation of the foam/water system based on the foam generator output, water flows, and pressure, and the most hydraulically demanding area of the sprinkler system in the hangar bay, as indicated on the drawings. Demonstrate the combined fire water demand calculation does not exceed the available fire water supply. Confirm that the resulting foam/water supply from this calculation does not exceed the quantity of foam concentrate shown on the plans.

Confirm that the foam/water demand does not exceed capacity of the foam concentrate pumps.

Provide a design that indicates the inductor's flow rate, inlet pressure, back pressure, and concentrate lift height for a near empty concentrate tank. Hydraulically calculate the back pressure for the inductor using the Hazen-Williams equation with a C-factor of a 100 for all piping downstream of the inductor.

c. Provide a Foam Spread/Coverage Calculations/diagram demonstrating the performance requirements to cover the aircraft silhouette are met within one minute. This calculation method does not remove the obligation to demonstrate system compliance during testing. Include the following parameters in determining the maximum foam spread after one minute:

1. Time for the FSCP to open the flow control valve after initiation.

2. Time for the foam/water reach the each generator based on the piping velocities in the hydraulic supply calculation.

3. Time for the foam to reach the floor of the hangar bay after discharging from the generator based on the height and orientation of each generator.

4. Time for the foam to spread across the floor based on the manufacturer's foam spread diagrams, or at a rate not to exceed 1 ft. /sec.

1.3.8 Flow Control Valves

Water flow through the foam concentrate proportioning system (ILBP proportioner) (inductor)and to the foam generator system shall be controlled by flow control valves. Flow control valves include control of the opening and closing speed of the valve, and provide pressure regulation to the discharge devices, and provide for remote closing of the valve from foam stop stations. Once activated, the system shall remain activated. However, foam flow will be interrupted/stopped momentarily by depressing and holding a manual foam stop station button which are placed on the hangar bay walls (and in corridors) as shown on the plans.

1.3.9 Foam Concentrate Pump and Foam Jockey Pump Control

Upon activation of the foam/water system, remote start the foam concentrate pump from the Foam System Control Panel (FSCP). Do not start the foam concentrate pump upon a drop in pressure. Upon depressing the manual foam stop station, stop the foam concentrate pump and the foam concentrate jockey pump to prevent excessive concentrate from being pumped into the foam solution piping. As long as the foam/water system is in alarm, releasing the manual foam stop station will restart the foam concentrate pump and foam concentrate jockey pump.

1.3.10 Manual Foam Stop Station Operation

Once depressed, and so long as the button is held down, design the system so the stop station prevents/stops discharge of the foam/water system regardless of whether or not the foam/water system was activated automatically or manually, and whether or not the activation occurs prior to or after the stop station is pressed and held. Program the stop stations to simultaneously stop the foam/water discharge from all zones viewable from the depressed stop station. Unless the FSCP has been reset and all activation alarms (manual and automatic) have been cleared; restore the foam/water system operation when the foam stop station button is released. Do not exceed 15 seconds to fully close the flow control valve (and stop the foam concentrate pump and foam concentrate jockey pump) when the foam stop station button is depressed under full flow. Where the foam/water system is still in alarm, do not exceed 5 seconds to fully open the flow control valve upon release of the foam stop station button.

1.3.11 Hose System

Hose systems including hose reels shall not be provided.

1.3.12 System Hydraulic Surge Analysis

Manufacturer's calculations are required for determining the minimum surge arrestor capacities where the following distances are exceeded from the fire pump discharge to the most remote dry-pipe, pre-action, or foam/water riser. Include the surge arrestor calculations performed by the manufacturer in the design calculations.

a. 1,500 feet for a system not exceeding a working pressure of 175 psi.

b. 1,000 feet for a system not exceeding a working pressure of 250 psi.

c. 500 feet for a system not exceeding a working pressure of 175 psi, and plastic piping is used (e.g. PVC, HDPE).

d. 300 feet for a system not exceeding a working pressure of 250 psi, and plastic piping is used (e.g. PVC, HDPE).

A surge protection analysis shall study the entire fire suppression system, including the foam water system, sprinkler system, site piping, fire pumps, and reservoirs using commercially available software. The study shall determine the pressure surges or water hammer due to pump starting and stopping, valves opening and closing, and foam water initially reaching the foam generators. The study shall consider fire water pumps starting when foam system is activated. The study shall be performed under the supervision of and certified by the Fire Protection Specialist.

1.3.13 Controls to Activate Diverter Valve

Trench Drainage Diverter Valve Controls. Design and install controls to activate diverter valve in site sanitary drainage system. This valve diverts hangar bay trench drain flow to the underground containment tank when the foam system is activated. In normal operation (when the foam system is not activated) trench drain flow is through the oil water separator to the waste water treatment plant. Activation shall be initiated by the fire alarm system. See civil site plans for location of motorized diverter valve, which will be outside the hangar on the site.

1.3.14 Foam System Control

Provide a foam system alarm and control consisting of an addressable foam system control panel (FSCP), optical flame detectors, manual foam releasing stations, manual foam stop stations, signage panels, visual notification appliances, and miscellaneous appurtenances and circuit wiring in conduit, as required for a complete, operational, and fully functioning system. All components comprising the foam system alarm and control shall be sourced through the manufacturer of the FSCP and optical flame detectors (which is Det-tronics), to ensure compatibility.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval.

Shop drawings and calculations shall be prepared by the sprinkler system designer and reviewed by the fire protection specialist. The fire protection specialist must review the shop drawings, hydraulic calculations and material submittals. The shop drawings must bear the Review Stamp of the fire protection specialist.

Shop drawings, product data and calculations shall be developed under the supervision of the fire protection specialist. The fire protection specialist shall place their registered professional engineer stamp on all drawings and the cover sheet for the product data and calculations prior to submittal to the Government. Shop drawings and calculations shall be prepared by the fire protection specialist.

The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES .

The AFCEC/COSM fire protection engineer, Judy Biddle, judy.biddle.1@us.af.mil will review and approve all submittals in this section requiring Government approval.

SD-01 Preconstruction Submittals

OPTICAL FLAME DETECTOR AND FOAM/WATER DISCHARGE TESTING, SAFETY, AND ENVIRONMENTAL PLAN; G

Submit high-expansion foam solution containment and disposal plan as required under paragraph entitled "PRELIMINARY ACCEPTANCE TEST (PAT) AND FINAL ACCEPTANCE TEST (FAT) CHECKLIST FOR THE HIGH-EXPANSION FOAM SYSTEM."

SD-02 Shop Drawings

High-Expansion Foam Systems; G

Prepare shop drawings in accordance with the requirements for "Plans" as specified in NFPA 11, "Working Plans" as specified in NFPA 13, and "Shop Drawings" as specified in NFPA 72. Drawings shall be the same size as the contract drawings or minimum 24 by 36 inches. Unless otherwise noted, floor plans shall be drawn to a scale not less than 1/8" = 1'-0". Show data essential for proper installation of each system. Show details, plan view, elevations and sections of the systems supply and piping. Show piping schematic of systems supply, devices, valves, pipe and fittings. Show point to point electrical wiring diagrams. Submit drawings stamped by the Fire Protection Specialist.

Do not commence work until the design of each system and the various components have been approved. Show:

a. Room, space or area layout and include data essential to the proper installation of each system

b. Foam generators and system piping layout annotated with reference points for design calculations. Piping plan for high-expansion foam system incorporating that shown. Abbreviated presentation forms will not be accepted. Each type of fitting used and the locations of bushings, reducing couplings, and welded joints shall be identified. A separate plan shall be provided for each overhead sprinkler system and each foam system. Piping plan and isometric drawing of the concentrate system and details of all associated valves, fittings, and other components.

c. Field wiring diagrams showing locations of devices and points of connection and terminals used for all electrical field connections in the system, with wiring color code scheme

d. Optical flame detector manufacturer's recommended detector layout (plan view) including horizontal and vertical angles for correct aiming. Provide a plan with the cone-of-visions and respective aim points. Provide elevation showing cone-of-visions and respective aim points demonstrating that the cone-of-visions do not extend more than 5 feet outside the hangar doors.

e. A descriptive index with drawings listed in sequence by number. A legend sheet identifying device symbols, nomenclature, and conventions in accordance with symbols shown in NFPA 170 used in the package.

f. Shop drawings of each inductor. Shop drawings shall be accompanied with an inductor datasheet fully annotated with the flow rate, inlet pressure, back pressure, inlet K-factor, and outlet K-factor to which the inductor will be calibrated.

f. Piping plan and isometric drawing of the concentrate pumping system, ILBP proportioner, and details of all associated valves, fittings, and other components. Drawing shall incorporate that shown.

g. Location of control panels, detectors, manual foam start stations, manual foam stop stations, supervisory switches, solenoids, notification appliances, and other electrical devices. Incorporate that shown. In addition, conduit routing and sizes, and the number of conductors contained in each shall be indicated.

h. Longitudinal and transverse building sections showing typical pipe routing and elevation above finished floor.

i. Equipment room layout drawings drawn to a scale of not less than 1/2 inch equals 1 foot to show details of each system component, clearances between each other and from other equipment and construction in the room.

j. Details of all components required for support of the sprinkler piping from the building structural system, including hangers and bracing, and details of all connections to the components of the metal building system. Provide plans, elevation drawings, and details as required to fully convey the clearances required for the floor and wall penetrations.

k. Connection drawings and control diagrams indicating overall operation of the high-expansion foam system. This shall include identification and operation of each major component of the system. Diagrams shall be supplemented with a narrative description of the system. Indicate foam system control panel, make and model of devices and equipment to which the system is connected.

l. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems which are supervised or controlled by the system. Diagrams shall show connections from field devices to the Foam System Control Panel (FSCP) and remote foam system control units, initiating circuits, switches, relays and terminals.

m. Field wiring diagrams showing locations of devices and points of connection and terminals used for all electrical field connections in the system, with wiring color code scheme

n. Interfacing with fire suppression control components shall be clearly indicated on drawings.

o. Details of each foam generator and mounting details, High-Expansion foam system control valve header and related components.

SD-03 Product Data

Pipe, Fittings and Couplings; G

Valves, including gate, check, and globe; G

Pipe hangers and supports; G

Waterflow Pressure Alarm Switch; G

Surge Arresters; G

Foam System Control Panel (FSCP); G

Battery Chargers; G

Batteries; G

Annunciator Panel; G

FOAM SYSTEM BEACONS; G

Battery Chargers; G

Manual Foam Releasing Stations; G

Manual Foam Stop Stations; G

Manual Foam Stop Station Operation; G

Optical Flame Detectors and Controller; G

In-Line Balanced Pressure Proportioner Assembly; G

FOAM GENERATORS; G

Sway Bracing; G

Water Tight Junction Boxes; G

Foam/Water Flow Control ValvesG

Strainer; G

Foam Concentrate; G

CONCENTRATE STORAGE TANK; G

Foam System Control Panel (FSCP); G

Containment Tank Remote Capacity Monitoring and Diverter Valve Panel - Army; G

Foam Concentrate Pump; G

Foam Concentrate Jockey Pump; G

FOAM/WATER PROPORTIONING BY ILBP PROPORTIONER; G

Trench Drainage Diverter Valve Controls; G

OPTICAL FLAME DETECTION SUPERVISED DISCONNECT IN HANGAR BAY; G

FOAM/WATER PROPORTIONING BY INDUCTOR; G

Surge Arresters; G

Manufacturer's catalog data for each separate piece of equipment proposed for use in the system. Data shall indicate the name of the manufacturer of each item of equipment, with data highlighted to indicate, for instance model, size, and options, proposed for installation. In addition, a complete equipment list with equipment description, model number, and quantity shall be provided.

Spare Parts; G

Spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

Foam Systems; G

A copy of the proposed diagrams and instructions for the overall foam system, prior to posting.

Sprinkler System Designer; G

Fire Protection Specialist; G

The name and documentation of certification of the proposed Fire Protection Specialist and Sprinkler System Designer, no later than 14 days after the Notice to Proceed and prior to the submittal of the system drawings and hydraulic calculations.

Installer's Qualifications; G

Data approved, prior to submittal of any other data or drawings, to substantiate that the proposed installer is regularly engaged in the installation of the type and complexity of fire protection system included in this project. Data shall identify the location of three systems recently installed by the proposed installer which are comparable to the system specified. Contractor shall certify that each system has performed satisfactorily, in the manner intended, for a period of not less than 6 months.

Post-discharge Test Requirements; G

Details of method proposed for post-discharge testing.

SD-05 Design Data

Standby Battery Power requirements calculations; G

Substantiating standby power calculations showing battery capacity, supervisory and alarm power requirements.

Provide complete battery calculations for both the alarm and supervisory power requirements. Ampere hour requirements for each system component shall be submitted with the calculations.

System hydraulic surge analysis; G

System hydraulic transit (surge) analysis showing hydraulic transit pressure occurring throughout the system at both design flow and non-flow conditions.

Flow Test Data; G

Hydraulic Calculations; G

Provide hydraulic calculations complying with the requirement of this section.

Foam Spread/Coverage Calculations; G

Seismic Calculations; G

Submit load calculations for sizing of sway bracing, for systems that are required to be protected against damage from earthquakes. Include the required features identified therein that are applicable to the specific piping system.

SD-06 Test Reports

Tests; G

Test Plan: Test plan shall be complete in describing what measurements are to be made and how they will be collected. Describe what tests are to be conducted, what data is to be collected, acceptable findings, corrective action for failure to meet acceptable findings, equipment required, personnel required, notification procedure for notifying contracting officer, list of manufacturers employees to assist, integration of test for sprinkler systems, fire pumps, high-expansion foam, and fire alarm systems. Verify that the fire pumps are adequate to support the fire protection systems.

Provide an initial test plan with test procedures prior to final acceptance test. Include the following information:
a. Schedule of tests for each day, Example: Day 1, Day 2, Day 3 .
b. List of tests.
c. Blank forms for recording test data for each test.
d. Test procedure for each test.
e. List of equipment required for each test.
f. Calibration certificate for testing equipment

Submit the preliminary acceptance test report to the Contracting Officer and AFCEC/COSM before requesting a Final Acceptance Test. Provide the complete preliminary acceptance test report, to include digital recording (video) of the preliminary test, a "Punch List" (list of deficiencies prepared at the completion of preliminary test) to AFCEC/COSM for review. AFCEC requires 10 working days to review a complete PAT report. After the review of the complete package is acceptable, AFCEC or their designated representative will be present for the Final Acceptance Testing. The FAT will be scheduled no sooner than two weeks after the acceptance of the complete PAT report.

Provide the Final Acceptance Test Report within 15 days after the completion of the Final Acceptance Test. Provide the final acceptance test report in booklet form showing field tests performed with the digital recording of the final test to document compliance with the specified performance criteria. Provide documentation of readings, test results, and indicate the final position of control valves. Include all required Final Acceptance Test NFPA forms. The Final Acceptance Test report shall include the resolution of punch list items developed during preliminary acceptance testing.

Reports for tests, as follows:

a. Reports as outlined in NFPA 13 documenting results of flushing and hydrostatic tests.

b. Trip tests of sprinkler system and foam deluge system.

c. Test report of foam concentrate proportioning system. Report shall include all pressure readings and settings of system components. Report shall include conductivity or refractive index readings for foam samples taken from the high-expansion foam proportioner. Report shall be signed by the factory-trained technical representative the foam concentrate manufacturer.

d. Test report of the foam system control panel and initiating and indicating devices. Report shall include a unique identifier for each device with an indication of test results. Report shall be signed by the factory-trained technician employed by the control panel manufacturer.

e. Digital recording of preliminary and final Hi-Ex foam discharge test.

f. Submit pressure discharge graphs or tables showing pressure discharge relationship for foam generators.

SD-07 Certificates

INSTALLER'S QUALIFICATIONS; G

Submit installer and systems technician qualifications as required under paragraph entitled Qualifications of Installer.

Materials and Equipment; G

Certificates from manufacturers to substantiate that components, equipment and material proposed for installation and use meet requirements as specified, concurrent with submittal of manufacturer's catalog data of equipment proposed for installation. Certificates shall be on a form for this purpose or on official letterhead of the manufacturer with specified information stated as required. Certificates shall be provided for the following:

a. Control panel. Certification that the foam system control panel is electrically compatible with the solenoid on the electrically-actuated automatic water control valve, and the solenoid is compatible with the electrically-actuated valve.Electronic solenoids used for release of the suppression system must be listed for use with both the Foam System Control Panel and the foam/water flow control valve.

b. Gaskets. Certification from the manufacturer and Fire Protection Specialist that gasket material is listed or approved for dry-pipe service on all foam/water solution piping.

c. Compliance with foam system control panel ground fault detection requirement.

SD-10 Operation and Maintenance Data

Foam System; G

Manuals in loose-leaf binder format and grouped by technical sections consisting of manufacturer's brochures, schematics, printed instructions, general operating procedures, and safety precautions. Manuals shall include a narrative description of the sequence or sequences of operation of the overall fire protection system and a separate description for each major subsystem. Information to be provided shall include specific settings for all adjustable valves. The manuals shall list routine maintenance procedures, possible breakdowns, and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout, and simplified wiring and control diagrams for the system as installed. The manuals shall include procedures and instructions pertaining to frequency of preventive maintenance, inspection, adjustment, lubrication and cleaning necessary to minimize corrective maintenance and repair.

SD-11 Closeout Submittals

As-built Drawings for the fire extinguishing system; G

Six copies, within 14 calendar days after successful completion of required testing. A separate set of approved submittal drawings of the overall system, marked up to indicate as-built conditions, shall be maintained on site. These drawings shall be maintained in a current condition at all times and shall be made available for review immediately upon request during normal working hours. Variations from the approved drawings, for whatever reason, including those occasioned by modifications, change orders, optional materials, and/or required for coordination between trades shall be indicated in sufficient detail to accurately reflect the as-built conditions.

1.5 SUBMITTAL PREPARER'S QUALIFICATIONS AND GENERAL RESPONSIBILITIES

1.5.1 Fire Protection Specialist

An individual who is a registered professional engineer (P.E.) who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience.

1.5.2 Sprinkler System Designer

The sprinkler system designer shall be certified as a Level [III] [IV] Technician by National Institute for Certification in Engineering Technologies (NICET) in the Water-Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7.

1.6 INSTALLER'S QUALIFICATIONS

Prior to commencing work, submit data showing that the Contractor has successfully installed automatic high-expansion foam fire extinguishing systems of the same type and design as specified herein, or that he has a firm contractual agreement with a subcontractor having the required experience. Include the names and locations of at least three installations where the Contractor, or the subcontractor referred to above, has installed such systems. Indicate the type and design of each system, and certify that the system has performed satisfactorily for a period of at least 18 months.

1.7 QUALITY ASSURANCE

1.7.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.7.2 Source Limitations

Obtain foam concentrate, proportioning system, foam generators, and major accessories through one manufacturer. All components shall be listed for use together as single system.

1.7.3 Code Compliance

1.8 SPARE PARTS

Provide six (6) complete sets of system keys. Keys shall be CAT 60 . Also, furnish 10 percent of each type of device below but no less than two:

a. Detectors (including optical flame detectors).

b. Notification appliances

c. Fuses required by the system.

d. Initiating devices(including Manual foam releasing station and stop stations.)

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR FIRE PROTECTION SERVICE

All equipment and material shall be listed, unless otherwise noted in this section. Listed, as used in this section, shall mean listed or approved by a Nationally Recognized Testing Laboratory (NRTL) as defined by OSHA.

2.2 NAMEPLATES

Major components of equipment shall have the manufacturer's name, address, type or style, and model or serial number on a plate permanently affixed to the item of equipment.

2.3 ABOVEGROUND PIPING SYSTEMS HANDLING WATER OR FOAM/WATER SOLUTION

2.3.1 General Requirements for Piping Handling Water or Foam/Water Solution

Galvanized piping is not permitted.

Pipe shall conform to ASTM A53/A53M. Pipe shall be marked as to the brand or name of the manufacturer, kind of pipe and the ASTM designation in accordance with the "Product Marking" provisions of the ASTM standard.

2.3.2 Piping Handling Water

Piping 2 inches and less shall be minimum schedule 40. Piping larger than 2 inches shall be minimum schedule 10.

2.3.3 Piping Handling Foam/Water Solution

Provide schedule 40 black steel foam/water solution piping.

Provide listed/approved gaskets for dry-pipe service on all foam/water solution piping.

2.3.4 General Fitting Requirements

Use of restriction orifices, reducing flanges, and plain-end fittings with mechanical couplings which utilize steel gripping devices to bite into the pipe when pressure is applied are not permitted.

Plain end fittings with mechanical couplings and fittings that use steel gripping devices to bite into the pipe are prohibited.

Saddle tees using rubber gasket fittings are not permitted.

Fittings, mechanical couplings, and rubber gaskets shall be from the same manufacturer.

2.3.5 Grooved Fittings and Couplings

Grooved fittings, couplings and bolts shall be provided by the same manufacturer. Fittings and couplings shall be malleable iron or ductile iron complying with ASTM A536. Couplings shall be of the rigid type except that flexible type will be provided where flexible joints are specifically required by NFPA 13. Coupling gaskets shall be Grade E (EPDM) approved for dry pipe fire protection service. Gasket shall be the flush type that fills the entire cavity between the coupling and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A183 and shall be cadmium plated or zinc electroplated.

2.3.6 Non-Grooved Fittings

Non-grooved fittings shall be threaded or flanged. Do not use fittings that couple plain-end pipe, welded sprinkler fittings or outlets for foam-water solution. Threaded fittings shall be cast iron or malleable iron.

2.3.7 Flanges and Gaskets

Flanges shall conform to NFPA 13. Flanges shall be the type that are welded or threaded to the pipe. Listed and approved grooved flange adapter fittings are also acceptable. Flange gaskets shall be full face type EPDM or other approved material. Gaskets shall be compatible with foam concentrate and to foam/water solution to which it will be exposed.

2.3.7.1 Bolts

Bolts shall be ASTM A449, Type 1 or 2. Bolts shall extend no less than three full threads beyond the nut with bolts tightened to the required torque.

2.3.7.2 Nuts

Nuts shall be ASTM A193/A193M, Grade 5.

2.3.7.3 Washers

Washers shall meet the requirements of ASTM F436. Flat circular washers shall be provided under all bolt heads and nuts.

2.3.8 Pipe Hangers

Hangers shall be suitable for the application, construction and size pipe involved.

2.3.9 Valves Affecting the Flow of Foam Solution or Concentrate Throughout the System

Unless otherwise indicated, valves shall be indicating type in accordance with NFPA 13.

Gate valves shall open by counterclockwise rotation.

2.3.9.1 Tamper Switches

Provide tamper switches to supervise in the normal position all foam system valves including foam generator isolation valves and drain valves.

2.3.9.2 Exception

Drain valves serving foam generators in aircraft hangars may be supervised by locking or sealing in the normal position as allowed by NFPA 11.

2.3.10 Check Valve

Check valves 4 inches and larger shall be flanged, swing type, cast or ductile iron body and cover, cast or ductile iron clapper with replaceable EPDM rubber facing. Valves shall be suitable for either vertical or horizontal mounting and equipped with a removable handhole cover. The direction of flow shall be indicated by an arrow cast in the valve body. The valve body shall include plugged pipe thread connections for a 2 inch drain.

2.3.11 Foam System Test Header

Provide a linear test header to meet the demand of the foam/water system.

The foam/water test system header and fire pump test header (when provided) may be combined. When a common test header is used, provide valving to permit independent testing of each foam/water riser and each fire pump.

Provide one 2-1/2 inch hose valve connection for each 375 gpm of flow, rounding up. Provide a control valve to isolate the test header from the remainder of the system.

Locate test header inside the aircraft servicing area within 20 ft. of an exterior door or directly outside the fire protection equipment room on an exterior wall. Locate test header to discharge effluent to a hard surface within 100 ft. hose lay.

In geographic locations having a 99.6 percent dry bulb temperature less than 32 degrees F per UFC 3-400-02 Engineering Weather Data, provide test header with automatic ball drip routed to the exterior.

2.3.12 Pressure and Vacuum Gauges

Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 3-1/2 inches in diameter with a range from 0 psig to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range. Gauge shall be liquid-filled type.

2.4 FOAM CONCENTRATE PIPING AND FITTINGS

2.4.1 Pipe

Pipe shall be schedule 40 stainless steel.

2.4.2 Fittings

Foam concentrate fittings shall be stainless steel. Fittings shall be of the same material as the pipe. Acceptable pipe joining methods are roll grooved fittings, welded joints and fittings, or flanged joints and fittings. If using welded joints and fittings, consideration must be given to the maintenance of the system and provide flanged joints at certain locations to allow for the ease of maintenance and equipment removal. Gasket material must be approved by the foam concentrate manufacturer.

2.4.3 Pipe Hangers

Hangers shall be listed or approved.

2.5 STRAINER

Provide strainer baskets with stainless steel mesh sized no greater than 1/4 inches.

Welded steel body fire main basket-type pipeline strainer. ASTM A53/A53M pipe and class 150 steel flanges.

The strainer shall be designed to permit removal of the strainer screen for replacement and repair without removing the body from the line. A flush outlet shall be provided with each strainer. Open screen area shall be at least 6 times greater than the nominal pipe size open area. Friction loss shall not exceed 1 PSI at design flow when tested with clean strainer screen and clean water.

2.6 FOAM/WATER FLOW CONTROL VALVES

Provide a flow control valve with remote resetting capability for each foam/water system. Provide flow control valve with automatic re-closing feature and adjustable speed control. For hydraulic calculations, include the manufacturer’s minimum pressure drop across flow control valve for the features indicated.

Arrange valve for manual release at the valve. Provide pressure gages and other appurtenances at the flow control valves as required by NFPA 13. All trim piping shall be brass with compatible fittings. Trim piping shall be factory configured and installed. Gaskets shall be made of EPDM. Valves shall be operated by a control system listed for releasing service and independent of the building fire alarm system. Valves located in electrical classified locations shall be listed for the classification of the area where located. Flow control valves shall include the following features as standard elements of the valve and trim package:

a. Solenoid valve shall be of the normally closed, de-energized type, which opens when energized upon receipt of an electrical signal from the releasing control panel to which it is connected. Solenoids used for release of the high-expansion foam must be listed for use with the foam system control panel and the foam/water control valve.

b. Flow control valves shall gradually open upon receipt of power from the foam system releasing panel and shall slowly close upon interruption of power. Speed control setting shall be such that valve closure occurs within 15 seconds after depression manual foam stop station, and will fully open the flow control valve within 5 seconds upon release of the manual stop station.

c. Provide field adjustable pressure reducing trim.

d. Pressure regulation shall maintain a constant pressure at the inductor and the discharge device (foam generator). Pressure deviation shall not exceed plus or minus 10 psig.

2.7 EMERGENCY FOAM/WATER SYSTEM SHUTDOWN

Provide sequential signage on the control valves for the emergency shutdown of the foam/water system. Locate these signs so they are readily visible near each valve used in the shutdown sequence.

Provide signs with white background and a minimum 1/2 inch wide blue border with red lettering not less than 1 inch high. At a minimum, provide each sign with the language "EMERGENCY FOAM SHUTDOWN PROCEDURE" and the order and action to be performed (e.g. "1 - CLOSE FOAM CONCENTRATE VALVE", "2 - CLOSE FOAM/WATER RISER CONTROL VALVE"). Continue the sequence as require for shutdown.

2.8 HIGH-EXPANSION FOAM LIQUID CONCENTRATE

Foam Concentrate

Concentrate shall be the product of one manufacturer that is listed or approved for use with the foam generator system, and shall not contain PFOS/PFOA components. Concentrate shall have a minimum 20-year shelf life. Manufacture date shall be no more than six months before ship date to site. Mixing of non-identical specification concentrate will not be permitted.

2.9 CONCENTRATE STORAGE TANK

Provide a vertical, closed cell double wall polyethylene concentrate storage tank compatible with the required concentrate. Enter the tank only through the top with no taps on the bottom or sides of the tank. There shall be no taps in the bottom or sides of the tank. Inductor dip tube shall enter through the top of the tank.

Provide a vertical, closed cell single wall polyethylene concentrate storage tank compatible with the required concentrate.

Provide a reverse float level gauge with minimum 50 gallon increments permanently marked on the tank or gauge. Indicate on the tank or gauge the empty, full, and minimum level required to operate the system. Do not include the inaccessible portion of concentrate at the bottom of the tank that cannot be accessed by the suction line, in the tank's capacity markings. Provide a closeable fill opening and pressure/vacuum vent assembly.

2.9.1 Tank Marking

Permanently label each tank with its capacity, concentrate manufacturer, and concentrate type and percentage of concentrate induction. The label shall specifically identify the required concentrate manufacturer's name, concentrate name, concentrate identifying product numbers/codes, concentrate manufacturer's contact information including process to obtain 24-hour concentrate re-supply. The label shall include a warning statement indicating only this specific concentrate is permitted to be used in this system.

Tank shall have a NFPA 704 diamond sign indicating Health = 1; flammability = 2; and instability = 0.

2.10 FOAM/WATER PROPORTIONING BY INDUCTOR

Foam proportioning shall be by a single foam inductor for each foam-water riser.

a. Tune the inductor specifically for the system required flow rate, inlet pressure, back pressure, concentrate type, proportioning ratio, and lift height of a near empty concentrate tank. Off the shelf pre-tuned generic model inductors are not permitted.

b. Design inductor to 115 percent of the nominal injection rate.

c. Size inductor for the exact orifice of foam/water pipe.

d. Fit concentrate suction line of the inductor with a low loss bronze or brass check valve assembly by the manufacturer that is included in the device's hydraulic design.

e. Potential manufacturers at the time of this publication include Fomtec, Skum, Matre Maskin, Wilson Foam, Ansul, Chemguard, and Delta Fire. Inductors from these manufacturers are approved.

2.11 FOAM/WATER PROPORTIONING BY ILBP PROPORTIONER

2.11.1 Foam Concentrate Pump

Foam concentrate pump shall be electric motor driven. Pump shall be a positive displacement rotary gear or vane type operating at a speed not greater than 1800 rpm. Pump capacity shall be as shown on the plans. Pump discharge pressure shall be as shown on the plans. Metallic pump components in contact with foam concentrate shall be of bronze or stainless steel construction. Each pump shall be furnished with suction strainer, relief valve, and suction and discharge gauges. Pump shall be mounted on a carbon steel base and shall have guards over couplings. Pump shall be direct-connected to electric motor with drip-proof enclosure. Motor size shall be as shown on plans.

Provide a reserve foam concentrate pump of equal capacity. Automatically operate the reserve pump upon failure of the primary pump. Arrange concentrate supply piping to meet the foam concentrate demand from either the primary or reserve foam pump.

2.11.2 Foam Concentrate Jockey Pump

Foam concentrate jockey pump shall be bronze construction, TEFC motor, horizontal close coupled regenerative turbine pump. Mechanical seal with stainless steel metal parts. Buna elastomers, ceramic seat, carbon washers. Stainless steel shaft or shaft sleeve. Vertically split pump casing, end suction. Motor shall prevent overloading at the highest head condition.

2.11.3 Pump Controller

Controller shall be a full Service Electric Fire Pump Controller, with NEMA 2 Enclosure. Controller shall be the automatic type and listed for fire pump service and shall be arranged for starting from the manual foam releasing stations or automatic fire detection system, and stopping from manual foam stop stations, all via signals from the Foam System Control Panel (FSCP). The controller shall monitor the status of the foam concentrate pump it controls(by voltage or other suitable means), and shall start the back-up foam pump upon failure of the primary foam pump. Controller shall be completely terminally wired, ready for field connections, and mounted in a NEMA Type 2 drip-proof enclosure arranged so that controller current carrying parts will not be less than 12 inches above the floor. The controller shall be equipped with an externally operable isolating switch which manually operates the motor circuit. Means shall be provided in the controller for measuring current for all motor circuit conductors. Controller shall monitor and provide individually displayed audible and visual alarms on the front panel for loss of a phase or line power, phase reversal, low foam concentrate level, and pump room temperature. Each alarm lamp shall be labeled with rigid etched plastic labels. The controller shall be equipped with the following:

a. Voltage surge arresters installed in accordance with NFPA 20.

b. The pressure switch for automatic starting of foam concentrate pump shall be disabled. The foam concentrate pump shall only start and stop from a signal from the Foam System Control Panel.

c. Thermostat switch with adjustable setting to monitor the pump room temperature and to provide an alarm when temperatures falls below 40 degrees F.

d. Terminals for remote monitoring of pump running, pump power supply trouble .

2.11.4 Power Supply

The source and arrangement of power supply to the pumps shall be as shown on the drawings and in accordance with NFPA 20.

2.11.5 In-Line Balanced Pressure Proportioner Assembly

Provide In-Line Balanced Pressure Proportioner Assembly (ILBP) that is factory assembled and tested by the manufacturer. Disassembly, reassembly, or modification of the ILBP by the installing contractor is prohibited.

The ILBP shall contain all necessary components including foam proportioner; pressure balancing spool valve; duplex gauge; control, drain and check valves; interconnecting brass pipe; and valve identification nameplates. The proportioner shall consist of a body, inlet nozzle, and metering orifice, all of which are corrosion resistant brass. Clearly marked on the proportioner shall be the flow direction arrow, as well as the type and percentage of concentrate the proportioner was designed. The metering orifice will be sized according to the type and percentage of concentrate used. The proportioner body shall be brass, bronze, or stainless steel. Balancing shall be accomplished through the use of a spool-type pressure balancing valve. This valve shall sense foam concentrate and water inlet pressures at the outer ends of a dumbbell-shaped piston and shall react to pressure changes by covering or uncovering the foam supply port to the proportioner. The balancing valve shall be of 83600 brass construction with a phosphor-bronze piston and Buna-N rubber O-rings and seals. The in-line balanced pressure proportioner shall be completely pressure tested by the manufacturer. Interconnecting foam concentrate piping shall be of brass construction. Pressure sensing hoses shall be Teflon® with stainless braid cover and permanently attached brass couplings. Valve nameplates shall be provided and shall specify valve function and normal operating position.

2.12 FOAM GENERATORS

Generator shall be capable of producing not less than 14,491 cubic feet of high expansion foam-water solution per minute.

Generator discharge characteristics shall not result in any foam solution being discharged on aircraft fuselage and wing components from direct impingement or misting. Generator operating pressure shall be such that high pressure fittings and system components shall not be used(except for upstream of the inductor).

Total nozzle obstruction shall not negatively impact the distribution system hydraulics or foam induction capabilities.

The foam generator shall be listed for use with the foam concentrate. The foam generator shall be powered by a water reaction motor. The water reaction motor shall provide both the screen wetting solution and the energy to drive the fan. The foam generator shall not require an outside power source, such as electricity. A stainless steel screen shall be provided for maximum reliability under fire conditions.

System shall be designed to provide at each generator the manufacturer's minimum operating pressure .

2.13 CONTROLS TO ACTIVATE DIVERTER VALVE - ARMY

Provide a Containment Tank Remote Capacity Monitoring and Diverter Valve Panel - Army. Provide monitoring panel with audible and visual (yellow strobe or beacon) alarms. Automatically activate audible and visual alarms when the capacity level exceeds 5 percent. Provide a silence switch for the audible alarm. Constantly illuminate visual alarms at the panel until the level condition is returned to normal.

Provide indication of the diverter valve position at the monitoring panel through the use of limit switches. Provide indication of when the valve is fully open or closed. Provide the valve with remote manual reset capability through a “Valve Position Restore” button. Provide the panel with a visual alarm (yellow strobe or beacon) that automatically illuminates when the valve position is "off normal" or "closed", and remains illuminated until valve is restored to the full normal "open" position. Install the diverter valve motorized operator above grade or list it for a submersible environment.

The containment system monitoring panel and diverter valve panel may be combined. At a minimum, provide NEMA 250 Type 4 panel(s).

Rate any devices, conduits, or electrical enclosures installed below grade or within the containment tank for prolonged submersion, minimum NEMA 250 Type 6P.

2.14 FOAM RELEASING SYSTEM

2.14.1 General

Provide a separate Fire Alarm Control Unit (FACU) and Foam System Control Panel (FSCP) for each building. Where multiple releasing systems are provided within a single building, they may be combined into a single FSCP. Combining the FACU and FSCP into a common control unit is not permitted.

Provide a FSCP for the control and release of the foam/water system. Design the system so the loss of a FACU or another FSCP does not prohibit the FSCP from functioning as intended. Do not connect the FSCP to other control unit through the use of a network cable. Communicate functionality between panels through addressable modules only. A common FSCP may control multiple releasing systems or agents.

Connect and supervise only initiating and notification devices used by the foam/water system. Release the foam/water system only by the initiating devices. Additional devices are not permitted to release the foam/water system.

2.14.2 Foam System Control Panel (FSCP)

The Foam System Control Panel (FSCP) shall be addressable and listed for "Releasing Device Service". Panel shall contain components and equipment required to provide the specified operational and supervisory functions of the system. Components shall be housed in a surface mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly factory assembled and wired unit. Panel shall include integral "power on," "alarm," and "trouble" lamps with annunciation of each alarm, supervisory and trouble signal. The panel shall have prominent rigid plastic or metal identification plates for zones, indicating lights, controls, meters, and switches. Lamps and fuses mounted on circuit boards shall be identified by permanent markings on the circuit board. Nameplates for fuses shall also include ampere rating. Control panel switches shall be within the locked cabinet. A suitable means shall be provided for testing the control panel visual indicating devices (meter and lamps). Meters and lamps shall be plainly visible when the cabinet door is closed. An integral graphical annunciator shall be provided to indicate and annunciate, by zone, any alarm, supervisory or trouble condition on the system, including the optical detection system, by use of LED and LCD indication. Upon restoration of power, start-up shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals.

2.14.3 Foam System Control Panel (FSCP)

The Foam System Control Panel (FSCP) shall be Det-Tronics Eagle Quantum Premier Fire Detection/ Releasing System, and shall be furnished complete with minimum 60-node Safety Systems Software (S3) configuration/logic programming/diagnostic tools software package including USB dongle key and RS232 cable.

FSCP drawings must be provided by the manufacturer (Det-Tronics), and the contractor must provide funding to the manufacturer as required to provide these drawings.

FSCP alarm, supervisory, and trouble signal reporting to the Fire Alarm Control Panel shall be via discrete dry contact output points.

Modular type panel installed in a surface mounted NEMA Type 4 painted steel cabinet with hinged door and cylinder lock. All detectors shall be listed for use with that panel.

IR detectors shall be networked with the panel so that during commission IR detectors can be calibrated from the releasing panel.

The FSCP shall provide a real time display of current IR levels at any detector, have the ability to set the detector sensitivity for each detector from the panel, be able to download detector level log history, have remote test and diagnostics capability (manual self-test, lens dirty, sensor failure, power out of tolerance, device non-responsive), and remote setup and programming of detector options (lens heater power level, detector alarm LED function, alarm latching or non-latching, device address, sensitivity level, timing and gate count for alarm).

FSCP shall be electro-magnetic interference/radio frequency interference (EMI)/(RFI) tolerant at all frequenciesand rated to SIL level 2 capability (IEC 61508), a safety assessment evaluation which evaluates critical fault paths, redundancies, and statistical measurement/prediction to ensure a specific level of long term reliable performance and stability to co-exist with aircraft radar systems.

The control panel shall be a neat, compact, factory-wired assembly containing all parts and equipment required to provide specified operating and supervisory functions of the system. Panel cabinet shall be finished on the inside and outside with factory-applied enamel finish. Provide main annunciator located on the exterior of the cabinet door or visible through the cabinet door. Provide audible trouble signal. Provide prominent engraved rigid plastic or metal identification plates, or silk-screened labels attached to the rear face of the panel viewing window, for all lamps and switches. System power shall be 120 volts AC service, transformed through a two winding isolation transformer and rectified to 24 volts DC for operation of all system initiating, actuating, signal sounding, trouble signal and fire alarm tripping circuits. System shall be electrically supervised on all circuits. A ground fault condition or a single break in any circuit which prevents the required operation of the system shall result in the operation of the system trouble signal. Loss of AC power, a break in the standby battery power circuits, or abnormal AC power or low battery voltage shall result in the operation of the system trouble signals. The abnormal position of any system switch in the control panel shall result in the operation of the system trouble signals. Trouble signals shall operate continuously until the system has been restored to normal at the control panel. System trouble shall also be annunciated on the appropriate zone of the building fire alarm and mass notification control panel. The manual foam releasing stations, abort stations, optical flame detectors, and all associated wiring shall be connected to and supervised by the foam system control panel. Control panel shall be equipped with a NEMA Type 4 enclosure. System control panel shall be ULFM listed, approved, or type accredited for extinguishing system control (releasing device service). Permanently label all switches. Provide panel with the following switches:

a. Trouble silencing switch which transfers audible trouble signals (including remote trouble devices, if provided) to an indicating lamp. Upon correction of the trouble condition, audible signals will again sound until the switch is returned to its normal position, or the trouble signal circuit shall be automatically restored to normal upon correction of the trouble condition. The silencing switch may be a momentary action, self-resetting type.

b. Alarm silencing switch which when activated will silence all associated alarm devices without resetting the panel, and cause operation of system trouble signals.

c. Individual zone disconnect switches which when operated will disable only their respective initiating circuit and cause operation of the system and zone trouble signals.

d. Reset switch which when activated will restore the system to normal standby status after the cause of the alarm has been corrected, and all activated initiating devices reset.

e. Lamp test switch.

f. System release disable switch to disable the releasing functions of the panel while leaving all detection and other functions of the panel operational. Activation of this switch shall transmit a non-latching supervisory alarm signal to the building fire alarm control panel. Switch shall be provided within a lockable control panel.

2.14.4 Annunciator Panel

Provide integral with the main control panel. Supervision will not be required provided a fault in the annunciator circuits results only in loss of annunciation and will not affect the normal functional operation of the remainder of the system. Annunciator shall have an alpha-numeric display and provide the description of the device.

2.14.5 Primary Power Supply

Power to the control panel shall be as indicated. Panel shall be permanently marked "FOAM FIRE PROTECTION SYSTEM".

2.14.6 Secondary Power Supply

Provide for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power shall be automatic and shall not cause transmission of a false alarm.

2.14.6.1 Batteries

Provide sealed, maintenance-free, sealed lead acid batteries as the source for emergency power to the FSCP. Batteries shall contain suspended electrolyte. The battery system shall be maintained in a fully charged condition by means of a solid state battery charger. Provide an automatic transfer switch to transfer the load to the batteries in the event of the failure of primary power.

2.14.6.1.1 Capacity

Sufficient capacity to operate the FSCP under supervisory and trouble conditions, including audible trouble signal devices for 48 hours and under alarm conditions for an additional 15 minutes. Include full current draw of solenoid in battery calculations.

2.14.6.2 Battery Chargers

Provide a solid state, fully automatic, variable charging rate battery charger. The charger shall be capable of providing 120 percent of the connected system load and shall maintain the batteries at full charge. In the event the batteries are fully discharged (20.4 Volts dc), the charger shall recharge the batteries back to 95 percent of full charge within 48 hours after a single discharge cycle as described in paragraph CAPACITY above. Provide pilot light to indicate when batteries are manually placed on a high rate of charge as part of the unit assembly if a high rate switch is provided.

2.14.7 Optical Flame Detection Inhibit Switch

Provide a 2-position non-key operated switch located within the FSCP enclosure, that when activated disables the releasing function of all optical flame detectors in the hangar bay through programming at the FSCP. When the switch is placed in inhibit mode, only the releasing functions of the optical flame detectors are disabled while leaving all other functions of the FSCP operational. Monitor the inhibit switch at the FSCP. Provide a supervisory signal to the receiving station indicating the optical flame detectors are inhibited, a trouble signal is not permitted. Label the switch "INHIBIT OPTICAL FLAME DETECTION." Provide engraved labels on the inhibit switch indicating when the optical flame detectors are in "NORMAL" or "INHIBIT" mode.

2.15 ALARM

2.15.1 Fire Alarm

Provide equipment and interconnections for the automatic transmittal of an alarm over the building fire alarm system as specified in Section 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM. Arrange so that actuation of any alarm initiating device (OFD or manual foam releasing station), trouble and supervisory conditions shall cause activation of the fire alarm and reporting systems.

2.15.2 Waterflow Pressure Alarm Switch

Unit shall include a 1/2 inch NPT male pipe thread, two 1/2 inchconduit knockouts, and two sets of SPDT (Form C) contacts. The switches shall be factory adjusted to transfer the contacts at 4 to 8 psi on rising pressure. Unit shall include a water-tight NEMA 4 die-cast aluminum housing with a tamper resistant cover which requires a special key for removal. The cover shall be provided with a tamper switch which shall operate upon removal of the cover. Units used on wet-pipe systems shall have an adjustable, instantly recycling pneumatic retard to prevent false alarms due to water pressure variation. Retard adjustment shall be factory set at approximately 20-40 seconds and adjustable between 0-90 seconds.

2.16 CONTROL VALVE SUPERVISORY (TAMPER) SWITCH

Electrically supervise normally open control valves.

Tamper switches shall be UL listed as "Extinguishing System Attachment" for the location and type of valve supervised. The device shall contain double pole, double throw contacts. Operation of the switch shall cause a supervisory signal to be transmitted to the FACU upon not more than two complete turns of the valve wheel or a closure of 10 percent, whichever is less. Tamper switches shall be equipped with screw terminals for each conductor.

2.17 FOAM SYSTEM BEACONS

Blue rotating beacons will not be less than 400 cd (208/120VAC) powered from a dedicated emergency panel.

2.18 MANUAL FOAM RELEASING STATIONS

Manual Foam Releasing Stations shall be as shown on the plans, and shall be weatherproof.

Provide conventional manual foam releasing stations. Provide distinctively different NEMA 250 Type 4 manual foam releasing stations and signage from the manual fire alarm pull stations. Provide tamper cover with colored portions in yellow and lettering on the cover reading “FOAM”; the words “FIRE”, “ALARM”, or “AGENT” are prohibited to appear on the cover. Provide locking type manual foam releasing stations that when activated require a key to be reset.

Stations shall be of all metal construction and have a dual action release configuration to prevent accidental system discharge. Break-glass-front stations are not permitted. Station shall provide positive visible indication of operation. Restoration shall require use of a key.

2.19 MANUAL FOAM STOP STATIONS

Provide NEMA 250 Type 4 manual foam stop stations of the "dead-man" type. Provide manual foam stop stations with distinctive signage at each device. Provide a red mushroom type push button and include the word “PUSH”. Provide the colored portions of the tamper cover in blue and lettering on the cover stating “STOP”; the words “FIRE”, “ALARM”, or “AGENT” are prohibited to appear on the cover or station.

2.20 OPTICAL FLAME DETECTORS

Optical Flame Detectors and Controller:

Provide triple infrared (IR) optical flame detectors that are listed/approved for the expected fuel hazards in the hangar bay. Provide detectors that are immune to radar and radio frequency emissions from hand held equipment or equipment on-board the aircraft. Provide shielded circuiting for both the signaling line circuit (SLC) and power circuit from the optical detectors to the Foam System Control Panel (FSCP) and ground shielding in accordance with the optical flame detector manufacturer.

Optical flame detectors shall not alarm on non-fire sources, including but not limited to, arc welding, lightning, sunlight, radiant heaters, aircraft engine exhaust, hot surfaces, strobes, and beacons. Provide detectors that are immune to radar and radio frequency emissions.

The optical detection system shall be interfaced with the building fire alarm and reporting system, but shall not rely on it for operation.

The system shall provide continuous and automated detection, while monitoring system operation through continuous supervision of its inputs/outputs. The detectors shall include continuous automatic periodic self-testing and calibration during operation, including lens cleanliness check, and IR sensor testing and automatic calibration. The detector shall have manual testing capability of the lens and sensors, that is easily performed and verified at the detector, without disassembly of the detector. Each detector shall have an integral indicator lamp, visible from the hangar floor, indicating whether it is in alarm (red), fault (amber), normal (green) status.

2.20.1 Manufacturer of Optical Flame Detectors and Controller

Provide X3301 Multispectrum IR Flame Detectors manufactured by Det-Tronics. Provide Detectors with Hangar Mode as the factory default. Control and monitor optical flame detectors from a factory assembled Eagle Quantum Premier fire detection/releasing control unit manufactured by Det-Tronics. Detector lens heating option shall be set to zero. Use a medium setting

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Protection of System Against Earthquake Damage

Seismically protect the system against damage from earthquakes. Install the seismic protection of the system components and piping, including sway bracing as required, in accordance with UFC 3-301-01, NFPA 13 and Annex A.

Seismically brace foam/water solution piping regardless of geographic location. Base bracing calculations on an Ss of 0.95 or as indicated in the seismic analysis, whichever is greater.

3.1.2 Aboveground Piping

Piping shall be installed straight and bear evenly on hangers and supports. Piping shall be concealed in areas with suspended ceiling and shall be inspected, tested and approved before being concealed.

3.1.2.1 Joints

Pipe joints shall conform to NFPA 13. Not more than four threads shall show after joint is made up. Joint compound shall be applied to male threads only. Joints shall be faced true, provided with gaskets and made square and tight. Flanged joints or mechanical groove couplings shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published installation instructions. All grooved couplings and fittings shall be from the same manufacturer. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.1.2.2 Fittings

Use flanged or welded fittings to transition the fire protection water service entrance from horizontal to vertical as it enters the building. Do not use gasketed compression fittings (including locking type) or flanged fittings with set screws.

3.1.2.3 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 1/2 inch.

3.1.2.4 Valves

Provide an OS&Y valve beneath each flow control valve in each riser, when more than one valve is supplied from the same water supply pipe.

3.1.2.5 Pipe Supports and Hangers

Installation methods outlined in NFPA 13 are mandatory. Protection of piping and all foam equipment including foam tanks and generators against damage from earthquakes shall be provided. Longitudinal and lateral sway bracing shall be provided for piping.

3.1.2.6 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings is not permitted.

3.1.2.6.1 Escutcheon Plates

Escutcheons shall be provided at finished surfaces where exposed piping passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe and shall be chromium-plated iron or chromium-plated brass, either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.1.2.6.2 Pipe Sleeves

Pipes penetrating concrete or masonry walls or concrete floors shall be provided with pipe sleeves fitted into place at the time of construction through its respective wall or floor, and shall be cut flush with each surface. Sleeve sizes and clearance between pipe and sleeve shall be in accordance with NFPA 13. Provide not less than 1/4 inch space between exterior of piping and interior of sleeve. Firmly pack space with insulation and calk at both ends of the sleeve with plastic waterproof cement. ASTM A53/A53M, schedule 40 or standard weight, zinc-coated steel pipe sleeves. Extend sleeves in floor slabs 3 inches above the finished floor.

Where pipes pass through fire walls, fire partitions, or floors, a fire seal shall be placed between the pipe and sleeve in accordance with Section 07 84 00 FIRESTOPPING.

3.1.2.6.3 Sleeves in Partitions

Provide zinc-coated steel sheet having a nominal weight of not less than 0.90 pounds per square foot.

3.1.2.7 Drains

Main drain piping shall be provided to discharge at safe points outside each building. Drains shall be of adequate size to readily receive the full flow from each drain under maximum pressure. Auxiliary drains shall be provided as required by NFPA 13 except that drain valves shall be used where drain plugs are otherwise permitted. Where branch lines terminate at low points and form trapped sections, such branch lines shall be manifolded to a common drain line. Each drain valve shall be provided with a metal sign identifying the type of drain connection or function of the valve.

3.1.2.8 Identification Signs

Signs shall be in accordance with NFPA 13. Properly lettered and approved metal signs shall be suitably affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate. See drawings for additional sign requirements. Identification signs shall indicate Normally Open or Normally Closed as appropriate

3.1.3 Surge Arresters

At a minimum, provide the following surge arresters. Increase the minimum capacities listed below, when manufacturer's calculations are required and demonstrate a large capacity.

a. Provide 25 gal of capacity for each foam/water riser located on the riser manifold supplying a hangar bay.

b. For each riser room, combine the surge capacity of the risers in the room into a single common surge arrestor. Where risers feed different fire areas, only use the greatest combined surge capacity from one fire area. Connect this common surge arrestor to the riser manifold immediately upstream of the protected risers.

c. Coordinate with surge arresters required for sprinkler riser and any fire pumps

d. Where surge arresters are 100 gal or larger in capacity, provide floor stands.

Provide each arrestor with an indicating isolation valve to separate it from the system. Electrically supervise this valve in the normally open position. Provide a drain after the isolation valve to relieve pressure from the surge arrestor during testing and maintenance. When connecting the surge arrestor to the riser, the use of piping, fittings, and valving smaller than the connecting orifice on the surge arrestor is not permitted.

After the surge arrestor is installed and pressurized in the field with nitrogen per the manufacturer’s written directions, provide a permanent label indicating the set pressure of the arrestor. Do not pressurize the surge arrestor during hydrostatic testing of the system.

3.1.4 Foam/Water Flow Control Valves

Install the manual release for the flow control valve no higher than 5 ft. above finished floor. For hydraulic calculations, include the manufacturer’s minimum pressure drop across flow control valve for the features indicated.

Provide pressure gages and other appurtenances at the flow control valves as required by NFPA 13.

3.1.5 Isolation Valve and Strainer

Provide an isolation valve and basket strainer in the piping ahead of foam system risers.

3.1.6 Foam Concentrate Appurtenances

Provide a brass, bronze, or stainless steel full bore quarter turn ball valve with an electrically supervised tamper switch in the concentrate line. The use of automatically controlled valves in the concentrate line is prohibited. For testing purposes, equip the concentrate line with fittings and valving to accommodate the connection to an auxiliary tank of alternate test foam concentrate. Cap auxiliary tank connection at all times, except when testing.

Provide a 3/4 inch copper line with ball valve from the fire water supply, that is used for flushing the concentrate line after use. Provide sign with the following instructions, "Flush concentrate line after discharge or testing. Close concentrate tank shut-off valve prior to opening this valve. After flushing, drain concentrate line through test connection prior to re-opening concentrate tank shut-off valve.

3.2 ELECTRICAL WORK

Except as modified herein, electric equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Alarm signal wiring connected to the building fire alarm control system shall be in accordance with Section 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE. Wiring color code shall remain uniform throughout the system.

3.2.1 Panels and Component Installation

Where panels are located in normally occupied areas, provide recessed panels and combine miscellaneous components in common recessed enclosures to provide a clean installation. Where an auxiliary battery supply is required and cannot be recessed within the wall, locate it remotely in a normally unoccupied area.

Where panels, devices, and appliances are subjected to water spray/runoff under normal operating conditions, provide NEMA 250 Type 4 enclosures and water tight conduit. Regardless of environmental conditions, do not provide openings or conduit entry into the top of the FSCP.

3.2.2 System Wiring

Signaling line circuits circuits shall be Class B wiring, No. 18 AWG size conductors at a minimum. Notification appliance and initiating device circuits shall be No. 16 AWG size conductors at a minimum. Circuits operating at 24 VDC shall not operate at less than 21.6 volts. Circuits operating at any other voltage shall not have a voltage drop exceeding 10 percent of nominal voltage. Power wiring, operating at 120 VAC minimum, shall be No. 12 AWG solid copper having similar insulation. Run conduit or tubing concealed unless specifically shown otherwise on the drawings. All wiring shall be installed splice free. Pull a dedicated earth ground conductor on all runs and bond to enclosures, boxes, and field devices which have ground terminals. Color coding is required for circuits and shall be maintained throughout the circuit.

All conductors must be installed in conduit (EMT minimum).

Pull all conductors splice free; conductors shall be continuous from device to device. The use of wire nuts, crimped connectors, or twisting of conductors is prohibited.

Run all wiring to and within control panels in the vertical or horizontal plane, make all turns at 90 degree angles, and tightly bundle and wrap conductors.

Wiring may be solid copper or stranded as permitted by NFPA 70.

All devices must have screw terminals. Where devices are only provided with pigtails from the manufacturer, pigtails must be landed on terminal strips mounted within the junction box.

All terminations must be at a terminal strip or the device screw terminals. Terminal strips are only permitted where direct connection to a device is not possible.

3.2.3 Operating Power

Power shall be 120 volts AC service, transformed through a two winding isolation type transformer and rectified to 24 volts DC for operation of all signal initiating, signal sounding, trouble signal, and actuating (releasing) circuits. Provide secondary DC power supply for operation of system in the event of failure of the AC supply. Transfer from normal to emergency power or restoration from emergency to normal power shall be fully automatic and shall not cause transmission of a false alarm. Obtain AC operating power for control panel, and battery charger as indicated on the drawings.

3.2.4 Conductor Identification

Identify all conductors individually with permanent markings. Conductor markings shall be printed labels, permanently affixed to the conductor via shrink wrap.

All conduit, junction/back boxes, covers and couplings, when provided, must be factory painted red in unfinished areas (e.g., above ceilings, mechanical rooms).

All conduit, junction/back boxes, covers and couplings, when provided, are permitted to be painted to match the room finishing in finished areas. The inside cover of the junction box must be identified as "Fire Alarm" and the conduit must have painted red bands 3/4-in. wide at 20 feet intervals and on both sides of all floor, wall, and ceiling penetrations.

3.3 CONDUIT INSTALLATION

Flexible conduit is only permitted when connecting to the following devices and appliances. Devices located on fire suppression equipment such as flow/pressure switches, solenoids, and tamper switches. Devices and appliances located in removable ceiling tiles, and where flexible conduit is specifically noted in this UFC (e.g. optical flame detectors). Where flexible conduit is permitted, it is limited to 6 feet.

A maximum of two conduit penetrations are permitted into a secured area. Most areas only require one penetration.

3.3.1 Conduit and Enclosure Installation within the Hangar Bay

Provide NEMA 250 Type 4 wall mounted devices and appliances within the hangar bay (including backboxes). Provide watertight conduit and Water Tight Junction Boxes throughout the hangar bay.

Route conduit into the bottom of the backbox for manual foam releasing stations, stop stations, and flame detectors. Provide the low point of this conduit with a drain. Where the conduit is in a hazardously classified area, provide breathers in isolated portions of the conduit (e.g. sealed off from the remaining conduit system). Rate drains and breathers for the electrical (hazard) classification in which they are installed, but not be less than NEMA 250 Type 4.

3.4 SURGE PROTECTIVE DEVICES (SPD)

Provide SPDs to protect all power supply circuits to the FACU and FSCP, including any subpanels such as autonomous control units, amplifier panels, notification appliance circuit(NAC) booster panels. Provide SPD to protect all fire alarm circuits leaving or entering the building. Devices mounted on an exterior wall such as wall mounted exterior speakers do not require an SPD when lighting protection is provided on the building. Mount SPDs in a separate enclosure, unless the SPD is listed and installed in the control panel by the factory. Installing SPDs not listed with the panel is prohibited.

3.5 FOAM RELEASING SYSTEM

Install the FSCP in a location readily accessible to the emergency responders and maintenance personnel.

3.5.1 Battery Power Calculations

a. Verify that battery capacity exceeds supervisory and alarm power requirements.

1. Substantiate the battery calculations for alarm, alert, and supervisory power requirements. Include ampere-hour requirements for each system component and each panel component, and compliance with UL 864.

2. Provide complete battery calculations for both the alarm, alert, and supervisory power requirements. Include full current draw of solenoid in battery calculations. Submit ampere-hour requirements for each system component with the calculations.

3. A voltage drop calculation to indicate that sufficient voltage is available for proper operation of the system and all components, at the minimum rated voltage of the system operating on batteries.

b. For battery calculations use the following assumptions: Assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Calculate the nominal battery voltage after operation on batteries for the specified time period. Using this voltage perform a voltage drop calculation for circuit containing device and/or appliances remote from the power sources.

1. Include full current draw of solenoid in battery calculations.

3.5.2 FSCP Supervised Disconnect

Provide a key operated FSCP Supervised Disconnect switch to physically disable the solenoid for each foam/water and pre-action riser (if provided). Provide switch that disables the releasing functions without the use of programming, while leaving all other functions of the panel operational. Do not provide a trouble signal upon operation of the disconnect.

Locate the disconnect switch in the riser room, in a readily accessible location near the solenoid. Provide a sign near the disconnect switch with a white background and a minimum 1/2 inch wide blue border, with “DISABLE FOAM SYSTEM" or "DISABLE PRE-ACTION SYSTEM" in red lettering not less than 1 inch high. Provide engraved labels on the disconnect switch indicating when the system is "ENABLED" or "DISABLED". Do not install backboxes or route conduit in front of sign in a manner that obstructs any lettering.

3.6 VALVE SUPERVISION

Electrically supervise normally open control valves. This includes, but is not limited to, providing tamper switches on all manual valves in the foam concentrate system and in-line Balanced Pressure Proportioning System.

All valves which control alarm functions or the flow of water, foam, foam concentrate, or that when closed will disrupt the proper operation of a system shall be electronically supervised. This includes, but is not limited to, deluge valve alarm isolation valve, foam concentrate tank outlet line valve, foam concentrate tank water inlet valve, and water operated foam mixing valve pilot line valve.

Electrical or mechanical supervision is not required for normally closed control valves, unless opening the valve is detrimental to the system operation. When supervision is required on normally closed valves, provide electrical supervision.

Mechanically lock or provide tamper seals such as zip-ties on trim valves, that when opened or closed are detrimental to the operation of the foam/water system such as the shutoff for the foam system pressure switch. Provide signage indicating the valve’s normal operating position.

Mechanically lock or provide tamper seals such as zip-ties on drain or trim valving in the closed position, that when opened will cause the discharge of the foam/water system such as the manual release valve on the foam/water system riser. Provide this valve with the following signage, "OPENING THIS VALVE WILL RELEASE THE FOAM SYSTEM."

3.7 SUPERVISION AND SIGNAGE

Report supervisory alarms as independent addresses as indicated on the plans. Grouped switches on common addresses are not permitted. Provide non-latching electronically supervisory devices.

3.8 FOAM SYSTEM BEACONS

Provide blue visual alarm signals (rotating beacons) within the aircraft servicing area to indicate foam system activation as shown on the plans.

Control the beacon initiation through the FSCP. A backup power supply or supervision of the power supply supplying the beacons is not required when supplied from the dedicated emergency panel. Mount beacons 20 - 30 ft. above the floor of the hangar bay. Provide a sign next to each blue beacon with a yellow or lime-yellow background matching the manual foam releasing station signage, with "FOAM RELEASE WHEN ILLUMINATED" in red lettering not less than 3 inches high. Blue beacons are in addition to any general fire alarm notification such as the general fire alarm strobes.

For drive through hangars, provide one beacon 10 - 25 ft. from each corner of the hangar bay. Provide additional beacons where at least one beacon is not viewable from normally occupied areas of the hangar bay. Locate beacons to take into account building construction, aircraft configuration and positioning in the hangar bay.

3.9 FOAM GENERATOR INSTALLATION

Install Hi-Ex foam generators to provide a minimum 20 inches clearance in front of the generator inlet. The use of all-thread rod for supporting generators is not permitted.

Tap the generator foam/water supply piping with a valve to allow for the attachment of a pressure gauge or sampling hose during testing.

Locate Hi-Ex generators to discharge within close proximity, but not directly upon the aircraft. When mounting generators in the horizontal position, take into account the throw pattern of the Hi-Ex foam discharge. Do not locate the generator where the Hi-Ex foam discharge is obstructed (e.g. structural members) or in areas that obstruct service equipment (e.g. crane travel path). Use the initial discharge from the foam generators to protect under the aircraft fuselage and underwing area, prior to spreading to the remaining hangar bay floor area.

Do not provide generators in locations where the developing foam blanket will block exits from the hangar bay within the first minute of discharge.

Blocked exits are defined as an exit that is obstructed by a foam blanket exceeding 5 ft. in depth. In small hangar bays where the entire floor may be covered with foam within the first minute, provide generator locations so exits are one of the last areas blocked.

3.10 INDUCTOR INSTALLATION

Provide a single foam inductor per foam/water riser meeting the requirements outlined below. Where more than one foam inductor is used, they may take suction from a common concentrate tank. Do not supply more than one fire area from a single inductor.

Install inductor in the horizontal piping over the top of the concentrate tank. Provide the minimum straight pipe on both sides of the inductor in accordance with the manufacturer. Install these sections of piping free of elbows, tees, and reducers. Provide liquid filled gauges, located no closer than 2 ft. before and after the inductor.

3.11 IN-LINE BALANCED PRESSURE PROPORTIONER ASSEMBLY

Install ILBP proportioners downstream of the flow control valve, and ensure that the ILBP meets the manufacturer's recommendation with regards to horizontal or vertical installation.

3.12 FOAM RELEASING SYSTEM

Locate the FSCP, releasing modules, and monitor modules integral to the releasing and stopping of the foam/water system in a normally occupied conditioned space with the following parameters: temperature between 60 - 80 degrees F and a relative humidity of 85 percent at 86 degrees F. Do not install these components in the hangar bay.

Where panels are located in normally occupied areas, provide recessed panels and combine miscellaneous components in common recessed enclosures to provide a clean installation. Where an auxiliary battery supply is required and cannot be recessed within the wall, locate it remotely in a normally unoccupied area.

Where panels, devices, and appliances are subjected to water spray/runoff under normal operating conditions, provide NEMA 250 Type 4 enclosures and water tight conduit. Regardless of environmental conditions, do not provide openings or conduit entry into the top of the FSCP.

3.13 FOAM RELEASING SYSTEM

For the purposes of this contract, all Det-Tronics installation recommendations shall be considered as mandatory requirements. All devices shall be grounded in strict accordance with the Det-Tronics installation instructions. All circuit wiring shall be installed as part of shielded cable assemblies, in rigid galvanized steel conduit, and grounded in strict conformance with the Det-Tronics installation instructions.

3.14 MANUAL FOAM RELEASING STATIONS INSTALLATION

Install manual foam releasing stations within the hangar bay so they are unobstructed, readily accessible, and located within 10 ft. of each required exit or exit access from the hangar bay. Manual foam releasing stations are not required outside the hangar bay. Maintain a minimum separation distance of 5 ft. between general fire alarm pull stations (if provided) and the manual foam releasing stations. When located at required exit doors, install the foam releasing station and the fire alarm pull station on opposite sides of the door.

Provide low-level high-expansion manual foam releasing stations where shown. Stations shall be of a type not subject to operation by jarring or vibration. Mount station on signage panel as specified herein and detailed on drawings. Manual foam releasing stations shall be locking type that, when activated, require a key to be reset. Manual foam releasing stations shall be surface mount.

Where a manual foam releasing station is installed near an exit or exit access, install it on the opposite side of the door from the general fire alarm pull station, if provided.

Do not locate addressable monitor modules for the manual foam releasing stations in the hangar bay.

Protect foam releasing stations located in the hangar bay from mechanical damage. Provide a clear plastic tamper cover over the manual foam releasing station that when lifted emits an audible alarm. Exception: Audible alarm is not required where a manual foam releasing station is installed in a hazardous (classified) location.

Provide additional 1 inch high black block lettering on the sign indicating which zone is served by the manual foam releasing station.

3.15 MANUAL FOAM STOP STATIONS

Provide manual foam stop stations at each manual foam releasing station. Use stop stations in conjunction with valves and equipment that stop the discharge of foam/water from the suppression system. Do not locate addressable monitor modules for the manual foam stop stations in the hangar bay.

Protect manual foam stop stations located in the aircraft servicing area from mechanical damage. Provide a clear plastic tamper cover (without audible alarm) over the manual foam stop station.

3.16 MANUAL FOAM STOP STATIONS IN CORRIDORS

Provide a manual foam stop station in the corridor of each required exit from the hangar bay through the support space. Locate the station on the support side of the door, such that it is within 5 ft. of the door and not obstructed when the door is fully open. Provide a 100 sq. in. fire rated door vision panel in these doors, such that an occupant can view into the hangar bay while operating the manual foam stop station.

3.17 MANUAL FOAM RELEASING STATION AND STOP STATION SIGNAGE

Provide two separate but adjacent metal signs a minimum of 24 inches high by 20 inches wide. Provide no more than 12 inches of separation between the two signs. Do not use the words "FIRE", "ALARM", or "AGENT" on these signs. Do not install backboxes or route conduit in front of sign in a manner that obstructs any lettering.

Provide the sign for the manual foam releasing station with a yellow or lime-yellow background with “START FOAM SYSTEM” in red lettering not less than 3 inches high. Locate the manual foam releasing station with tamper cover on the lower portion of the sign. Provide the word “START” in minimum

1 inch high green lettering placed directly above the manual foam releasing station.

Provide the sign for the manual foam stop station with a white background and a minimum 1/2 inch wide blue border with “STOP FOAM SYSTEM” in blue lettering not less than 3 inches high. Locate the manual foam stop station with tamper cover on the lower left portion of the sign. Provide the word “STOP” in minimum 1 inch high red lettering placed directly above the manual foam stop station.

To the right of the stop button provide the following in minimum 1/2 inch high black lettering "To stop foam system, press and continuously hold STOP button until relieved by emergency responders. There may be up to a 30 second delay after pressing the STOP button before the foam stops."

3.18 OPTICAL FLAME DETECTION SUPERVISED DISCONNECT IN HANGAR BAY

Provide a key operated supervised disconnect switch to disable all optical flame detectors in the hangar bay. Provide a switch that disables the releasing and notification functions of the optical flame detectors, while leaving all other functions of the Foam System Control Panel (FSCP) operational. Operation of the switch will not create a trouble signal. Monitor the disconnect at the Foam System Control Panel (FSCP). Provide a supervisory signal to the receiving station upon operation of the disconnect. While the switch is in the disable mode, the optical flame detectors will not retain any history of alarm conditions such that when the switch is placed in the enable mode the FSCP will not immediately go into alarm.

Locate the disconnect switch in the hangar bay, in a readily accessible location near a manual foam stop station. Provide a NEMA 250 Type 4 switch and backbox or house the components in a NEMA 250 Type 4 enclosure. Provide a non-flashing or rotating red indicating light not less than 400 cd (208/120VAC) powered from a dedicated emergency panel. Control light initiation through the FSCP. A backup power supply or supervision of the power supply to the light is not required when supplied from the dedicated emergency panel. Mount the light above the disconnect switch. Provide a sign with a white background and a minimum 1/2 inch wide blue border, with "OPTICAL FLAME DETECTION DISABLED WHEN ILLUMINATED" in red lettering not less than 1 inch high. Provide engraved labels on the disconnect switch indicating when the optical flame detectors are "ENABLED" or "DISABLED". Do not install backboxes or route conduit in front of sign in a manner that obstructs any lettering.

3.19 OPTICAL FLAME DETECTOR INSTALLATION

Provide a sufficient number of optical flame detectors around the perimeter of the hangar bay, such that all portions of the hangar bay are within the range and cone-of-vision of at least three detectors. Exception: The area of the hangar bay within 5 ft. of the perimeter wall is not required to be within the cone-of-vision of an optical flame detector. No aircraft silhouette will be solely visible from optical flame detectors located on one side of the fuselage. A minimum of two optical flame detectors covering the aircraft silhouette are required on each side of the fuselage.

Provide flame detector installation shop drawings directly from the manufacturer.

Angle detectors and provide blinds (field of view inhibitors) so the cone-of-vision is contained within its designated suppression zone and does not extend more than 5 ft. outside the hangar bay, into another fire area such as through a normally open roll-up fire door, or is within the view of hot sources such as radiant heaters. Locate optical flame detectors at a sufficient distance per the manufacturer's recommendations from sources that may cause false alarms such as welding, solar glare, radiant heaters, aircraft engine exhaust, strobes, hot surfaces and other relevant sources.

Mount detectors in accordance with their listing at approximately 8 ft. above the finished floor of the hangar bay. Do not mount optical detectors in inaccessible locations. Provide optical flame detectors with 5 ft. of flexible conduit to allow for minor adjustments during testing or changes in the mission of the hangar bay.

At least three separate dedicated zones shall be provided for reporting the status of the optical detection system to the remote location. One dedicated zone for the first optical detector in alarm, a second dedicated zone for the second optical detector in alarm, and a third dedicated zone for a fault signal in the optical detections system.

Calibrate optical flame detectors to operate upon viewing the flame signature of the expected fuel(s) to be in the hangar bay. Use a 2 ft. x 2 ft. pool fire as the bases to set the sensitivity of the optical flame detectors. Upon the 2 ft. x 2 ft. pool fire reaching full development, all detectors within the cone-of-vision are required to activate within 30 seconds.

3.20 PIPE PAINTING AND LABELING

3.20.1 Painting

Paint all exposed, interior, black steel piping the same color as the walls and or ceiling, or a complementing color. Do not paint exposed interior fire protection piping red. Exposed piping in the fire protection equipment room and mechanical rooms may be left unpainted. Stainless steel piping may be cleaned and left unpainted.

Clean, prime, and paint new foam systems including valves, piping, conduit, hangers, miscellaneous metal work, and accessories. Clean the surfaces in accordance with SSPC SP 11. Immediately after cleaning, prime the metal surfaces with one coat of SSPC Paint 25 or SSPC Paint 25 primer applied to a minimum dry film thickness of 1.5 mils. Exercise care to avoid the painting of sprinklers and operating devices. Upon completion of painting, remove materials which were used to protect sprinklers and operating devices while painting is in process. Remove sprinklers and operating devices which have been inadvertently painted and provide new clean sprinklers and operating devices of the proper type. Finish primed surfaces as follows:

3.20.2 Pipe Identification,

Mark all exposed interior piping with plastic wrap around-type pipe labels conforming to ASME A13.1. Indicate the type of fluid carried and direction of flow. Labels that stick-on (adhesive backed) or are held on with straps/adhesive tape are not permitted. Labels are not required on any fire suppression system branch lines regardless of size, or mains and cross-mains less than a nominal 2-1/2 in. Labels are not required on piping routed below the floor line in trenches or pits. At a minimum, the following labels are required.

a. FIRE PROTECTION WATER - Used on dedicated potable and non-potable fire protection water supply piping.

b. FOAM CONCENTRATE - Used on foam concentrate piping.

c. FIRE SPRINKLER - Used on water-only sprinkler piping.

d. HIGH-EXPANSION FOAM - Used on Hi-Ex foam/water piping.

3.21 FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall inspect the system periodically during the installation to assure the system is being provided and installed in accordance with the contract requirements. The Fire Protection Specialist shall witness all the preliminary and final acceptance tests, and shall review and sign the test reports. After the preliminary acceptance testing has been completed, the Fire Protection Specialist shall certify in writing that the system is ready for the final acceptance inspections and tests. This report shall document any discrepancies found and what actions will be taken to correct. Any discrepancy noted during the periodic site visits or the preliminary testing shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.22 FACTORY AUTHORIZED PERSONNEL

Provide a factory authorized representative for the startup and/or testing of the following systems as outlined below:

a. Fire Pump System, as applicable (Start Up)

b. Fire Alarm and Mass Notification System (FACU/ACU) (Preliminary and Final Acceptance Testing)

c. Foam Proportioning, Foam Suppression, and Foam/Water Releasing System (FSCP) (Preliminary and Final Acceptance Testing). Provide the services of representatives or technicians from the manufacturers of the low-level high-expansion foam system and foam system control panel experienced in the installation and operation of the type of system being provided, to supervise installation, adjustment, preliminary testing, and final testing of the system and to provide instruction to Government personnel. The foam system control panel manufacturer shall provide a minimum of 4-days startup assistance.

d. Optical Flame Detection System (Preliminary and Final Acceptance Testing). The representative from the manufacturer of the optical flame detection system shall perform all programming on, and witness and certify acceptance testing (including witnessing pan fire tests on site), on the triple IR detection system. The manufacturer's representative, who programs, and certifies and witness the acceptance tests, shall submit qualifications to the government for approval.

3.23 OPTICAL FLAME DETECTOR AND FOAM/WATER DISCHARGE TESTING, SAFETY, AND ENVIRONMENTAL PLAN

The contractor shall prepare a plan for conducting the test, to include the duties of the test team members, as follows:

a. Who will perform the testing and who will be the onsite factory authorized representatives.

b. What are the safety precautions taken during testing. Provide a safety plan for conducting the test of the High-Expansion Foam system. The contractor shall remove any mobile / portable equipment from the hangar servicing area that is not needed for the test. Provide a sketch of safe egress path for persons conducting and witnessing the test to exit the building without entering the foam blanket. Obtain approval from the installation Safety Manager.

c. Describe how the foam/water system will be tested to demonstrate that the performance criteria is been met.

d. How will the event be recorded for future review.

e. What are the testing procedures to demonstrate the coordination and communication of the fire protection systems associated with the foam/water discharge.

f. Provide protection for the facility, including electrical and mechanical equipment exposed to possible damage during foam discharge tests. This shall include provision of sandbags or similar means for preventing migration of foam solution into adjacent areas. The contractor shall cover the hangar walls and surface mounted equipment with plastic sheeting from the finished floor to 20 feet above the finished floor. Doors into adjacent areas shall be protected to prevent foam-water solution leaking into the adjacent areas during the test and subsequent clean-up. The test and any re-test will begin with the system in normal configuration; no recharging of the system piping is allowed. Hangar doors will be closed and will remain closed until the hangar is released to the contractor's clean-up team.

g. How will the foam be captured during the discharge and disposed. Provide temporary measures to prevent high-expansion foam solution or high-expansion foam concentrate from entering storm drains, sanitary sewers, drainage ditches, streams and water courses. Do not allow high-expansion foam concentrate or solution to come in contact with earth. Contain all discharged HIGH-EXPANSION FOAM on paved surfaces. Collect all discharged high-expansion foam solution; all rinse and flushing water and dispose of it in an , State/EPA - approved industrial waste-water, ; installation industrial waste-water treatment facility which provides secondary (biological) treatment. Prior to the start of construction, submit written plan for high-expansion foam containment and disposal methods(s) to the Contracting Officer for approval.

   Temporary measures shall be provided to prevent foam solution from entering storm drains, sanitary sewers, drainage ditches, streams and other water sources. Discharged foam shall be contained on paved surfaces and shall not be allowed to come in contact with the earth.

h. The test, safety, and environmental plan shall be submitted and approved by the Contractor Officer.

i. The test plan shall be submitted and approved by the Fire Protection Specialist.

j. Obtain local, state or federal environmental permits as applicable.

k. Obtain approval from Base Environmental Engineer or Base Civil Engineer.

l. Obtain approval from the fire department.

m. Provide Hi-Ex Foam Disposal Plan and Procedures.

3.24 PRELIMINARY TESTING

Provide the following preliminary testing reports before performing acceptance testing for the foam fire suppression, foam releasing system, optical flame detection system, and fire alarm and mass notification systems.

Testing reports must have been reviewed and approved by the Contracting Officer and Fire Protection Specialist.

a. Contractor's Material and Testing Certificate for Underground Piping per NFPA 13 and NFPA 24. Provide photos of installation prior to burial.

b. Contractor's Material and Test Certificate for Aboveground Piping per NFPA 13 for each riser, manifold, and fire department connection.

c. Fire pump test report demonstrating compliance with NFPA 20 acceptance testing criteria. Where a concentrate pumping system is also provided, demonstrate compliance with NFPA 11 and NFPA 20 acceptance testing criteria.

d. Residual pressure test report for the most remote generator with the simultaneous operation of the foam/water system, overhead hangar bay sprinkler system simulation, and exterior hose demand (when applicable). A water only test is acceptable.

d. Residual pressure test report for the most remote generator with only the foam/water system operating. Include the inlet and outlet pressures of the flow control valve and inductor. A water only test is acceptable. Include verification of the hydraulic performance of the system.

e. Provide a proportioning system test report demonstrating compliance in accordance with NFPA 11.

f. System record of Inspection and Testing, Notification appliance supplementary Record of Inspection and Testing, Initiating Device Supplementary Record of Inspection and Testing, Interface Component Supplementary Record of Inspection and Testing, and Mass Notification System Supplementary Record of Inspection and Testing per NFPA 72 for the FACU and FSCP.

3.25 FLUSHING

Underground water mains shall be flushed in accordance with NFPA 13 and NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less than the maximum water demand rate of the system.

3.26 HYDROSTATIC TESTS

The aboveground piping systems, including foam concentrate, shall be hydrostatically tested in accordance with NFPA 13 at not less than 200 psi, or 50 psi in excess of maximum system operating pressure, whichever is greater, for 2 hours. There shall be no visible leakage from the piping when the system is subjected to the hydrostatic test.

3.27 TEST TRENCH DRAINAGE SYSTEM DIVERTER VALVE TO UNDERGROUND CONTAINMENT TANK

Test and verify operation of trench drainage system diverter valve to underground containment tank.

3.28 FOAM CONCENTRATE SYSTEM

The contractor shall provide high-expansion foam concentrate for all testing (initial and acceptance) and any required retesting. Concentrate tanks shall be full (not less than that shown in the contract, or not less than the minimum quantity intended to provide the 15 minute operating time, whichever is greater) for all tests. Foam concentrate removed from the tank for repairs or adjustments shall not be reused unless the concentrate manufacturer certifies the removed concentrate is of the same quality as original new concentrate. Following approval of all testing by the Contracting Officer and completion of all "punch list items" the contractor shall replenish the concentrate storage tank with not less than the minimum design quantity shown on the contract, or at least enough to provide 15 minutes of operating time, whichever is greater.

Tests shall be conducted under the supervision of a technical representative employed by the foam concentrate manufacturer. The complete foam concentrate system shall be adjusted and tested to assure proper operation. Test results, including all pressure settings and readings, shall be recorded on an appropriate test form signed and dated by manufacturer's representative certifying that the system is in compliance with contract requirements and the manufacturer's recommended practices. Testing shall include, but not be limited to, the following:

a. Filling the foam concentrate tank.

b. Adjustment of proportioners.

c. Collection of foam samples and testing with a conductivity meter to verify proportioning accuracy.

d. Other operational checks recommended by the Hi-Ex proportioner manufacturer.

e. Readings of high-expansion foam in tanks before and after testing shall be taken, along with test time, to determine adequacy of tank for 15 minute supply.

3.28.1 ILBP Proportioning System Tests

The in-line balanced pressure proportioning system (ILBP) shall be flow tested to determine that proportioning accuracy is within specified limits. The ILBP proportioner shall be tested at the design flow rate with the overhead sprinkler flow being simulated using the test header. Foam samples from ILBP shall be accomplished in accordance with NFPA 11 and the approved test plan. Foam solution concentrations shall be determined using a refractometer or conductivity measurements and the methods outlined in

NFPA 11.

3.28.2 Inductor Tests

The inductor shall be flow tested to determine that proportioning accuracy is within specified limits. The inductor shall be tested at the design flow rate with the overhead sprinkler flow being simulated using the test header. Foam samples from inductor shall be accomplished in accordance with NFPA 11 and the approved test plan. Foam solution concentrations shall be determined using a refractometer or conductivity measurements and the methods outlined in NFPA 11.

3.29 BREAK-IN PERIOD FOR FACU AND FSCP

Provide a break-in period of at least 14 consecutive days after the FACU and FSCP have been enabled, prior to any formal testing. Provide a written request for a final test from the Fire Protection Specialist, after preliminary testing is complete, adjustments have been made to the system, and the system is ready for service.

3.30 FIRE ALARM, MASS NOTIFICATION AND FOAM RELEASING SYSTEM PRELIMINARY ACCEPTANCE TESTING (PAT) AND FINAL ACCEPTANCE TESTING (FAT)

Every feature and function of the FACU and FSCP, including initiating, alarm, and actuation systems shall be operated.

The contractor and foam system manufacturer's representatives shall conduct these test under the direction of USACE and the fire department. The PAT and FAT shall be witnessed by the Contracting Officer's Representative, the fire department, USACE, and the fire protection specialist. Additionally, after successful PAT, the AHJ (USACE FPE)(AFCEC FPE), Fire Protection Specialist, and fire protection designer of record, shall witness and approve the FAT.

At a minimum, operation and supervision of the following functions and devices shall be demonstrated:

a. All operational and supervisory functions of the control and annunciator panels.

b. Each foam system manual foam releasing station and manual stop stations and associated circuit(s) without foam discharge. For this test, the actuating solenoid shall be removed from the foam system control valve, and a bolt placed in it to indicate when it receives power.

c. All optical flame detectors and associated circuits.

d. Each general alarm initiating device (manual pull stations, flow switches, pressure switches, and associated circuit(s).

e. Each supervisory initiating device or function (for instance valve tamper switch, tank level supervisory panels, fire pump controllers) and associated circuit(s).

f. All alarms and associated circuits.

g. All actuator circuits and system control valve(s) (without foam discharge).

h. Activation of the building fire evacuation alarm system.

i. Activation of the installation fire alarm reporting system (receipt of fire alarm, trouble, supervisory signals at receiving station).

j. Automatic and manual operation of the HIGH-EXPANSION FOAM containment system diverter valve. Not Used.

k. All of the above tests shall then be repeated with the system on battery power only.

l. Annunciator lamp and notification appliance. This shall include bells, horns, electronic signaling, and similar devices.

m. Test of each function of the control panel.

n. Test of each circuit in both trouble and normal modes.

o. Tests of the battery charger and batteries. For this test, the batteries shall operate the fire alarm, mass notification, and foam releasing system, for 72 hours under supervisory conditions. After 48 hours in standby, the shall operate the solenoid at full current draw for 15 minutes. The actuating solenoid shall be removed from the foam system control valve, and a bolt placed in it to indicate when it receives power. Coordinate this testing with Section 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM.

p. Opening the circuit at each alarm initiating device and notification appliance to test the wiring supervisory feature.

q. Visual inspection of wiring connections.

r. Ground fault testing.

s. Short circuit fault testing.

t. Demonstrate the functionality of the fire alarm system is in compliance with the FACU and FSCP functional matrixes.

u. Verify the proper operation of the Low Level Auto Disable Switch in the FSCP, if provided.

v. Verify whether the foam start and stop stations, associated conduit and back boxes, meet watertight and NEMA 4 requirements to prevent moisture entry.

w. Verify whether power supplies to FSCP panels are provided and identified in accordance with NFPA 72.

x. Verify that wire-nuts are not used in the fire alarm, mass notification, and releasing systems. Perform random checks by opening junction boxes to verify that screw type terminal blocks have been used throughout.

y. Verify that conduit routing for alarm systems are in accordance with NFPA 72 for conduit separation distances for horizontal and vertical runs.

z. Verify that if a valve is installed in the connection between an alarm initiating device intended to signal activation of a fire suppression system, the valve is supervised per NFPA 72. Presence of TS should be noted on Tamper Switch matrix.

aa. 100 percent Circuit Integrity Testing of devices (open, short, ground on 100 percent of devices) will be completed at the PAT (not necessary to repeat at FAT).

3.31 FOAM/WATER FLOW CONTROL VALVE (FCV) FUNCTIONAL TESTING

Foam/Water Flow Control Valve (FCV) functional testing. Operate flow control valves and adjust valve open/closure speed and discharge pressure settings as specified. Demonstrate proper pressure settings and valve operation speed by utilizing the nozzle test/drain assembly at the most remote nozzle to record system pressure and by using the system abort station to stop and restart flow. Seal the pressure regulator, opening speed, and closure speed valves in their final "set" position with safety wire in the same manner as aviation mechanics seal critical fasteners on powerplants. Wire seals shall prohibit casual movement of valves. Permanently record the final FCV discharge pressure setting on each valve.

3.32 FINAL ACCEPTANCE TESTING WITNESS AND APPROVAL

The Final Acceptance Test (FAT) shall be a repeat of Preliminary Acceptance Tests (FAT).

The Contractor shall provide written notification from the Fire Protection Specialist requesting the Final Acceptance Test, at least 14 days prior to date of Final Test, that preliminary tests have been successfully completed. The Contracting Officer shall notify immediately the USACE district fire protection engineer and AHJ (USACE FPEAFCEC FPE)and Fire Protection Specialist.

Final testing of the high expansion foam system, optical flame detection system, and fire alarm & mass notification system shall be witnessed and approved in writing by a delegated representative of the Air Force Civil Engineer Center, Operations Director (AFCEC/CO). the Army Corps of Engineers Fire Protection Engineer who is a registered professional engineer (P.E.) who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience.

Additionally, the manufacturer's representative (including the representatives for fire alarm, releasing, optical flame detection, and foam systems), Fire Protection Specialist, and fire protection designer of record, shall witness and approve the FAT.

3.33 PRELIMINARY ACCEPTANCE TESTING (PAT) AND FINAL ACCEPTANCE TESTING (PAT) OF THE OPTICAL FLAME DETECTION SYSTEM

The contractor and optical flame detector manufacturer's representative shall conduct pan fire testing under the direction of the fire protection specialist, USACE and the fire department.

Post suitable signs the day prior to and during testing indicating the date and time fire detection testing is to occur.

During testing, all suppression systems shall be disconnected. The foam system shall be deactivated prior to beginning testing, to prevent accidental discharge. Remove solenoid from the foam/water control valve.

Corrections shall be made to triple IR detectors or controls not responding and tests repeated as necessary. If the sensitivity of a detector(s) needs to be changed to pass a test, all other tests, and certifications/qualifications for immunity against false alarms, performed up to that time need to be repeated. The Contractor shall protect the building and installed equipment from possible smoke and/or fire damage.

Demonstrate the performance requirements of the optical flame detector coverage has been met through pan fire acceptance testing.

Use a clean burning fuel in a 2 foot x 2 foot test pan, all of which is approved and provided by the optical flame detector manufacturer to simulate the expected fuel.

Use a clean burning fuel in a 2 foot x 2 foot test pan, all of which is approved and provided by the optical flame detector manufacturer to simulate the expected fuel.
At a minimum, place the test fire in each designated aircraft parking position (minimum of three).

Place the test fires at locations provided by AFCEC.

To pass, all detectors within the cone-of-vision of this test fire shall activate within 30 seconds of fuel ignition.

Center the test fire 10 ft. outside the hangar bay opening. To pass, no detectors should active after 30 seconds of full fire development.

Disconnect the signal to the foam concentrate pump and foam jockey pumps.

In addition to the pan fire test, the following tests shall be performed in the hangar bay:

a. Activate each optical flame detector manually (e.g. using a magnet per manufacturer's recommendation) and individually, and confirm that blue beacons are activated, and confirm that a single optical detector does not activate the foam system.

b. Simultaneously manually activate each optical flame detector with each of the other optical flame detectors individually, and confirm that blue beacons are activated, that the disconnected foam/water control valve solenoid is activated, that the start signal is sent to the foam concentrate pump and fire water pump (Army only), and that fire alarm speakers and strobes are turned on via the fire alarm mass notification control panel.

c. Ensure that the following outputs from the triple IR controller are received by the releasing panel, fire alarm control panel, and fire reporting receiving station: triple IR first alarm, triple IR second alarm, and triple IR fault. Confirm that the triple IR bypass switch disables the triple IR system.

d. At each aircraft parking location, and one additional location determined by the COR, perform arc welding of plate steel inside the hangar bay, at 125 amps for five minutes, and confirm that the detectors do not activate.

e. Perform welding activities on the facility for a maximum of five minutes, at one location determined by the COR, and confirm there is no feedback through the building ground to the triple IR detection system.

The contractor shall provide written documentation of tests and state that the system is fully functional in accordance with all criteria.

The contractor shall properly dispose of fire testing materials.

3.34 PRELIMINARY ACCEPTANCE TEST (PAT) AND FINAL ACCEPTANCE TEST (FAT) FOR THE HIGH-EXPANSION FOAM SYSTEM

All high-expansion foam concentrate, instruments, and equipment for testing shall be furnished by the Contractor. Contractor shall provide concentrate, gauges, sample collection apparatus, instruments, hose, personnel, elevating platforms, scaffolding, ladders, appliances and any other equipment necessary to fulfill testing requirements specified. All necessary tests encompassing all aspects of system operation shall be made including the following, and any deficiency found shall be corrected and the system retested at no cost to the Government.

The contractor shall have provided written documentation of a successful PAT for the optical flame detection, fire alarm, mass notification, and foam releasing system PAT before scheduling the High-Expansion Foam System FAT and state that these systems are fully functional in accordance with all criteria.

Preliminary Acceptance Test reports, including the required video of the Preliminary Acceptance Tests, have been submitted and approved by the Contracting Officer, USACE district fire protection engineer and AHJ (USACE FPEAFCEC FPE), Fire Protection Specialist, and fire protection specialist before scheduling the Final Acceptance Test.

When all of these systems operate to the satisfaction of the system manufacturer's technical representative and the AFCEC Fire Protection Engineer; the contractor shall conduct a full complete discharge test of the each system servicing each separated fire area. The test shall be performed to demonstrate satisfactory performance, proper high expansion foam concentration,operation of valves, release devices, alarms, and interlocks which control the protected areas. These tests shall be conducted by experienced personnel according to the equipment and high expansion foam manufacturers' recommendations.

Develop a check list prior to commencing preliminary and final acceptance tests which includes the following:

a. Conduct a safety meeting(s) with attendance required for all witnesses (government and non-government personnel)immediately before the test.

b. Provide a safety plan as described in this specification in the applicable paragraph for conducting test of High-Expansion Foam System (Hi-Ex). Provide a sketch of safe egress path for persons conducting and witnessing the test to exit the building without entering the foam blanket. During the discharge test, no one is permitted on the floor of aircraft servicing area. Persons witnessing the test will be required to view from an elevated position (or equivalent) that does not require them to exit the building through the foam. Ensure that there is adequate egress off the elevated position (or equivalent) which complies with NFPA 101. The foam blanket will reach a level above the average person's height causing spatial and acoustic disorientation possibly resulting in injury. Provide procedures for taking protective measures to avoid damage to life and property during and after the test, as described in the applicable paragraph in this specification section. Obtain approval from the Base Safety Manager, Contracting Officer, and the fire department.

c. Provide a signup sheet with signature mandatory for all witnesses. No person shall be permitted in the hangar vicinity during the test who has not signed the signup sheet and also attended the safety meeting.

d. The contractor shall have a countdown commencing an adequate time prior to the test, to allow all witnesses to get into position. Time points shall be announced for all witnesses in the hangar vicinity.

e. Provide environmental permits as described in this specification section in the applicable paragraph.

f. Provide a test plan for each day of the test such as Day 1, Day 2.

g. One hundred percent testing will be done during PAT and FAT. Simultaneously conducting more than one test is not permitted. The contractor and foam system manufacturer's representatives shall conduct these test under the direction of USACE and the fire department. The PAT and FAT shall be witnessed by the Contracting Officer's Representative, the fire department, USACE, and the fire protection specialist. Additionally, after successful PAT, the FAT shall be witnessed and approved by the personnel stated in the paragraph above.

h. Provide a procedure for each test.

i. Provide blank test data recording form for each test. The attendee-sign-up sheet shall be separate from test data recording form. Use NFPA forms when available.

j. Provide calibration certificates for each instrument used for testing. The testing equipment shall be calibrated within previous 12 months from the date of testing. The flow tests are invalid without calibration certificates.

k. Obtain and provide test procedures (from the equipment manufacturer and NFPA) for the following equipment:

    1. Foam System.
    2. Foam proportioner test.
    3. Foam System Control Panel (FSCP).

l. Provide names and credentials of manufacturers' representatives who will be conducting the tests.

m. Provide foam tank volume graph indicating volume in gallons corresponding to foam concentrate level in foam tank. This information will be used to calculate concentrate volume required to flow the foam for 15 minutes. The foam tank levels shall be checked by foam manufacturer's representative.

n. Measure foam tank level at the beginning and end of the foam test.

Calculate concentrate volume required to flow the foam for 15 minutes. The foam tank levels shall be checked by foam manufacturer's representative.

o. Provide a procedure for simulating maximum sprinkler system demand based on sprinkler hydraulic calculations. The flow shall be measured by using calibrated equipment such as liquid-filled gages and pitot tubes. Prior to the foam test, with the foam system disconnected, simulate the overhead sprinkler system and hose demand (as applicable) through the test header, using fire hose, hose monsters, pitot measurements and liquid filled pressure gages, or equivalent. The overhead foam generators in the hangar should be simultaneously flowing water only. The fire protection specialist shall witness the flow simulation. When the test is complete, and before the foam test, the hangar floor shall then be cleared of any water and shall be dry.

o. Not Used.

p. Provide liquid filled test gages at each foam generator and at the foam system riser. This information is used to substantiate the hydraulic calculations and to determine actual flow from each generator. It is recommended that sufficient length of hose or tube is provided to take pressure reading at the floor during water only flow. Alternately, pressure transducers may be used to take readings. Note that there may be difficulty transmitting signals from pressure transducers through the high expansion foam.

q. Measure the residual pressure at the most remote generator with only the foam/water system operating. Measure the inlet and outlet pressures of the flow control valve and inductor. A water only test is acceptable. Use this information to verify the hydraulic performance of the system.

r. Measure the residual pressure at the most remote generator with the simultaneous operation of the foam/water system, overhead hangar bay sprinkler system simulation, and exterior hose demand (when applicable). Measure the inlet and outlet pressures of the flow control valve. A water only test is acceptable. Use this information to verify the hydraulic performance of the system.

5. Mark aircraft outline (silhouette) on the floor with bright red tape and 1 meter cones. This is to determine the amount of time required to cover the aircraft silhouette from the activation of manual foam releasing station. Mark the floor with additional colored tape as required to subdivide the aircraft outline into sections to assist in determining the foam coverage percent during the test and review of the video. Ensure that the tape can be readily seen in the video used during the test.

t. The amount of time required to cover 90 percent of the aircraft silhouette from the activation of manual foam releasing station shall not exceed 60 seconds. No foam shall fall from the foam generators within the projected aircraft silhouette.

u. Mark the walls or place 1 meter cones or posts at or near the walls, and along and within the aircraft silhouette. Ensure that the 1 meter cones do not interfere with the flow of foam. This is needed to determine the amount of time needed to cover the hangar floor to a depth of 3 feet.

v. The High-Expansion foam system discharge test is to begin with the fire pump(s) not running.

w. Record the amount of time required to cover the entire floor area with foam to a depth of 3 feet which shall not exceed 4 minutes. Once the test director indicates the 1 meter depth has been achieved, depress a "Foam Stop" button on a station remote to the activation station used to initiate the discharge. The foam control valve shall close not faster than 5 seconds and not more than 15 seconds. Upon release of the "foam stop" button, the foam/water control valve shall completely open within 5 seconds.

x. Foam Test:

1. Perform foam flow test of the combined system flowing simultaneously (with foam) to verify both one minute criteria and 4 minute criteria.
2. Develop Foam Spread diagrams if not available from the manufacturer.

y. Provide values of design parameters including:

1. Design pressure at the base of foam system riser.
2. Design pressure at hydraulically most remote foam generator.
3. Value of maximum fire water demand.
4. Value of maximum foam solution flow.
5. Limits of foam solution concentration in accordance with the UL listing of foam and contract requirements.

6. Design inlet and discharge pressures at the inductor.
6. Not Used.

z. Designate a person to stop the foam test (e.g. by appropriate means such as closing the manual control valve) based on radio communications, etc. when receiving notification that the 3 feet depth has been achieved or in case of an emergency. In case of a loss of communication, this person should be given instructions that the foam test should be stopped no later than 4 minutes after the foam test has commenced.

aa. Sprinkler Flow Test:

1. Provide the number of playpipes used for each flow test.
2. Indicate GPM per playpipe.
3. Indicate pitot pressure for each playpipe.

aa. Not Used

bb. Demonstrate that the foam test header isolation valve is working properly.

cc. Test the foam proportioner prior to the full foam test at a flow and for a time recommended by the manufacturer. The intent is to ensure that the foam proportioner is performing as intended prior to the full foam test. Repeat this test during the foam test.

dd. Test the foam inductor prior to the full foam test at a flow and for a time recommended by the manufacturer. The intent is to ensure that the foam inductor is performing as intended prior to the full foam test. Repeat this test during the foam test.

ee. The foam test shall not be conducted with standing water on the hangar floor. Crews and equipment shall be provided to remove standing water. The hangar floor shall not be wet at the start of the test.

ff. Provide equipment used for the test such as radios, stop watch, foam fill pump, foam to top the foam tank, lifts, ladders, extension pole, smoke generator, manometer, sufficient cameras and tripods.

gg. Designate personnel to witness test readings, and video record (digitally) each test as follows:

1. Provide an adequate number of cameras in the hangar area to facilitate complete coverage without panning across the hangar floor. At least one video view will be from a ceiling mounted camera. Use stationary overhead cameras with a full view of the aircraft silhouette during the foam test, to use for later determination of the percent aircraft silhouette coverage at 60 seconds and 1-meter depth in 4 minutes. Cameras shall have a full view of the bright red tape on the floor to outline the aircraft silhouette, and additional bright red tape on the floor to subdivide the silhouette into sections. The subdivision will assist in reviewing the video for percent silhouette coverage with foam at 60 seconds.

2. Video the tests in disc (or digital)format and record the date and time-lapse, in seconds, from start to finish of each portion of the test as directed by the Contracting Officer. The high-expansion foam (HEF) discharge test will most likely require several cameras for complete documentation. The cameras filming the high-expansion foam discharge on the hangar floor cannot pan. Four copies of the disc (or digital) shall be submitted before the system will be considered accepted.

3. Sound an air horn or equivalent from the location of the foam start station used to activate the system. This horn shall be sounded when the system is activated. The government shall bear witness that the horn is sounded simultaneously with activation of the foam start station, and shall note and record any time difference in seconds. The horn shall be capable of being heard in the video and by all witnesses throughout the hangar, for time zero determination. This air horn will be used to establish the start time in the video to evaluate the foam coverage of the silhouette in 60 seconds and the foam depth of one meter in four minutes.

4. A government witness at the foam start station shall radio a government witness in the foam room the exact moment the start station is enabled, so that the government witnesses in the foam room and fire pump room can provide a visible or audible signal for the recording cameras indicating time zero.

The government witness in the foam room shall record how many seconds after the test start time before the sprinkler test header valve is fully open.

5. Provide a camera in foam room and pump house to record gage pressures, fire pump start time, foam water control valve opening time, and the foam water control valve is closed at the end of the

test.

Record gauge pressures at the inlet and outlet of the inductor.

6. All cameras shall show the elapsed time on the video.

hh. Verify and and record whether a fire pump start signal is provided from the foam system control panel to fire pump and foam pump controllers

hh. Not used.

ii. Verify and specifically note that under no circumstances the fire suppression system pressure exceeds 175 psi.

ii. Not Used.

jj. Verify and specifically note that surge arrestor pre-charge pressure is indicated on surge arresters.

kk. Verify and specifically note that a pressure gage with isolation valve is provided at surge arresters to monitor pressure. Record pressure.

ll. Verify that a tamper switch is provided for foam concentrate shutoff valve. Presence of TS should be noted on Tamper Switch matrix.

38. Not Used.

mm. Demonstrate the performance criteria for opening and closing the flow control valve is met upon actuation of the manual foam stop stations. A water only test is acceptable.

nn. Verify that any and all valves in the system that when closed will disrupt or stop the flow of foam solution, foam concentrate, water, or that will disrupt or prevent an alarm signal or disrupt or prevent the opening of the deluge valves are electronically supervised. Presence of TS should be noted on Tamper Switch matrix.

oo. Verify and specifically note that all pipe and conduit penetrations are sealed with listed fire proofing material. Provide catalog cut of fireproofing material.

pp. Verify and specifically note that all fire protection pipes, valves, test headers, FDC are labeled and that labels have been adapted to properly indicate flow direction.

qq. Provide system restoration and flushing procedure after the completion of acceptance test.

rr. Ensure sufficient quantity of foam is available to top the foam tank at the end of the tests.

ss. Provide a pump for filling the foam tank from the foam drums.

tt. Preliminary Test Report:

1. Provide preliminary test report for all fire protection related specification sections with table of contents in a binder for approval prior to scheduling final acceptance test.
2. Include copies of all test reports required by the specifications and NFPA codes such as NFPA 11, NFPA 13, NFPA 20, NFPA 24, and NFPA 72.

3. Include copies of test procedures for each fire protection related specification section.
4. Include copies of forms to record test readings.
5. Include copies of credentials of manufacturer's representatives who will actually be present at the site.

uu. Final Acceptance Test Plan:

1. Please include table of contents.
2. Please submit hard copy of Final Acceptance Testing Plan and Procedures, and forms for recording test data in a three ring binder with tabs. This will be very help full during final acceptance test.
3. Provide electronic copy of Final Acceptance Testing Plan and Procedures.
4. Note that the Final Acceptance Test is a repeat of the Preliminary Acceptance Test, with the exception of hydrostatic tests of aboveground and underground pipe, underground pipe flush, and loop resistance tests.

vv. General:
1. Determine the status of each item prior to commencing final acceptance test.
2. Take appropriate action to make this a successful test.
3. Determine the status of each item after the completion of final acceptance test.

ww. Any and all tests which are left as incomplete after the FAT shall be corrected then successfully retested in the presence of the USACE district fire protection engineer and AHJ (USACE FPEAFCEC FPE), Fire Protection Specialist, and fire protection designer of record.

xx. The purpose of the PAT is to ensure that the FAT is conducted flawlessly. It is the contractor's responsibility to perform tests and make repairs to the system until they can conduct a "perfect" PAT completely and without incident or failure. If a failure is noted during any portion of the PAT, the item shall be corrected and then the entire testing process shall be repeated until it is completed flawlessly from start to finish. Then a successful PAT has been completed. Only after a successful PAT is completed and the report reviewed and accepted by government can a FAT be scheduled.

3.35 POST-DISCHARGE TEST REQUIREMENTS

Following the successful completion of the tests, the contractor shall completely drain any water or foam water solution between foam system control valves and foam generators. Thus all piping between the foam control deluge valves and foam generators is dry. The Contractor shall remove the foam solution from the site as indicated on the approved foam waste containment and disposal plan. Contractor shall replenish foam concentrate consumed during the tests. The entire fire protection system shall be returned to automatic operation and the facility restored to operational capability. Discharged solution shall be contained and disposed of in a manner acceptable to local authorities and as identified on the approved test plan. Once tests are completed, systems shall be returned to fully operational status, including filling of High-Expansion Foam concentrate tanks with concentrate and filling of solution piping with premix as required.

3.36 DISPOSAL PLAN AND PROTECTION

Provide Foam Containment Plan and Procedures. Provide Foam Disposal Plan and Procedures.

3.36.1 Protective Measures

Provide procedures for taking protective measures to avoid damage to property during and after the test protection of property during the Final Acceptance Test.

3.37 PRELIMINARY ACCEPTANCE TEST REPORT

Submit the Preliminary Acceptance Test report, and video recording of the event, to the Contracting Officer Representative, before requesting a Final Acceptance Test. Provide the "Punch List" (list of deficiencies prepared at the completion of preliminary test), and a Final Acceptance Test plan 15 days prior to final acceptance test

3.38 FINAL ACCEPTANCE TEST REPORT AND AS-BUILT DRAWINGS

Provide the Final Acceptance Test Report within 15 days after the completion of the Final Acceptance Test. Provide the final acceptance test report in booklet form showing field tests performed with the digital or videotape of the final test to document compliance with the specified performance criteria. Provide documentation of readings, test results, and indicate the final position of control valves. Include all required Final Acceptance Test NFPA forms. The Final Acceptance Test report shall include the resolution of punch list items developed during preliminary acceptance testing. Submit As-built Drawings

3.39 FLUSHING AND RINSING

After completion of tests flush all piping carrying HIGH-EXPANSION FOAM solution with fresh water. Rinse with fresh water all equipment and building surfaces exposed to HIGH-EXPANSION FOAM discharge.

3.40 POSTED INSTRUCTIONS

Framed description of system operation, instructions and schematic diagrams of the overall foam system and each subsystem, shall be posted where directed. Condensed operating instructions explaining the system for normal operation, refilling the foam storage tank, and routine testing shall be included.

Provide instructions for operating the fire extinguishing system at control equipment and at each remote control station. Instructions shall clearly indicate all necessary steps for the operation of the system. Submit the proposed legend for operating instructions for approval prior to installation. Instructions shall be in engraved white letters on red rigid plastic or red enameled steel backgrounds and shall be of adequate size to permit them to be easily read.

3.41 TRAINING

Prior to final acceptance, the Contractor shall provide two sessions of at least 8 hours each of operation and maintenance training to the installation Civil Engineering; Installation Fire Emergency Service; Installation Ground Safety Activity personnel on two different days to accommodate both shifts of the Installation Fire Emergency Services. Each training session shall include a walk-through of the facility while describing the operation of the equipment and system, and video of this description for future review by maintenance personnel. Each training session shall also include emergency procedures, and demonstrate how to perform all the routine maintenance, and unique maintenance and safety requirements. The contractor or subcontractor (e.g. foam contractor, optical flame detector contractor, fire pump contractor) shall demonstrate (on or at the equipment itself), and video for future review by maintenance staff, all the routine maintenance (e.g. weekly, monthly, yearly,) in the equipment manuals and cut sheets, and required by military criteria or NFPA standards. The contractor or subcontractor, during walk thru of the facility, shall describe the warning signs of equipment failure, but the contractor is not required to demonstrate how to repair equipment. Training areas will be provided by the Government in the same building as the protected areas. The training conducted shall use operation and maintenance manuals specified in paragraph entitled "Operations and Maintenance Manuals". Dates and times of the training period shall be coordinated through the Contracting Officer not less than two weeks prior to the sessions.

A lessons plan shall be submitted prior to the training, that will outline the scope of the training. Lesson plans, operating instructions, maintenance procedures, and training data shall be furnished in manual format for the training courses. The operations training course shall familiarize designated government personnel with proper operation of the fire protection systems. The maintenance training course shall provide designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system. The training sessions shall be given for two different work shifts. The schedule of training shall be approved by the Contracting Officer. Training sessions shall start after successful completion of the Final Acceptance Test. The field instruction shall cover all of the items contained in the approved O&M manual. Film or tape all training sessions and provide to the Government.

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SECTION 21 23 00.00 20

WET CHEMICAL FIRE EXTINGUISHING FOR KITCHEN CABINET
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 17A	(2021) Standard for Wet Chemical Extinguishing Systems
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 96	(2021) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

UNDERWRITERS LABORATORIES (UL)

UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 SYSTEM REQUIREMENTS

Provide new and modify existing preengineered wet chemical fire extinguishing system for protection of new and existing cooking equipment including exhaust hoods, ducts, and related work. Equipment, materials, installation, workmanship, inspection, and testing shall be in strict accordance with the required and advisory provisions of the manufacturer's installation manual, NFPA 17A and NFPA 96, except as modified herein. Each system shall include materials, accessories, and equipment necessary to provide each system complete and ready for use. Provide each system to give full consideration to blind spaces, piping, electrical equipment, ducts, and other construction and equipment in accordance with detailed working drawings to be submitted for approval. Devices and equipment for fire protection service shall be UL Fire Prot Dir listed or FM APP GUIDE approved for use with wet chemical fire extinguishing systems. In the NFPA publications referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" shall be interpreted to mean the Base/Post Fire Chief.

1.2.1 Detail Drawing

Submit electrical wiring diagrams and dimensioned or scaled piping layout showing components, pipe sizes, pipe lengths, nozzle and valvelocations in relation to cooking appliances and fusible link locations.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fire Extinguishing System; G

SD-03 Product Data

Storage Cylinder; G

Fusible Links; G

Release Mechanisms; G

Valve; G

Discharge Nozzle; G

Pipe and Fittings; G

Piping and Accessories; G

Remote Manual Actuation Stations; G

Pressure-operated Switches; G

Manufacturer's Installation and Maintenance Manuals; G

SD-07 Certificates

Qualifications of Installer; G

SD-08 Manufacturer's Instructions

Fire Extinguishing System; G

Submit the extinguishing system manufacturer's installation manual.

SD-10 Operation and Maintenance Data

Fire Extinguishing System, Data Package 3; G

System As-built Drawings, Data Package 3; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Sign Legends; G

1.4 ELECTRICAL WORK

Associated with this section shall be provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, except for control and fire alarm wiring. Fire alarm system is specified in Section 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE. Provide control and fire alarm wiring , including connections to fire alarm systems, under this section in accordance with NFPA 70. Provide wiring in rigid metal conduit or intermediate metal conduit, except electrical metallic tubing conduit may be provided in dry locations not enclosed in concrete or where not subject to mechanical damage.

1.5 QUALITY ASSURANCE

1.5.1 Qualifications of Installer

Prior to installation, submit data showing that the Contractor has successfully installed systems of the same type and design as specified herein, or that the Contractor has a firm contractual agreement with a subcontractor having such required experience. The data shall include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems. Indicate type and design of each system and certify that each system has performed satisfactorily in the manner intended for not less than 18 months.

Qualifications of System Technician: Installation drawings, shop drawing and as-built drawings shall be prepared, by or under the supervision of, an individual who is experienced with the types of works specified herein, and is currently certified by the National Institute for Certification in Engineering Technologies (NICET) as an engineering technician with minimum Level-III certification in Special Hazard System program. Contractor shall submit data for approval showing the name and certification of all involved individuals with such qualifications at or prior to submittal of drawings.

PART 2 PRODUCTS

2.1 PREENGINEERED WET CHEMICAL FIRE EXTINGUISHING SYSTEMS

Systems shall comply with NFPA 17A and NFPA 96, except as modified herein. Piping and accessories within the hood shall be stainless steel or chrome plated. All other piping shall be chrome or nickel plated or stainless steel . Exhaust hoods with grease extractors UL Fire Prot Dir listed or FM APP GUIDE approved are not required to have protection downstream of the grease extractors. Wet chemical agent shall be listed for the particular system and recommended by the manufacturer of the system. Provide systems for protection of new and existing cooking equipment, including exhaust hoods and ducts for cooking equipment requiring protection by NFPA 96.

2.2 SYSTEM CONTROLS

Each system shall be mechanically actuated by fusible links and by remote manual actuation stations connected to the extinguishing system release mechanisms by stainless steel cables. Arrange each system to automatically shut off the flow of fuel and electrical power to cooking appliances as indicated and to automatically actuate the building fire alarm fire alarm system as indicated and to automatically transmit an alarm over the base fire alarm system as indicated. Electrical power to hood exhaust fans shall not be shut off unless specifically required by the UL Fire Prot Dir listing or FM APP GUIDE approval. Provide operating instructions at all system remote manual actuation stations.

2.3 EXISTING BUILDING FIRE ALARM CONTROL PANEL

The fire extinguishing system shall be connected to the zone currently serving a spare zone module. The fire alarm panel zone identification label shall be replaced with new label of similar construction which indicates the equipment connected to the zone module. Discharge of the extinguishing system shall actuate the fire alarm control panel in the same manner as other actuating devices. Extinguishing system wiring shall be supervised in the same manner as other devices connected to the fire alarm system.

2.4 IDENTIFICATION SIGNS

Provide red rigid plastic signs with engraved 0.25 inch high white lettering at each remote manual actuation station. Sign legends shall be "Fire Extinguishing System" followed by a brief description of the equipment protected.

PART 3 EXECUTION

3.1 INSTALLATION

Equipment, materials, installation, workmanship, inspection, and testing shall be in accordance with the manufacturer's installation and maintenance manuals and NFPA 17A, except as modified herein.

3.2 FIELD QUALITY CONTROL

Perform tests to determine compliance with the specified requirements in the presence of the Contracting Officer. Test, inspect, and approve piping before covering or concealing.

3.2.1 Preliminary Tests

Upon completion and before final acceptance of the work, test each pipe and fittings system by discharging a minimum of one storage cylinderof same size as system cylinder of compressed air or nitrogen (do not use wet chemical) to demonstrate the reliability and proper functioning of all pressure-operated switches, electrical and gas shutoff features, and the discharge of gas from each system discharge nozzle. Individually test remote control stations and other components and accessories to demonstrate proper functioning. Testing shall also include automatic and manual actuation, and fuel or electrical power shutoff and automatic actuation of the building fire alarm system. When tests have been completed and corrections made, submit a signed and dated certificate, with a request for formal inspection and tests.

3.2.2 Formal Tests and Inspection

The Contracting Officer and Base/Post Fire Chief, will witness formal tests and approve systems before acceptance. Submit a written request for formal inspection at least 15 working days prior to inspection date. An experienced technician regularly employed by the system installer shall be present during the inspection. At the inspection, repeat any or all of the required tests as directed. Provide plastic containers, hose fittings, and hose at each nozzle to capture the wet chemical and discharge each system to demonstrate uniform distribution of the wet chemical among the nozzles. Furnish compressed air, nitrogen, wet chemical equipment, and personnel for the tests. Refill and reset systems after tests have been completed.

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SECTION 21 30 00

FIRE PUMPS
04/08, CHG 1: 08/13

PART 1 GENERAL

1.1 SUMMARY

Except as modified in this Section or on the drawings, install fire pumps in conformance with NFPA 20, NFPA 70, and NFPA 72. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification governs. Devices and equipment for fire protection service must be UL Fire Prot Dir listed or FM APP GUIDE approved. Interpret all reference to the authority having jurisdiction to mean the Contracting Officer .

1.2 SEQUENCING

1.2.1 Primary Fire Pump

Primary fire pump shall automatically operate when the pressure drops to 110 psi . The fire pump shall automatically stop operating when the system pressure reaches 125 psi and after the fire pump has operated for the minimum pump run time specified herein.

1.2.2 Secondary Fire Pump

Secondary fire pump shall operate at 10 psi increments, set below the primary fire pump starting pressure. The fire pump shall automatically stop running at 125 psi and after the fire pump has operated for the minimum pump run time. Fire pumps shall be prevented from starting simultaneously and shall start sequentially at intervals of 5 to 10 seconds.

1.2.3 Pressure Maintenance Pump

Pressure maintenance pump shall operate when the system pressure drops to 115 psi. Pump shall automatically stop when the system pressure reaches 125 psi and after the pump has operated for the minimum pump run time specified herein.

1.3 FIRE PUMP INSTALLATION RELATED SUBMITTALS

The Fire Protection Specialist shall prepare a list of the submittals, from the Contract Submittal Register, that relate to the successful installation of the fire pump(s), no later than 7 days after the approval of the Fire Protection Specialist and the Manufacturer's Representative. The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Fire Protection Specialist when submitted to the Government.

1.4 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(2018) Hypochlorites
AWWA B301	(2018) Liquid Chlorine
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C500	(2019) Metal-Seated Gate Valves for Water Supply Service
AWWA C606	(2015) Grooved and Shouldered Joints

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A183	(2014; R 2020) Standard Specification for

Carbon Steel Track Bolts and Nuts

ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A449	(2014; R 2020) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A795/A795M	(2021) Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B135/B135M	(2017) Standard Specification for Seamless Brass Tube
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM F436	(2011) Hardened Steel Washers

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 20	(2022;TIA 21-1; TIA 21-2) Standard for the Installation of Stationary Pumps for Fire Protection
NFPA 24	(2022) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 37	(2021) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 72	(2022) National Fire Alarm and Signaling Code
NFPA 1963	(2019) Standard for Fire Hose Connections

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(2012) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Automatic Sprinkler System Layout

UNDERWRITERS LABORATORIES (UL)

UL 80	(2007; Reprint Jan 2014) Standard for Steel Tanks for Oil-Burner Fuels and Other Combustible Liquids
UL 142	(2006; Reprint Jan 2021) UL Standard for Safety Steel Aboveground Tanks for Flammable and Combustible Liquids

UL 262	(2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service
UL 448	(2020) UL Standard for Safety Centrifugal Stationary Pumps for Fire-Protection Service
UL 1247	(2007; Reprint Jun 2020) Diesel Engines for Driving Stationary Fire Pumps
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Fire Pump Installation Related Submittals

Fire Protection Specialist; G

No later than days after the Notice to Proceed and prior to the submittal of the fire pump installation drawings

SD-02 Shop Drawings

Installation Drawings; G

copies

As-Built Drawings; G

Piping Layout; G

Pump Room; G

SD-03 Product Data

Catalog Data; G

Spare Parts

Preliminary Tests

At least 14 days prior to the proposed date and time to begin Preliminary Tests

Field Tests; G

At least 2 weeks before starting field tests

Manufacturer's Representative; G

Field Training; G

Army Final Acceptance Test

Navy Formal Inspection and Tests

SD-06 Test Reports

Preliminary Tests

3 copies of the completed Preliminary Tests Reports, no later that 7 days after the completion of the Preliminary Tests.

Army Final Acceptance Test
Navy Formal Inspection and Tests; G

SD-07 Certificates

Fire Protection Specialist

No later than 14 days after the Notice to Proceed and prior to the submittal of the fire pump installation drawings

Qualifications of Welders

Qualifications of Installer

Preliminary Test Certification

Final Test Certification

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G

At least 14 days prior to conducting field training

Flow Meter

Submit Data Package 2 for flow meter and controllers in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6 EXTRA MATERIALS

Submit Spare Parts data for each different item of equipment and material specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

1.7 QUALITY ASSURANCE

1.7.1 Fire Protection Specialist

Work specified in this section shall be performed under the supervision of and certified by the Fire Protection Specialist. Submit the name and documentation of certification of the proposed Fire Protection Specialists. The Fire Protection Specialist shall be an individual who is a registered professional engineer and a Full Member of the Society of Fire Protection Engineers or who is certified as a Level IV Technician by National Institute for Certification in Engineering Technologies (NICET) in the Automatic Sprinkler System Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7. The Fire Protection Specialist shall be regularly engaged in the design and installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.7.2 Qualifications of Welders

Submit certificates of each welder's qualifications prior to site welding; certifications shall not be more than one year old.

1.7.3 Qualifications of Installer

Prior to installation, submit data for approval showing that the Contractor has successfully installed fire pumps and associated equipment of the same type and design as specified herein, or that he has a firm contractual agreement with a subcontractor having such required experience. The data shall include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems. Indicate the type and design of each system and certify that each system has performed satisfactorily in the manner intended for a period of not less than 18 months.

1.7.4 Preliminary Test Certification

When preliminary tests have been completed and corrections made, submit a signed and dated certificate with a request for a formal inspection and tests.

1.7.5 Final Test Certification

Concurrent with the Final Acceptance Test Report, submit certification by the Fire Protection Specialist that the fire pump installation is in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

1.7.6 Manufacturer's Representative

Work specified in this section shall be performed under the supervision of and certified by a representative of the fire pump manufacturer. Submit the name and documentation of certification of the proposed Manufacturer's Representative, concurrent with submittal of the Fire Protection Specialist Qualifications. The Manufacturer's Representative shall be regularly engaged in the installation of the type and complexity of fire pump(s) specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.8 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall be either capped or plugged until installed.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

a. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

b. Submit manufacturer's catalog data included with the Fire Pump Installation Drawings for each separate piece of equipment proposed for use in the system. Catalog data shall indicate the name of the manufacturer of each item of equipment, with data annotated to indicate model to be provided. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided. Catalog data for material and equipment shall include, but not be limited to, the following:

(1) Fire pumps, drivers and controllers including manufacturer's certified shop test characteristic curve for each pump. Shop test curve may be submitted after approval of catalog data but shall be submitted prior to the final tests.

(2) Pressure maintenance pump and controller.

(3) Piping components.

(4) Valves, including gate, check, globe and relief valves.

(5) Gauges.

(6) Hose valve manifold test header and hose valves.

(7) Flow meter.

(8) Restrictive orifice union.

(9) Associated devices and equipment.

c. All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number. Pumps and motors shall have standard nameplates securely affixed in a conspicuous place and easy to read. Fire pump shall have nameplates and markings in accordance with UL 448. Diesel driver shall have nameplate and markings in accordance with UL 1247. Electric motor nameplates shall provide the minimum information required by NFPA 70, Section 430-7.

2.2 FIRE PUMP

Fire pump shall be electric motor driven or diesel engine driven. Each pump capacity shall be rated at 2500 gpm with a rated net pressure of 200 psi. Fire pump shall furnish not less than 150 percent of rated flow capacity at not less than 65 percent of rated net pressure. Pump shall be centrifugal horizontal split case, vertical shaft turbine, end-suction, or in-line fire pump. Horizontal pump shall be equipped with automatic air release devices. The maximum rated pump speed shall be 2100 rpm when driving the pump at rated capacity. Pump shall be automatic start and automatic stop. Pump shall conform to the requirements of UL 448. Fire pump discharge and suction gauges shall be oil-filled type.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

2.3.1 General Requirements

Materials and Equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM APP GUIDE.

2.3.2 Alarms

Provide audible and visual alarms as required by NFPA 20 on the controller. Provide remote supervision as required by NFPA 20, in accordance with NFPA 72. Provide remote alarm devices located as indicated. Alarm signal shall be activated upon the following conditions: engine drive controller has operated into an engine running condition, engine drive controller main switch has been turned to OFF or to MANUAL position, trouble on engine driven controller or engine. Exterior alarm devices shall be weatherproof type. Provide alarm silencing switch and red signal lamp, with signal lamp arranged to come on when switch is placed in OFF position.

2.4 UNDERGROUND PIPING COMPONENTS

2.4.1 Pipe and Fittings

Provide outside-coated, cement mortar-lined, ductile-iron pipe (with a rated working pressure of 175 psi) conforming to NFPA 24 for piping under the building and less than 5 feet outside of the building walls. Anchor the joints in accordance with NFPA 24; provide concrete thrust block at the elbow where the pipe turns up toward the floor, and restrain the pipe riser with steel rods from the elbow to the flange above the floor. Minimum pipe size shall be 6 inches. Minimum depth of cover shall be as required by NFPA 24, but no less than 3 feet. Piping more than 5 feet outside of the building walls shall be provided under Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to AWWA C110/A21.10. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to AWWA C111/A21.11.

2.4.3 Valves and Valve Boxes

Valves shall be gate valves conforming to AWWA C500 or UL 262. Valves shall have cast-iron body and bronze trim. Valve shall open by counterclockwise rotation. Except for post indicator valves, all underground valves shall be provided with an adjustable cast-iron or ductile iron valve box of a size suitable for the valve on which the box is to be used, but not less than 5.25 inches in diameter. The box shall be coated with bituminous coating. A cast-iron or ductile-iron cover with the word "WATER" cast on the cover shall be provided for each box.

2.4.4 Gate Valve and Indicator Posts

Gate valves for underground installation shall be of the inside screw type with counterclockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 3 feet above finished grade. Gate valves and indicator posts shall be provided with one coat of primer and two coats of red enamel paint and shall be listed in UL Fire Prot Dir or FM APP GUIDE.

2.4.5 Buried Utility Warning and Identification Tape

Detectable aluminum foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping shall be provided for all buried piping. Tape shall be detectable by an electronic detection instrument. Tape shall be provided in rolls, 3 inches minimum width, color-coded for the utility involved and imprinted in bold black letters continuously and repeatedly over the entire tape length. Warning and identification shall be "CAUTION BURIED WATER PIPING BELOW" or similar wording. Code and lettering shall be permanent and unaffected by moisture and other substances contained in the trench backfill material. Tape shall be buried at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavement.

2.5 ABOVEGROUND PIPING COMPONENTS

2.5.1 Pipe Sizes 2.5 inches and Larger

2.5.1.1 Pipe

Piping shall be ASTM A795/A795M, Weight Class STD (Standard), Schedule 40 (except for Schedule 30 for pipe sizes 8 inchesand greater in diameter), Type E or Type S, Grade A; black steel pipe. Steel pipe shall be joined by means of flanges welded to the pipe or mechanical grooved joints only. Piping shall not be jointed by welding or weld fittings. Suction piping shall be galvanized on the inside in accordance with NFPA 20.

2.5.1.2 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 175 psi service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A183 and shall be cadmium plated or zinc electroplated.

2.5.1.3 Flanges

Flanges shall be ASME B16.5, Class 150 flanges. Flanges shall be provided at valves, connections to equipment, and where indicated.

2.5.1.4 Gaskets

Gaskets shall be AWWA C111/A21.11, cloth inserted red rubber gaskets.

2.5.1.5 Bolts

Bolts shall be ASTM A449, Type 1. Bolts shall extend no less than three full threads beyond the nut with bolts tightened to the required torque.

2.5.1.6 Nuts

Nuts shall be ASTM A193/A193M, Grade 5.

2.5.1.7 Washers

Washers shall meet the requirements of ASTM F436. Flat circular washers shall be provided under all bolt heads and nuts.

2.5.2 Piping Sizes 2 inches and Smaller

2.5.2.1 Steel Pipe

Steel piping shall be ASTM A795/A795M, Weight Class STD (Standard), Schedule 40, Type E or Type S, Grade A, zinc-coated steel pipe with threaded end connections. Fittings shall be ASME B16.39, Class 150, zinc-coated threaded fittings. Unions shall be ASME B16.39, Class 150, zinc-coated unions.

2.5.2.2 Copper Tubing

Copper tubing shall be ASTM B88, Type L or K, soft annealed. Fittings shall be ASME B16.26, flared joint fittings. Pipe nipples shall be ASTM B42 copper pipe with threaded end connections.

2.5.3 Pipe Hangers and Supports

Pipe hangers and support shall be MSS SP-58 and shall be the adjustable type. Finish of rods, nuts, washers, hangers, and supports shall be zinc-plated after fabrication.

2.5.4 Valves

Valves shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE for fire protection service. Valves shall have flange or threaded end connections.

2.5.4.1 Gate Valves and Control Valves

Gate valves and control valves shall be outside screw and yoke (O.S.&Y.) type which open by counterclockwise rotation. Butterfly-type control valves are not permitted.

2.5.4.2 Tamper Switch

The suction control valves, the discharge control valves, valves to test header and flow meter, and the by-pass control valves shall be equipped with valve tamper switches for monitoring by the fire alarm system.

2.5.4.3 Check Valve

Check valve shall be clear open, swing type check valve with flange or threaded inspection plate.

2.5.4.4 Relief Valve

Relief valve shall be pilot operated or spring operated type conforming to NFPA 20. A means of detecting water motion in the relief lines shall be provided where the discharge is not visible within the pump house.

2.5.4.5 Circulating Relief Valve

An adjustable circulating relief valve shall be provided for each fire pump in accordance with NFPA 20.

2.5.4.6 Suction Pressure Regulating Valve

Suction pressure regulating valve shall be FM approved FM APP GUIDE. Suction pressure shall be monitored through a pressure line to the controlling mechanism of the regulating valve. Valve shall be arranged in accordance with the manufacturer's recommendations.

2.5.5 Hose Valve Manifold Test Header

Construct header of steel pipe. Provide ASME B16.5, Class 150 flanged inlet connection to hose valve manifold assembly. Provide approved bronze hose gate valve with 2.5 inch National Standard male hose threads with cap and chain; locate 3 feet above grade in the horizontal position for each test header outlet. Welding shall be metallic arc process in accordance with ASME B31.1.

2.5.6 Pipe Sleeves

A pipe sleeve shall be provided at each location where piping passes entirely through walls, ceilings, roofs, and floors, including pipe entering buildings from the exterior. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, a fire seal shall be provided between the pipe and the sleeve in accordance with Section 07 84 00 FIRESTOPPING.

a. Sleeves in Masonry and Concrete Walls, Ceilings, Roofs, and Floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron pipe sleeves. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves provided that cavities in the core-drilled hole be completely grouted smooth.

b. Sleeves in Other Than Masonry and Concrete Walls, Ceilings, Roofs, and Floors: Provide galvanized steel sheet pipe not less than 0.90 psf.

2.5.7 Escutcheon Plates

Provide one-piece or split-hinge metal plates for piping entering floors, walls, and ceilings in exposed areas. Provide polished stainless steel or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on plates in unfinished spaces. Plates shall be secured in place.

2.6 DISINFECTING MATERIALS

2.6.1 Liquid Chlorine

Liquid chlorine shall conform to AWWA B301.

2.6.2 Hypochlorites

Calcium hypochlorite and sodium hypochlorite shall conform to AWWA B300.

2.7 ELECTRIC MOTOR DRIVER

Motors, controllers, contactors, and disconnects shall be provided with their respective pieces of equipment, as specified herein and shall have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Controllers and contactors shall have a maximum of 120-volt control circuits, and auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of providing additional electrical service and related work shall be included under this section. Motor shall conform to NEMA MG 1 Design B type. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. Motor horsepower shall be of sufficient size so that the nameplate horsepower rating will not be exceeded throughout the entire published pump characteristic curve. The motor and fire pump controller shall be fully compatible.

2.8 DIESEL ENGINE DRIVER

Diesel engine driver shall conform to the requirements of UL 1247 and shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE for fire pump service. Driver shall be of the make recommended by the pump manufacturer. The engine shall be closed circuit, liquid-cooled with radiator and engine-driven fan. Diesel engine shall be electric start type taking current from 2 battery units. Engine shall be equipped with a fuel in-line filter-water separator. Engine conditions shall be monitored with engine instrumentation panel that has a tachometer, hour meter, fuel pressure gauge, lubricating oil pressure gauge, water temperature gauge, and ammeter gauge. Engine shall be connected to horizontal-shaft pump by flexible couplings. For connections to vertical-shaft fire pumps, right-angle gear drives and universal joints shall be used. An engine jacket water heater shall be provided to maintain a temperature of 120 degrees F in accordance with NFPA 20.

2.8.1 Engine Capacity

Engine shall have adequate horsepower to drive the pump at all conditions of speed and load over the full range of the pump performance curve. The horsepower rating of the engine driver shall be as recommended by the pump manufacturer and shall be derated for temperature and elevation in accordance with NFPA 20. Ambient temperature at the pump location shall be 95 degrees F.

2.8.2 Exhaust System External to Engine

Exhaust system shall comply with the requirements of NFPA 20 and NFPA 37. An exhaust muffler shall be provided for each diesel engine driver to reduce noise levels less than 95 dBA. A flexible connector with flange connections shall be provided at the engine. Flexible sections shall be stainless steel suitable for diesel-engines exhaust gas at 1000 degrees F.

2.8.2.1 Steel Pipe and Fittings

ASTM A53/A53M, Schedule 40, black steel, welding end connections. ASME B16.9 or ASME B16.11 welding fittings shall be of the same material and weight as the piping.

2.8.2.2 Flanges

ASME B16.5, Class 300. Flanges shall be provided at connections to diesel engines, exhaust mufflers, and flexible connections. Gaskets shall be ASME B16.21, composition ring, 0.0625 inch. ASTM A193/A193M, Grade B8 bolts and ASTM A194/A194M, Grade 8 nuts shall be provided.

2.8.2.3 Piping Insulation

Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING. Products containing asbestos will not be permitted. Exhaust piping system including the muffler shall be insulated with ASTM C533 calcium silicate insulation, minimum of 3 inches. Insulation shall be secured with not less than 0.375 inch width fibrous glass reinforced waterproof tape or Type 304 stainless steel bands spaced not more than 8 inches on center. An aluminum jacket encasing the insulation shall be provided. The aluminum jacket shall have a minimum thickness of 0.016 inches, a factory-applied polyethylene and kraft paper moisture barrier on the inside surface. The jacket shall be secured with not less than 0.5 inch wide stainless steel bands, spaced not less than 8 inches on centers. Longitudinal and circumferential seams of the jacket shall be lapped not less than 3 inches. Jackets on horizontal line shall be installed so that the longitudinal seams are on the bottom side of the pipe. The seams of the jacket for the vertical lines shall be placed on the off-weather side of the pipe. On vertical lines, the circumferential seams of the jacket shall overlap so the lower edge of each jacket overlaps the upper edge of the jacket below.

2.9 FIRE PUMP CONTROLLER

Controller shall be the automatic type and UL listed UL Fire Prot Dir or FM approved FM APP GUIDE for fire pump service. Pump shall be arranged for automatic start and stop, and manual push-button stop. Automatic stopping shall be accomplished only after all starting causes have returned to normal and after a minimum pump run time has elapsed. Controllers shall be completely terminally wired, ready for field connections, and mounted in a NEMA Type 4 watertight and dust tight enclosure arranged so that controller current carrying parts will not be less than 12 inches above the floor. Controller shall be provided with voltage surge arresters installed in accordance with NFPA 20. Controller shall be equipped with a bourdon tube pressure switch or a solid state pressure switch with independent high and low adjustments, automatic starting relay actuated from normally closed contacts, visual alarm lamps and supervisory power light. Controller shall be equipped with a thermostat switch with adjustable setting to monitor the pump room temperature and to provide an alarm when temperatures falls below 40 degrees F Controller shall be equipped with a sequential start timer/relay feature to start multiple fire pumps in sequence.

2.9.1 Controller for Electric Motor Driven Fire Pump

Controller shall be electronic soft start starting type. Controller shall be designed as indicated. Controller and transfer switch shall have a short circuit rating as indicated. An automatic transfer switch (ATS) shall be provided for each fire pump. The ATS shall comply with NFPA 20 and shall be specifically listed for fire pump service. The ATS shall transfer source of power to the alternate source upon loss of normal power. Controller shall monitor pump running, loss of a phase or line power, phase reversal and pump room temperature. Alarms shall be individually displayed in front of panel by lighting of visual lamps. Each lamp shall be labeled with rigid etched plastic labels. Controller shall be equipped with terminals for remote monitoring of pump running, pump power supply trouble (loss of power or phase and phase reversal), and pump room trouble (pump room temperature), and for remote start. Limited service fire pump controllers are not permitted, except for fire pumps driven by electric motors rated less than 15 hp. Controller shall be equipped with a 7-day electric pressure recorder with 24-hour spring wound back-up. The pressure recorder shall provide a readout of the system pressure from 0 to 15 hp, time, and date. Controller shall require the pumps to run for ten minutes for pumps with driver motors under 200 horsepower and for 15 minutes for pumps with motors 200 horsepower and greater, prior to automatic shutdown. The controller shall be equipped with an externally operable isolating switch which manually operates the motor circuit. Means shall be provided in the controller for measuring current for all motor circuit conductors.

2.9.2 Controller for Diesel Engine Driven Fire Pump

Controller shall require the pump to run for 30 minutes prior to automatic shutdown. Controller shall be equipped with two battery chargers; two ammeters; two voltmeters, one for each set of batteries. Controller shall automatically alternate the battery sets for starting the pumps. Controller shall be equipped with the following supervisory alarm functions:

a. Engine Trouble (individually monitored)

    (1) Engine overspeed

    (2) Low Oil Pressure

    (3) High Water Temperature

    (4) Engine Failure to Start

    (5) Battery

    (6) Battery Charger/AC Power Failure

b. Main Switch Mis-set

c. Pump Running

d. Pump Room Trouble (individually monitored)

    (1) Low Fuel

    (2) Low Pump Room Temperature

    (3) Low Reservoir Level

Alarms shall be individually displayed in front of panel by lighting of visual lamps, except that individual lamps are not required for pump running and main switch mis-set. Controller shall be equipped with a 7-day electric pressure recorder with 24-hour back-up mounted inside the controller. The pressure recorder shall provide a readout of the system pressure from 0 to 300 psi, time, and date. The controller shall be equipped with an audible alarm which will activate upon any engine trouble or pump room trouble alarm condition and alarm silence switch. Controller shall be equipped with terminals for field connection of a remote alarm for main switch mis-set, pump running, engine trouble and pump room trouble; and terminals for remote start. When engine emergency overspeed device operates, the controller shall cause the engine to shut down without time delay and lock out until manually reset.

2.10 BATTERIES

Batteries for diesel engine driver shall be sealed lead calcium batteries. Batteries shall be mounted in a steel rack with non-corrosive, non-conductive base, not less than 12 inches above the floor.

2.11 PRESSURE SENSING LINE

A completely separate pressure sensing line shall be provided for each fire pump and for the jockey pump. The sensing line shall be arranged in accordance with Figure A-7-5.2.1. of NFPA 20. The sensing line shall be 1/2 inchH58 brass tubing complying with ASTM B135/B135M. The sensing line shall be equipped with two restrictive orifice unions each. Restricted orifice unions shall be ground-face unions with brass restricted diaphragms drilled for a 3/32 inch. Restricted orifice unions shall be mounted in the horizontal position, not less than 5 feet apart on the sensing line. Two test connections shall be provided for each sensing line. Test connections shall consist of two brass 1/2 inch globe valves and 1/4 inch gauge connection tee arranged in accordance with NFPA 20. One of the test connections shall be equipped with a 0 to 300 psi water oil-filled gauge. Sensing line shall be connected to the pump discharge piping between the discharge piping control valve and the check valve.

2.12 PRESSURE MAINTENANCE PUMP

2.12.1 General

Pressure maintenance pump shall be electric motor driven, horizontal shaft or in-line vertical shaft, centrifugal type with a rated discharge of 10 gpm at 125 psig. Pump shall draft as indicated and shall discharge into the system at the downstream side of the pump discharge gate valve. An approved indicating gate valve of the outside screw and yoke (O.S.&Y.) type shall be provided in the maintenance pump discharge and suction piping. Oil-filled water pressure gauge and approved check valve in the maintenance pump discharge piping shall be provided. Check valve shall be swing type with removable inspection plate.

2.12.2 Pressure Maintenance Pump Controller

Pressure maintenance pump controller shall be arranged for automatic and manual starting and stopping and equipped with a "manual-off-automatic" switch. The controller shall be completely prewired, ready for field connections, and wall-mounted in a NEMA Type 2 drip-proof enclosure. The controller shall be equipped with a bourdon tube pressure switch or a solid state pressure switch with independent high and low adjustments for automatic starting and stopping. A sensing line shall be provided connected to the pressure maintenance pump discharge piping between the control valve and the check valve. The sensing line shall conform to paragraph, PRESSURE SENSING LINE. The sensing line shall be completely separate from the fire pump sensing lines. An adjustable run timer shall be provided to prevent frequent starting and stopping of the pump motor. The run timer shall be set for 2 minutes.

2.13 DIESEL FUEL SYSTEM EXTERNAL TO ENGINE

Fuel system shall be provided that meets all requirements of NFPA 20 and NFPA 37. The fuel tank vent piping shall be equipped with screened weatherproof vent cap. Vents shall be extended to the outside. Each tank shall be equipped with a fuel level gauge. Flexible bronze or stainless steel piping connectors with single braid shall be provided at each piping connection to the diesel engine. Supply, return, and fill piping shall be steel piping, except supply and return piping may be copper tubing. Fuel lines shall be protected against mechanical damage. Fill line shall be equipped with 16 mesh removable wire screen. Fill lines shall be extended to the exterior. A weatherproof tank gauge shall be mounted on the exterior wall near each fill line for each tank. The fill cap shall be able to be locked by padlock. The engine supply (suction) connection shall be located on the side of the fuel tank so that 5 percent of the tank volume provides a sump volume not useable by the engine. The elevation of the fuel tank shall be such that the inlet of the fuel supply line is located so that its opening is no lower than the level of the engine fuel transfer pump. The bottom of the tank shall be pitched 1/4 inch/foot to the side opposite the suction inlet connection, and to an accessible 1 inch plugged globe drain valve.

2.13.1 Fuel Piping

As specified in NFPA 20.

2.13.2 Diesel Fuel Tanks

UL 80 or UL 142 for aboveground tanks.

2.13.3 Valves

Provide an indicating and lockable ball valve in the supply line adjacent to the tank suction inlet connection. Provide a check valve in fuel return line. Valves mustl be suitable for oil service. Valves must have union end connections or threaded end connections.

2.13.3.1 Globe Valve

MSS SP-80 Class 125

2.13.3.2 Check Valve

MSS SP-80, Class 125, swing check

2.13.3.3 Ball Valve

Full port design, copper alloy body, 2-position lever handle

2.14 JOINTS AND FITTINGS FOR COPPER TUBE

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Grooved mechanical joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D2000 for circulating medium up to 239 degrees F. Grooved joints shall conform to AWWA C606 Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A183.

2.15 PUMP BASE PLATE AND PAD

Provide a common base plate for each horizontal-shaft fire pump for mounting pump and driver unit. Construct the base plate of cast iron with raised lip tapped for drainage or welded steel shapes with suitable drainage. Provide each base plate for the horizontal fire pumps with a 1 inchgalvanized steel drain line piped to the nearest floor drain. For vertical shaft pumps, pump head shall be provided with a cast-iron base plate and shall serve as the sole plate for mounting the discharge head assembly. Mount pump units and bases on a raised 6 inches reinforced concrete pad that is an integral part of the reinforced concrete floor.

2.16 HOSE VALVE MANIFOLD TEST HEADER

Hose valve test header shall be connected by ASME B16.5, Class 150 flange inlet connection. Hose valves shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE bronze hose gate valves with 2.5 inches American National Fire Hose Connection Screw Standard Threads (NH) in accordance with NFPA 1963. The number of valves shall be in accordance with NFPA 20. Each hose valve shall be equipped with a cap and chain, and located no more than 3 feet and no less than 2 feet above grade.

2.17 FLOW METER

Meter shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE as flow meters for fire pump installation with direct flow readout device. Flow meter shall be capable of metering any waterflow quantities between 50 percent and 150 percent of the rated flow of the pumps. Arrange piping to permit flow meter to discharge to pump suction and to discharge through test header. The meter throttle valve and the meter control valves shall be O.S.&Y. valves. Provide automatic air release if flow meter piping between pump discharge and pump suction forms an inverted "U". Meter shall be of the venturi type.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall periodically perform a thorough inspection of the fire pump installation, including visual observation of the pump while running, to assure that the installation conforms to the contract requirements. There shall be no excessive vibration, leaks (oil or water), unusual noises, overheating, or other potential problems. Inspection shall include piping and equipment clearance, access, supports, and guards. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered. The Fire Protection Specialist shall witness the preliminary and final acceptance tests and, after completion of the inspections and a successful final acceptance test, shall sign test results and certify in writing that the installation the fire pump installation is in accordance with the contract requirements.

3.3 INSTALLATION

Equipment, materials, workmanship, fabrication, assembly, erection, installation, examination, inspection and testing shall be in accordance NFPA 20, except as modified herein. In addition, the fire pump and engine shall be installed in accordance with the written instructions of the manufacturer.

3.3.1 Installation Drawings

Submit Fire Pump Installation Drawings consisting of a detailed plan view, detailed elevations and sections of the pump room, equipment and piping, drawn to a scale of not less than 1/2 inch = 1 foot. Drawings shall indicate equipment, piping, and associated pump equipment to scale. Indicate all clearance, such as those between piping and equipment; between equipment and walls, ceiling and floors; and for electrical working distance clearance around all electrical equipment. Include a legend identifying all symbols, nomenclatures, and abbreviations. Indicate a complete piping and equipment layout including elevations and/or section views of the following:

a. Fire pumps, controllers, piping, valves, and associated equipment.

b. Sensing line for each pump including the pressure maintenance pump.

c. Engine fuel system for diesel driven pumps.

d. Engine cooling system for diesel driven pumps.

e. Pipe hangers and sway bracing including support for diesel muffler and exhaust piping.

f. Restraint of underground water main at entry-and exit-points to the building including details of pipe clamps, tie rods, mechanical retainer glands, and thrust blocks.

g. A one-line schematic diagram indicating layout and sizes of all piping, devices, valves and fittings.

h. A complete point-to-point connection drawing of the pump power, control and alarm systems, as well as interior wiring schematics of each controller.

3.3.2 Pump Room Configuration

Provide detail plan view of the pump room including elevations and sections showing the fire pumps, associated equipment, and piping. Submit working drawings on sheets not smaller than 24 by 36 inches; include data for the proper installation of each system. Show piping schematic of pumps, devices, valves, pipe, and fittings. Provide an isometric drawing of the fire pump and all associated piping. Show point to point electrical wiring diagrams. Show piping layout and sensing piping arrangement. Show engine fuel and cooling system. Include:

a. Pumps, drivers, and controllers

b. Hose valve manifold test header

c. Circuit diagrams for pumps

d. Wiring diagrams of each controller

3.3.3 Accessories

Tank supports, piping offsets, fittings, and any other accessories required shall be furnished as specified to provide a complete installation and to eliminate interference with other construction.

3.4 PIPE AND FITTINGS

Piping shall be inspected, tested and approved before burying, covering, or concealing. Fittings shall be provided for changes in direction of piping and for all connections. Changes in piping sizes shall be made using tapered reducing pipe fittings. Bushings shall not be used. Photograph all piping prior to burying, covering, or concealing.

3.4.1 Cleaning of Piping

Interior and ends of piping shall be clean and free of any water or foreign material. Piping shall be kept clean during installation by means of plugs or other approved methods. When work is not in progress, open ends of the piping shall be securely closed so that no water or foreign matter will enter the pipes or fittings. Piping shall be inspected before placing in position.

3.4.2 Threaded Connections

Jointing compound for pipe threads shall be polytetrafluoroethylene (PTFE) pipe thread tape conforming to ASTM D3308 and shall be applied to male threads only. Exposed ferrous pipe threads shall be provided with one coat of zinc molybdate primer applied to a minimum of dry film thickness of 1 mil.

3.4.3 Pipe Hangers and Supports

Additional hangers and supports shall be provided for concentrated loads in aboveground piping, such as for valves and risers.

3.4.3.1 Vertical Piping

Piping shall be supported at each floor, at not more than 10 foot intervals.

3.4.3.2 Horizontal Piping

Horizontal piping supports shall be spaced as follows:

MAXIMUM SPACING (FEET)										
Nominal Pipe Size (inches)	1 and Under	1.25	1.5	2	2.5	3	3.5	4	5	6+
Copper Tube	6	7	8							
Steel Pipe	7	8	9	10	11	12	13	14	16	17

3.4.4 Underground Piping

Installation of underground piping and fittings shall conform to NFPA 24. Joints shall be anchored in accordance with NFPA 24. Concrete thrust block shall be provided at elbow where pipe turns up towards floor, and the pipe riser shall be restrained with steel rods from the elbow to the flange above the floor. After installation in accordance with NFPA 24, rods and nuts shall be thoroughly cleaned and coated with asphalt or other corrosion-retard material approved by the Contracting Officer. Minimum depth of cover shall be 3 feet.

3.4.5 Grooved Mechanical Joint

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.5 ELECTRICAL WORK

Electric motor and controls shall be in accordance with NFPA 20, NFPA 72 and NFPA 70, unless more stringent requirements are specified herein or are indicated on the drawings. Electrical wiring and associated equipment shall be provided in accordance with NFPA 20 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide wiring in rigid metal conduit or intermediate metal conduit, except electrical metallic tubing conduit may be provided in dry locations not enclosed in concrete or where not subject to mechanical damage.

3.6 PIPE COLOR CODE MARKING

Color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS.

3.7 FLUSHING

The fire pump suction and discharge piping shall be flushed at 120 percent of rated capacity of each pump. Where the pump installation consists of more than one pump, the flushing shall be the total quantity of water flowing when all pumps are discharging at 120 percent of their rated capacities. The new pumps may be used to attain the required flushing volume. No underground piping shall be flushed by using the fire pumps. Flushing operations shall continue until water is clear, but not less than 10 minutes. Submit a signed and dated flushing certificate before requesting field testing.

3.8 FIELD TESTS

Submit system diagrams that show the layout of equipment, piping, and storage units, and typed condensed sequence of operation, wiring and control diagrams, and operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

3.8.1 Hydrostatic Test

Piping shall be hydrostatically tested at 225 psigfor a period of 2-hours, or at least 50 psiin excess of the maximum pressure, when the maximum pressure in the system is in excess of 175 psi in accordance with NFPA 20.

3.8.2 Preliminary Tests

Submit proposed procedures for Preliminary Tests prior to the proposed date and time to begin Preliminary Tests. The Fire Protection Specialist shall take all readings and measurements. The Manufacturer's Representative, a representative of the fire pump controller manufacturer, and a representative of the diesel engine manufacturer (when supplied) shall witness the complete operational testing of the fire pump and drivers. The fire pump controller manufacturer's representative and the diesel engine manufacturer's representative shall each be an experienced technician employed by the respective manufacturers and capable of demonstrating operation of all features of respective components including trouble alarms and operating features. Fire pumps, drivers and equipment shall be thoroughly inspected and tested to insure that the system is correct, complete, and ready for operation. Tests shall ensure that pumps are operating at rated capacity, pressure and speed. Tests shall include manual starting and running to ensure proper operation and to detect leakage or other abnormal conditions, flow testing, automatic start testing, testing of automatic settings, sequence of operation check, test of required accessories; test of pump alarms devices and supervisory signals, test of pump cooling, operational test of relief valves, and test of automatic power transfer, if provided. Pumps shall run without abnormal noise, vibration or heating. If any component or system was found to be defective, inoperative, or not in compliance with the contract requirements during the tests and inspection, the corrections shall be made and the entire preliminary test shall be repeated. Submit Preliminary Tests Reports, to include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Report shall be signed by the Fire Protection Specialist and the Manufacturer's Representative.

3.8.3 Test Equipment

Provide all equipment and instruments necessary to conduct a complete final test, including 2.5 inch diameter hoses, playpipe nozzles, pitot tube gauges, portable digital tachometer, voltage and ampere meters, and calibrated oil-filled water pressure gauges. Provide all necessary supports to safely secure hoses and nozzles during the test. The Contractor shall furnish water for the tests.

3.9 DISINFECTION

After all system components are installed including pumps, piping, and other associated work, and all hydrostatic tests are successfully completed, thoroughly flush the pumps and all piping to be disinfected with potable water until there is no visible sign of dirt or other residue. and hydrostatic test are successfully completed, each portion of the piping specified in this Section system to be disinfected shall be thoroughly flushed with potable water until all entrained dirt and other foreign materials have been removed before introducing chlorinating material.

3.9.1 Chlorination

The chlorinating material shall be hypochlorites or liquid chlorine. The chlorinating material shall be fed into the sprinkler piping at a constant rate of 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or liquid chlorine injected into the system through a solution-fed chlorinator and booster pump shall be used. Chlorination application shall continue until the entire system if filled. The water shall remain in the system for a minimum of 24 hours. Each valve in the system shall be opened and closed several times to ensure its proper disinfection. Following the 24-hour period, no less than 25 ppm chlorine residual shall remain in the system.

3.9.2 Flushing

The system shall then be flushed with clean water until the residual chlorine is reduced to less than one part per million. Samples of water in disinfected containers for bacterial examination will be taken from several system locations which are approved by the Contracting Officer.

3.9.3 Sample Testing

Samples shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA 10084. The testing method shall be either the multiple-tube fermentation technique or the membrane-filter technique. The disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.10 SYSTEM STARTUP

Fully enclose or properly guard coupling, rotating parts, gears, projecting equipment, etc. so as to prevent possible injury to persons that come in close proximity of the equipment. Conduct testing of the fire pumps in a safe manner and ensure that all equipment is safely secured. Hoses and nozzles used to conduct flow tests shall be in excellent condition and shall be safely anchored and secured to prevent any misdirection of the hose streams.

Post operating instructions for pumps, drivers, controllers, and flow meters.

3.11 CLOSEOUT ACTIVITIES

3.11.1 Field Training

The Fire Protection Specialist and the Manufacturer's Representative shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit the proposed schedule for field training at least 14 days prior to the start of related training. Training shall be provided for a period of 2 hours of normal working time and shall start after the fire pump installation is functionally complete and after the Final Acceptance Test. The field instruction shall cover all of the items contained in the approved Operating and Maintenance Instructions. Submit manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Data Package 3 shall be submitted for fire pumps and drivers in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

3.11.2 As-Built Drawings

Submit As-Built Drawings, no later than 14 days after completion of the Final Tests. Update he Fire Pump Installation Drawings to reflect as-built conditions after all related work is completed and shall be on reproducible full-size mylar film.

3.12 PROTECTION

Carefully remove materials so as not to damage material which is to remain. Replace existing work damaged by the Contractor's operations with new work of the same construction.

-- End of Section --

SECTION 22 00 00

PLUMBING, GENERAL PURPOSE
11/15, CHG 4: 05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 1010	(2002) Self-Contained, Mechanically Refrigerated Drinking-Water Coolers

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.10.1/CSA 4.1	(2019) Gas Water Heaters Vol. I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less
ANSI Z21.10.3/CSA 4.3	(2019) Gas-Fired Water Heaters Vol.III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous
ANSI Z21.22/CSA 4.4	(2015; R 2020) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-6 2021; Addenda AS-BF 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 146	(2020) Method of Testing and Rating Pool Heaters

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.1.2	(2012; R 2017; R 2022) Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)
ASME A112.6.1M	(1997; R 2017) Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use
ASME A112.6.3	(2019) Standard for Floor and Trench Drains

ASME A112.6.4	(2003: R 2012) Roof, Deck and Balcony Drains
ASME A112.14.1	(2003; R 2017; R 2022) Backwater Valves
ASME A112.19.1/CSA B45.2	(2013) Enameled Cast Iron and Enameled Steel Plumbing Fixtures
ASME A112.19.2/CSA B45.1	(2018; ERTA 2018) Standard for Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals
ASME A112.19.3/CSA B45.4	(2017; Errata 2017) Stainless Steel Plumbing Fixtures
ASME A112.19.5	(2017) Flush Valves and Spuds for Water Closets, Urinals, and Tanks
ASME A112.19.17	(2010; R 2018) Manufactured Safety Vacuum Release Systems (SVRS) for Residential and Commercial Swimming Pool, Spa, Hot Tub, and Wading Pool Suction Systems
ASME A112.36.2M	(1991; R 2017) Cleanouts
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2021) Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.12	(2019) Cast Iron Threaded Drainage Fittings
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.23	(2021) Cast Copper Alloy Solder Joint Drainage Fittings - DWV
ASME B16.24	(2022) Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.29	(2017) Wrought Copper and Wrought Copper

	Alloy Solder-Joint Drainage Fittings - DWV
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.50	(2021) Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
ASME B16.51	(2013) Copper and Copper Alloy Press-Connect Pressure Fittings
ASME B31.1	(2020) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME CSD-1	(2021) Control and Safety Devices for Automatically Fired Boilers

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1001	(2021) Performance Requirements for Atmospheric Type Vacuum Breakers
ASSE 1003	(2020) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1010	(2021) Performance Requirements for Water Hammer Arresters
ASSE 1011	(2017) Performance Requirements for Hose Connection Vacuum Breakers
ASSE 1012	(2021) Performance Requirements for Backflow Preventer with an Intermediate Atmospheric Vent
ASSE 1013	(2021) Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies

ASSE 1018	(2001; R 2021) Performance Requirements for Trap Seal Primer Valves - Potable Water Supplied (ANSI Approved 2002
ASSE 1019	(2011; R 2016) Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance
ASSE 1020	(2020) Performance Requirements for Pressure Vacuum Breaker Assemblies
ASSE 1037	(2015; R 2020) Performance Requirements for Pressurized Flushing Devices for Plumbing Fixtures

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(2018) Hypochlorites
AWWA B301	(2018) Liquid Chlorine
AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C606	(2015) Grooved and Shouldered Joints
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C652	(2019) Disinfection of Water-Storage Facilities
AWWA C700	(2020) Cold-Water Meters - Displacement Type, Metal Alloy Main Case
AWWA C701	(2019) Cold-Water Meters - Turbine Type for Customer Service
AWWA D100	(2021) Welded Steel Tanks for Water Storage

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.2/B2.2M	(2016) Specification for Brazing Procedure and Performance Qualification

ASSOCIATION OF POOL & SPA PROFESSIONALS (APSP)

ANSI/APSP-16	(2011) Standard Suction Fittings for Use in Swimming Pools, Wading Pools, Spas, and Hot Tubs

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A74	(2021) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A515/A515M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A518/A518M	(1999; R 2018) Standard Specification for Corrosion-Resistant High-Silicon Iron Castings
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM A888	(2021a) Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B43	(2020) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B75/B75M	(2020) Standard Specification for Seamless

	Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B111/B111M	(2018) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B306	(2020) Standard Specification for Copper Drainage Tube (DWV)
ASTM B370	(2022) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B584	(2014; R 2022) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B828	(2016) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM C564	(2020a) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C1053	(2000; R 2010) Standard Specification for Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D1004	(2013) Initial Tear Resistance of Plastic Film and Sheeting
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe,

	Schedules 40, 80, and 120
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2235	(2004; R 2016) Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
ASTM D2239	(2012) Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2464	(2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007; R 2015) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D2661	(2014; E 2018) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40, Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2672	(2014) Joints for IPS PVC Pipe Using Solvent Cement
ASTM D2683	(2020) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2737	(2012a) Polyethylene (PE) Plastic Tubing
ASTM D2822/D2822M	(2005; R 2011; E 2011) Standard Specification for Asphalt Roof Cement, Asbestos-Containing

ASTM D2846/D2846M	(2019) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3035	(2015) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3122	(1995; R 2009) Solvent Cements for Styrene-Rubber (SR) Plastic Pipe and Fittings
ASTM D3138	(2004; R 2016) Standard Specification for Solvent Cements for Transition Joints Between Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Non-Pressure Piping Components
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3311	(2017) Standard Specification for Drain, Waste, and Vent (DWV) Plastic Fittings Patterns
ASTM D4101	(2017) Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials
ASTM D4551	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E96/E96M	(2022) Standard Test Methods for Gravimetric Determination ofWater Vapor

	Transmission Rate of Materials
ASTM F409	(2017) Standard Specification for Thermoplastic Accessible and Replaceable Plastic Tube and Tubular Fittings
ASTM F437	(2021) Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438	(2017) Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F439	(2019) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F441/F441M	(2020) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F442/F442M	(2020) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F493	(2020) Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F628	(2022) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe with a Cellular Core
ASTM F877	(2020) Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems
ASTM F891	(2016) Standard Specification for Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core
ASTM F1290	(2019) Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings
ASTM F1760	(2016; R 2020) Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content
ASTM F2387	(2021) Standard Specification for Manufactured Safety Vacuum Release Systems (SVRS) for Swimming Pools, Spas, and Hot

	Tubs
ASTM F2389	(2021) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

CAST IRON SOIL PIPE INSTITUTE (CISPI)

CISPI 301	(2018) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
CISPI 310	(2012) Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2016; 14/17) Copper Tube Handbook

CSA GROUP (CSA)

CSA B45.5-17/IAPMO Z124	(2017; Errata 2017; Errata 2018) Plastic Plumbing Fixtures

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO PS 117	(2005b) Press Type Or Plain End Rub Gasketed W/ Nail CU & CU Alloy Fittings 4 Install On CU Tubing
IAPMO Z124.8	(1990) Plastic Bathtub Liners

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities
ICC IPC	(2018) International Plumbing Code

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)

ANSI/ISEA Z358.1	(2014) American National Standard for Emergency Eyewash and Shower Equipment

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-44	(2019) Steel Pipeline Flanges
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MSS SP-67	(2017; Errata 1 2017) Butterfly Valves
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	(2014) Class 3000 Steel Pipe Unions Socket Welding and Threaded
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NACE INTERNATIONAL (NACE)

NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2020) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2021) National Fuel Gas Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF 372	(2016) Drinking Water System Components - Lead Content

NSF/ANSI 14	(2021) Plastics Piping System Components and Related Materials
NSF/ANSI 61	(2020) Drinking Water System Components - Health Effects

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

PPFA Fire Man	(2016) Firestopping: Plastic Pipe in Fire Resistive Construction

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI G 101	(2010) Testing and Rating Procedure for Hydro Mechanical Grease Interceptors with Appendix of Installation and Maintenance
PDI WH 201	(2010) Water Hammer Arresters Standard

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1508	(2009) Hose Clamp Specifications

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

PL 93-523	(1974; A 1999) Safe Drinking Water Act

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 430	Energy Conservation Program for Consumer Products
21 CFR 175	Indirect Food Additives: Adhesives and Components of Coatings
40 CFR 141.80	National Primary Drinking Water Regulations; Control of Lead and Copper; General Requirements

UNDERWRITERS LABORATORIES (UL)

UL 174	(2004; Reprint Dec 2021) UL Standard for Safety Household Electric Storage Tank Water Heaters
UL 499	(2014; Reprint Jun 2022) UL Standard for Safety Electric Heating Appliances
UL 732	(2018; Reprint Aug 2018) UL Standard for Safety Oil-Fired Storage Tank Water Heaters
UL 1951	(2011; Reprint Jun 2020) UL Standard for Safety Electric Plumbing Accessories

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Plumbing System; G

Detail drawings consisting of schedules, performance charts, instructions, diagrams, and other information to illustrate the requirements and operations of systems that are not covered by the Plumbing Code. Detail drawings for the complete plumbing system including piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams and wiring diagrams or connection and interconnection diagrams. Detail drawings shall indicate clearances required for maintenance and operation. Where piping and equipment are to be supported other than as indicated, details shall include loadings and proposed support methods. Mechanical drawing plans, elevations, views, and details, shall be drawn to scale.

SD-03 Product Data

Recycled Content for Steel Pipe; S

Recycled Content for Cast Iron Pipe; S

Backflow Prevention Assemblies; G

Shower Faucets; G

Swimming Pool Suction Fittings; G

WaterSense Label for Lavatory Faucet; S

Fixtures

List of installed fixtures with manufacturer, model, and flow rate.

Flush Valve Water Closets

WaterSense Label for Flush Valve Water Closet; S

Flush Valve Urinals

WaterSense Label for Urinal; S

Flush Tank Water Closets

WaterSense Label for Flush Tank Water Closet; S

Wall Hung Lavatories

Countertop Lavatories

Kitchen Sinks

Service Sinks

Drinking-Water Coolers; G

Energy Star Label for Electric Water Cooler; S

Energy Star Label for Wheelchair Electric Water Cooler; S

WaterSense Label for Showerhead; S

Plastic Bathtubs

Plastic Shower Stalls

Plastic Bathtub Liners

Plastic Bathtub Wall Surrounds

Water Heaters; G

Energy Star Label for Gas Storage Water Heater; S

Energy Star Label for Gas Instantaneous Water Heater; S

Pumps; G

Pool Water Pump Safety Vacuum Release System; G

Welding

A copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

Vibration-Absorbing Features; G

Details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

Plumbing System

Diagrams, instructions, and other sheets proposed for posting. Manufacturer's recommendations for the installation of bell and spigot and hubless joints for cast iron soil pipe.

SD-06 Test Reports

Tests, Flushing and Disinfection

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Each test report shall indicate the final position of controls.

Test of Backflow Prevention Assemblies; G.

Certification of proper operation shall be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, the Contractor shall have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. The Contractor shall provide written documentation of the tests performed and signed by the individual performing the tests.

SD-07 Certificates

Materials and Equipment

Where equipment is specified to conform to requirements of the ASME Boiler and Pressure Vessel Code, the design, fabrication, and installation shall conform to the code.

Bolts

Written certification by the bolt manufacturer that the bolts furnished comply with the specified requirements.

SD-10 Operation and Maintenance Data

Plumbing System; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.3 STANDARD PRODUCTS

Specified materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products. Specified equipment shall essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.1 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.2 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.3 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.3.4 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.3.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 PERFORMANCE REQUIREMENTS

1.5.1 Welding

Piping shall be welded in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. The

Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practicable. Welders or welding operators shall apply their assigned symbols near each weld they make as a permanent record. Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING. Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING. Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

1.5.2 Cathodic Protection and Pipe Joint Bonding

Cathodic protection and pipe joint bonding systems shall be in accordance with Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM.

1.6 REGULATORY REQUIREMENTS

Unless otherwise required herein, plumbing work shall be in accordance with ICC IPC.

1.7 PROJECT/SITE CONDITIONS

The Contractor shall become familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.8 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.9 ACCESSIBILITY OF EQUIPMENT

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 MATERIALS

Materials for various services shall be in accordance with TABLES I and II.

Cement pipe shall contain recycled content as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Steel pipe shall contain a minimum of 25 percent recycled content, with a minimum of 16 percent post-consumer recycled content. Provide data identifying percentage of recycled content for steel pipe. Pipe schedules shall be selected based on service requirements. Pipe fittings shall be compatible with the applicable pipe materials. Plastic pipe, fittings, and solvent cement shall meet NSF/ANSI 14 and shall be NSF listed for the service intended. Plastic pipe, fittings, and solvent cement used for potable hot and cold water service shall bear the NSF seal "NSF-PW." Polypropylene pipe and fittings shall conform to dimensional requirements of Schedule 40, Iron Pipe size and shall comply with NSF/ANSI 14, NSF/ANSI 61 and ASTM F2389. Polypropylene piping that will be exposed to UV light shall be provided with a Factory applied UV resistant coating. Pipe threads (except dry seal) shall conform to ASME B1.20.1. Grooved pipe couplings and fittings shall be from the same manufacturer. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF/ANSI 61, Annex G or NSF 372. In line devices such as water meters, building valves, check valves, meter stops, valves, fittings and back flow preventers shall comply with PL 93-523 and NSF/ANSI 61, Section 8. End point devices such as drinking water fountains, lavatory faucets, kitchen and bar faucets, residential ice makers, supply stops and end point control valves used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9. Hubless cast-iron soil pipe shall not be installed underground, under concrete floor slabs, or in crawl spaces below kitchen floors. Cast-iron pipe shall contain a minimum of 95 percent recycled content. Provide data identifying percentage of recycled content for cast iron pipe. Plastic pipe shall not be installed in air plenums. Plastic pipe shall not be installed in a pressure piping system in buildings greater than three stories including any basement levels.

2.1.1 Pipe Joint Materials

Grooved pipe and hubless cast-iron soil pipe shall not be used underground. Solder containing lead shall not be used with copper pipe. Cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Institute. Joints and gasket materials shall conform to the following:

a. Coupling for Cast-Iron Pipe: for hub and spigot type ASTM A74, AWWA C606. For hubless type: CISPI 310

b. Coupling for Steel Pipe: AWWA C606.

c. Couplings for Grooved Pipe: Ductile Iron ASTM A536 (Grade 65-45-12) Malleable Iron ASTM A47/A47M, Grade 32510. Copper ASTM A536.

d. Flange Gaskets: Gaskets shall be made of non-asbestos material in accordance with ASME B16.21. Gaskets shall be flat, 1/16 inch thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Gaskets shall be the full face or self centering flat ring type. Gaskets used for hydrocarbon service shall be bonded with NBR.

e. Brazing Material: Brazing material shall conform to AWS A5.8/A5.8M, BCuP-5.

f. Brazing Flux: Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides; and contain fluorides.

g. Solder Material: Solder metal shall conform to ASTM B32.

h. Solder Flux: Flux shall be liquid form, non-corrosive, and conform to ASTM B813, Standard Test 1.

i. PTFE Tape: PTFE Tape, for use with Threaded Metal or Plastic Pipe.

j. Rubber Gaskets for Cast-Iron Soil-Pipe and Fittings (hub and spigot type and hubless type): ASTM C564.

k. Rubber Gaskets for Grooved Pipe: ASTM D2000, maximum temperature 230 degrees F.

l. Flexible Elastomeric Seals: ASTM D3139, ASTM D3212 or ASTM F477.

m. Bolts and Nuts for Grooved Pipe Couplings: Heat-treated carbon steel, ASTM A183.

n. Solvent Cement for Transition Joints between ABS and PVC Nonpressure Piping Components: ASTM D3138.

o. Plastic Solvent Cement for ABS Plastic Pipe: ASTM D2235.

p. Plastic Solvent Cement for PVC Plastic Pipe: ASTM D2564 and ASTM D2855.

q. Plastic Solvent Cement for CPVC Plastic Pipe: ASTM F493.

r. Flanged fittings including, but not limited to, flanges, bolts, nuts and bolt patterns shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A105/A105M. Blind flange material shall conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A193/A193M.

s. Plastic Solvent Cement for Styrene Rubber Plastic Pipe: ASTM D3122.

t. Press fittings for Copper Pipe and Tube: Copper press fittings shall conform to the material and sizing requirements of ASME B16.51 and performance criteria of IAPMO PS 117. Sealing elements for copper press fittings shall be EPDM, FKM or HNBR. Sealing elements shall be factory installed or an alternative supplied fitting manufacturer. Sealing element shall be selected based on manufacturer's approved application guidelines.

u. Copper tubing shall conform to ASTM B88, Type K, L or M.

v. Heat-fusion joints for polypropylene piping: ASTM F2389.

2.1.2 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

a. Water Hammer Arrester: PDI WH 201.

b. Copper, Sheet and Strip for Building Construction: ASTM B370.

c. Asphalt Roof Cement: ASTM D2822/D2822M.

d. Hose Clamps: SAE J1508.

e. Supports for Off-The-Floor Plumbing Fixtures: ASME A112.6.1M.

f. Metallic Cleanouts: ASME A112.36.2M.

g. Plumbing Fixture Setting Compound: A preformed flexible ring seal molded from hydrocarbon wax material. The seal material shall be nonvolatile nonasphaltic and contain germicide and provide watertight, gastight, odorproof and verminproof properties.

h. Coal-Tar Protective Coatings and Linings for Steel Water Pipelines: AWWA C203.

i. Hypochlorites: AWWA B300.

j. Liquid Chlorine: AWWA B301.

k. Gauges - Pressure and Vacuum Indicating Dial Type - Elastic Element: ASME B40.100.

l. Thermometers: ASTM E1. Mercury shall not be used in thermometers.

2.1.3 Pipe Insulation Material

Insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

Pipe hangers, inserts, and supports shall conform to MSS SP-58.

2.3 VALVES

Valves shall be provided on supplies to equipment and fixtures. Valves 2-1/2 inches and smaller shall be bronze with threaded bodies for pipe and solder-type connections for tubing. Valves 3 inches and larger shall have flanged iron bodies and bronze trim. Pressure ratings shall be based upon the application. Grooved end valves may be provided if the manufacturer certifies that the valves meet the performance requirements of applicable MSS standard. Valves shall conform to the following standards:

Description	Standard
Butterfly Valves	MSS SP-67
Cast-Iron Gate Valves, Flanged and Threaded Ends	MSS SP-70
Cast-Iron Swing Check Valves, Flanged and Threaded Ends	MSS SP-71

Ball Valves with Flanged Butt-Welding Ends for General Service	MSS SP-72
Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends	MSS SP-110
Cast-Iron Plug Valves, Flanged and Threaded Ends	MSS SP-78
Bronze Gate, Globe, Angle, and Check Valves	MSS SP-80
Steel Valves, Socket Welding and Threaded Ends	ASME B16.34
Cast-Iron Globe and Angle Valves, Flanged and Threaded Ends	MSS SP-85
Backwater Valves	ASME A112.14.1
Vacuum Relief Valves	ANSI Z21.22/CSA 4.4
Water Pressure Reducing Valves	ASSE 1003
Water Heater Drain Valves	ASME BPVC SEC IV, Part HLW-810: Requirements for Potable-Water Heaters Bottom Drain Valve
Trap Seal Primer Valves	ASSE 1018
Temperature and Pressure Relief Valves for Hot Water Supply Systems	ANSI Z21.22/CSA 4.4
Temperature and Pressure Relief Valves for Automatically Fired Hot Water Boilers	ASME CSD-1 Safety Code No., Part CW, Article 5

2.3.1 Backwater Valves

Backwater valves shall be either separate from the floor drain or a combination floor drain, P-trap, and backwater valve, as shown. Valves shall have cast-iron bodies with cleanouts large enough to permit removal of interior parts. Valves shall be of the flap type, hinged or pivoted, with revolving disks. Hinge pivots, disks, and seats shall be nonferrous metal. Disks shall be slightly open in a no-flow no-backwater condition. Cleanouts shall extend to finished floor and be fitted with threaded countersunk plugs.

2.3.2 Wall Faucets

Wall faucets with vacuum-breaker backflow preventer shall be brass with 3/4 inch male inlet threads, hexagon shoulder, and 3/4 inch hose connection. Faucet handle shall be securely attached to stem.

2.3.3 Wall Hydrants (Frostproof)

ASSE 1019 with vacuum-breaker backflow preventer shall have a nickel-brass or nickel-bronze wall plate or flange with nozzle and detachable key handle. A brass or bronze operating rod shall be provided within a galvanized iron casing of sufficient length to extend through the wall so that the valve is inside the building, and the portion of the hydrant between the outlet and valve is self-draining. A brass or bronze valve with coupling and union elbow having metal-to-metal seat shall be provided. Valve rod and seat washer shall be removable through the face of the hydrant. The hydrant shall have 3/4 inch exposed hose thread on spout and 3/4 inch male pipe thread on inlet.

2.3.4 Lawn Faucets

Lawn faucets shall be brass, with either straight or angle bodies, and shall be of the compression type. Body flange shall be provided with internal pipe thread to suit 3/4 inch pipe. Body shall be suitable for wrench grip. Faucet spout shall have 3/4 inch exposed hose threads. Faucet handle shall be securely attached to stem.

2.3.5 Yard Hydrants

Yard box or post hydrants shall have valve housings located below frost lines. Water from the casing shall be drained after valve is shut off. Hydrant shall be bronze with cast-iron box or casing guard. "T" handle key shall be provided.

2.3.6 Relief Valves

Water heaters and hot water storage tanks shall have a combination pressure and temperature (P&T) relief valve. The pressure relief element of a P&T relief valve shall have adequate capacity to prevent excessive pressure buildup in the system when the system is operating at the maximum rate of heat input. The temperature element of a P&T relief valve shall have a relieving capacity which is at least equal to the total input of the heaters when operating at their maximum capacity. Relief valves shall be rated according to ANSI Z21.22/CSA 4.4. Relief valves for systems where the maximum rate of heat input is less than 200,000 Btuh shall have 3/4 inch minimum inlets, and 3/4 inch outlets. Relief valves for systems where the maximum rate of heat input is greater than 200,000 Btuh shall have 1 inch minimum inlets, and 1 inch outlets. The discharge pipe from the relief valve shall be the size of the valve outlet.

2.3.7 Thermostatic Mixing Valves

Provide thermostatic mixing valve for lavatory faucets. Mixing valves, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced shall be line size and shall be constructed with rough or finish bodies either with or without plating. Each valve shall be constructed to control the mixing of hot and cold water and to deliver water at a desired temperature regardless of pressure or input temperature changes. The control element shall be of an approved type. The body shall be of heavy cast bronze, and interior parts shall be brass, bronze, corrosion-resisting steel or copper. The valve shall be equipped with necessary stops, check valves, unions, and sediment strainers on the inlets. Mixing valves shall maintain water temperature within 5 degrees F of any setting.

2.4 FIXTURES

Water closet replacements in major renovations may have a flush valve of up to 1.6 GPF to accommodate existing plumbing capacity. Fixtures for use by the physically handicapped shall be in accordance with ICC A117.1. Vitreous China, nonabsorbent, hard-burned, and vitrified throughout the body shall be provided. Porcelain enameled ware shall have specially selected, clear white, acid-resisting enamel coating evenly applied on surfaces. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings. Each fixture and piece of equipment requiring connections to the drainage system, except grease interceptors, shall be equipped with a trap. Brass expansion or toggle bolts capped with acorn nuts shall be provided for supports, and polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Internal parts of flush valves and flushometer valves, shower mixing valves, shower head face plates, pop-up stoppers of lavatory waste drains, and pop-up stoppers and overflow tees and shoes of bathtub waste drains may contain acetal resin, fluorocarbon, nylon, acrylonitrile-butadiene-styrene (ABS) or other plastic material, if the material has provided satisfactory service under actual commercial or industrial operating conditions for not less than 2 years]. Plastic in contact with hot water shall be suitable for 180 degrees F water temperature.

2.4.1 Lavatories

Provide WaterSense labeled faucet with a maximum flow rate of 0.5 gpm at a flowing pressure of 60 psi. Water volume must be limited to 0.25 gal per metering cycle. Provide data identifying WaterSense label for lavatory faucet.

2.4.2 Automatic Controls

Provide automatic, sensor operated faucets and flush valves to comply with ASSE 1037 and UL 1951 for lavatory faucets, urinals, and water closets. Flushing and faucet systems shall consist of solenoid-activated valves with light beam sensors. Flush valve for water closet shall include an override pushbutton. Flushing devices shall be provided as described in paragraph FIXTURES AND FIXTURE TRIMMINGS.

2.4.3 Flush Valve Water Closets

ASME A112.19.2/CSA B45.1, white vitreous china, siphon jet, elongated bowl, floor-mounted, floor outlet. Top of toilet seat height above floor shall be 14 to 15 inches, except 17 to 19 inches for wheelchair water closets. Provide wax bowl ring including plastic sleeve. Provide white solid plastic elongated open-front seat .

Water flushing volume of the water closet and flush valve combination shall not exceed 1.28 gallons per flush. Water closets must meet the EPA WaterSense product definition specified in http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for flush valve water closet.

Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be nonhold-open type. Mount flush valves not less than 11 inches above the fixture. Mounted height of flush valve shall not interfere with the hand rail in ADA stalls.

2.4.4 Flush Valve Urinals

ASME A112.19.2/CSA B45.1, white vitreous china, ,wall-mounted, wall outlet, siphon jet, integral trap, and extended side shields. Provide urinal with the rim 17 inches above the floor. Provide urinal with the rim 24 inches above the floor. Water flushing volume of the urinal and flush valve combination shall not exceed 0.5 gallons per flush. Urinals must meet the specifications of http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for urinal. Provide ASME A112.6.1M concealed chair carriers with vertical steel pipe supports. Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be nonhold-open type. Mount flush valves not less than 11 inches above the fixture.

2.4.5 Wheelchair Flush Valve Type Urinals

ASME A112.19.2/CSA B45.1, white vitreous china, ,wall-mounted, wall outlet, blowout action, integral trap, elongated projecting bowl, 20 inches long from wall to front of flare, and ASME A112.19.5 trim. Provide large diaphragm (not less than 2.625 inches upper chamber inside diameter at the point where the diaphragm is sealed between the upper and lower chambers), nonhold-open flush valve of chrome plated cast brass conforming to ASTM B584, including vacuum breaker and angle (control-stop) valve with back check. The water flushing volume of the flush valve and urinal combination shall not exceed 0.5 gallon per flush. Urinals must meet the specifications of http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for wheelchair flush valve urinal. Furnish urinal manufacturer's certification of conformance. Provide ASME A112.6.1M concealed chair carriers. Mount urinal with front rim a maximum of 17 inches above floor and flush valve handle a maximum of 44 inches above floor for use by handicapped on wheelchair. Provide solenoid-activated flush valves including electrical-operated light-beam-sensor to energize the solenoid.

2.4.6 Flush Tank Water Closets

ASME A112.19.2/CSA B45.1, white vitreous china, , siphon jet, round bowl, pressure assisted, floor-mounted, floor outlet. Top of toilet seat height above floor shall be 14 to 15 inches, except 17 to 19 inches for wheelchair water closets. Provide wax bowl ring including plastic sleeve. Water flushing volume of the water closet shall not exceed 1.28 gallons per flush. Tank-type water closets must meet the specifications of http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for flush tank water closet. Provide white solid plastic round closed-front seat with cover.

2.4.7 Wall Hung Lavatories

ASME A112.19.2/CSA B45.1, white vitreous china, ,straight back type, minimum dimensions of 19 inches, wide by 17 inches front to rear, with supply openings for use with top mounted centerset faucets, and openings for concealed arm carrier installation.Provide lavatory faucets and accessories meeting the flow rate and product requirements of the paragraph LAVATORIES. Provide ASME A112.6.1M concealed chair carriers with vertical steel pipe supports and concealed arms for the lavatory. Mount lavatory with the front rim 34 inches above floor and with 29 inches minimum clearance from bottom of the front rim to floor. Provide top mounted washerless centerset lavatory faucets.

2.4.8 Countertop Lavatories

ASME A112.19.2/CSA B45.1, white vitreous china, ,self-rimming, minimum dimensions of 19 inches wide by 17 inches front to rear, with supply openings for use with top mounted centerset faucets. Furnish template and mounting kit by lavatory manufacturer.Provide lavatory faucets and accessories meeting the flow rate and product requirements of the paragraph LAVATORIES. Mount counter with the top surface 34 inches above floor and with 29 inches minimum clearance from bottom of the counter face to floor. Provide top mounted washerless centerset lavatory faucets.

2.4.9 Kitchen Sinks

ASME A112.19.3/CSA B45.4, 20 gage stainless steel with integral mounting rim for flush installation, minimum dimensions of 33 inches wide by 21 inches front to rear, two compartments, with undersides fully sound deadened, with supply openings for use with top mounted washerless sink faucets with hose spray, and with 3.5 inch drain outlet.Water flow rate shall not exceed 2.2 gpm when measured at a flowing water pressure of 60 psi. Provide stainless steel drain outlets and stainless steel cup strainers. Provide separate 1.5 inch P-trap and drain piping to vertical vent piping from each compartment. Provide top mounted washerless sink faucets with hose spray.

2.4.10 Service Sinks

ASME A112.19.2/CSA B45.1, white vitreous china with integral back and wall hanger supports, minimum dimensions of 22 inches wide by 20 inches front to rear, with two supply openings in 10 inch high back. Provide floor supported wall outlet cast iron P-trap and stainless steel rim guards as recommended by service sink manufacturer. Provide back mounted washerless service sink faucets with vacuum breaker and 0.75 inch external hose threads.

2.4.11 Drinking-Water Coolers

AHRI 1010 with more than a single thickness of metal between the potable water and the refrigerant in the heat exchanger, wall-hung, bubbler style, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor and basin, bottle filler and stainless steel cabinet. Bubblers shall be controlled by push levers or push bars, front mounted or side mounted near the front edge of the cabinet. Bubbler spouts shall be mounted at maximum of 36 inches above floor and at front of unit basin. Spouts shall direct water flow at least 4 inches above unit basin and trajectory parallel or nearly parallel to the front of unit. Provide filters for chlorine in supply piping to faucets. Provide ASME A112.6.1M concealed steel pipe chair carriers. Provide electric water cooler that is Energy Star labeled. Provide data identifying Energy Star label for electric water cooler.

2.4.12 Wheelchair Drinking Water cooler

AHRI 1010, wall-mounted bubbler style with ASME A112.6.1M concealed chair carrier, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor, and all stainless steel cabinet, with 27 inch minimum knee clearance from front bottom of unit to floor and 36 inch maximum spout height above floor and bottle filler. Bubblers shall also be controlled by push levers, by push bars, or touch pads one on each side or one on front and both sides of the cabinet. Provide electric water cooler that is Energy Star labeled. Provide data identifying Energy Star label for wheelchair electric water cooler.

2.4.13 Plastic Bathtub/Shower Units

CSA B45.5-17/IAPMO Z124 four piece white solid acrylic pressure molded fiberglass reinforced plastic bathtub/shower units. Units shall be scratch resistant, waterproof, and reinforced. Provide showerheads meeting the requirements of the paragraph BATHTUB AND SHOWER FAUCETS AND DRAIN FITTINGS. Provide recessed type units approximately 60 inches wide, 30 inches front to rear, 72 inches high with 15 inches high rim for through-the-floor drain installation with unit bottom or feet firmly supported by a smooth level floor. Provide left or right drain outlet units as required. Units shall have built-in soap dish and minimum of 12 inch long stainless steel horizontal grab bar located on back wall for standing use. Units shall meet performance requirements of CSA B45.5-17/IAPMO Z124 and shall be labeled by NAHB Research Foundation, Inc. for compliance. Install unit in accordance with the manufacturer's written instructions. Finish installation by covering unit attachment flanges with wall board in accordance with unit manufacturer's recommendation. Provide smooth 100 percent silicone rubber white bathtub caulk between the unit and the adjacent walls and floor surfaces.

2.4.14 Plastic Bathtubs

CSA B45.5-17/IAPMO Z124 one piece white solid acrylic pressure molded fiberglass reinforced plastic bathtubs. Bathtubs shall be scratch resistant, waterproof, and reinforced. Provide recessed type bathtubs approximately 60 inches wide, 30 inches front to rear, 15 inches high rim for through-the-floor drain installation with bathtub bottom or feet firmly supported by a smooth level floor. Provide left or right drain outlet bathtub as required.Bathtubs shall meet performance requirements of CSA B45.5-17/IAPMO Z124 and shall be labeled by NAHB Research Foundation, Inc. for compliance. Install bathtub in accordance with the manufacturer's written instructions. Finish installation by covering bathtub attachment flanges with dry-wall in accordance with bathtub manufacturer's recommendation. Provide smooth 100 percent silicone rubber white bathtub caulk between the bathtub and the adjacent walls and floor surfaces.

2.4.15 Plastic Shower Stalls

CSA B45.5-17/IAPMO Z124 four piece white solid acrylic pressure molded fiberglass reinforced plastic shower stalls. Shower stalls shall be scratch resistant, waterproof, and reinforced. Provide showerheads meeting the requirements of the paragraph BATHTUB AND SHOWER FAUCETS AND DRAIN FITTINGS. Provide recessed type shower stalls approximately 36 inches wide, 36 inches front to rear, 76 inches high, and 5 inch high curb with shower stall bottom or feet firmly supported by a smooth level floor. Provide PVC shower floor drains and stainless steel strainers. Shower stalls shall meet performance requirements of CSA B45.5-17/IAPMO Z124 and shall be labeled by NAHB Research Foundation, Inc. for compliance. Install shower stall in accordance with the manufacturer's written instructions. Finish installation by covering shower stall attachment flanges with dry-wall in accordance with shower stall manufacturer's recommendation. Provide smooth 100 percent silicone rubber white bathtub caulk between the top, sides, and bottom of shower stalls and bathroom walls and floors.

2.4.16 Plastic Bathtub Liners

IAPMO Z124.8 one piece white plastic bathtub liners. Existing bathtubs shall be identified and measured to insure proper identification in order that each new bathtub liner shall be custom molded to fit the exact contours of the existing bathtubs. Provide left or right drain outlet bathtub liners as required. Bathtub liners shall be inserted over and into the existing bathtubs without disturbing the existing ceramic tile wainscot walls and existing floor material. Prepare the existing cast-iron bathtubs, ceramic tile wainscots, and floor to receive the new bathtub liners in accordance with the bathtub liner manufacturer's written instructions. Installation personnel shall be trained by the bathtub liner manufacturer. Seal the bathtub liner to existing bathtub with waterproof adhesive as required to keep moisture out from behind the bathtub liner. Provide smooth white waterproof bathtub sealant between bathtub drains, bathtub, and bathtub liners. Provide replacement chromium-plated overflow cover plates and push-pull bathtub drain stopper assembly. Provide smooth 100 percent silicone rubber white bathtub caulk between the bathtub liner and the adjacent walls and floor surfaces in accordance with the bathtub liners manufacturer's written instructions.

2.4.17 Plastic Bathtub Wall Surrounds

CSA B45.5-17/IAPMO Z124 three piece white sectional pressure molded fiberglass plastic bathtub wall surrounds suitable for installation with existing bathtubs which are approximately 60 inches wide by 30 inches front to rear. Wall surrounds shall have built-in soap dish and minimum of 12 inch long stainless steel horizontal grab bar located on back wall for standing use. Bathtub wall surrounds shall meet performance requirements of CSA B45.5-17/IAPMO Z124 and shall be labeled by NAHB Research Foundation, Inc. for compliance. Install bathtub wall surrounds in accordance with the manufacturers written instructions. Finish installation by covering bathtub wall surround attachment flanges with dry-wall in accordance with bathtub wall surround manufacturer's recommendations. Provide smooth 100 percent silicone rubber white bathtub caulk between the bathtubs and the adjacent walls and floor surfaces.

2.4.18 Precast Terrazzo Shower Floors

Terrazzo shall be made of marble chips cast in white portland cement to produce 3000 psi minimum compressive strength 7 days after casting. Provide floor or wall outlet copper alloy body drain cast integral with terrazzo, with polished stainless steel strainers.

2.4.19 Precast Terrazzo Mop Sinks

Terrazzo shall be made of marble chips cast in white portland cement to produce 3000 psi minimum compressive strength 7 days after casting. Provide floor or wall outlet copper alloy body drain cast integral with terrazzo, with polished stainless steel strainers.

2.4.20 Bathtubs, Cast Iron

ASME A112.19.1/CSA B45.2, white enameled cast iron, recessed type, minimum dimensions of 60 inches wide by 30 inches front to rear by 16 inches high with drain outlet for above-the-floor drain installation. Provide left or right drain outlet bathtub as indicated.

2.4.21 Bathtubs, Porcelain

ASME A112.19.1/CSA B45.2, white porcelain bonded to enameling grade metal, bonded to a structural composite, recessed type, minimum dimensions of 60 inches wide by 30 inches front to rear by 16 inches high with drain outlet for above-the-floor drain installation. Provide left or right drain outlet bathtub as indicated.

2.4.22 Emergency Eyewash and Shower

ANSI/ISEA Z358.1, floor supported free standing unit. Provide deluge shower head, stay-open ball valve operated by pull rod and ring or triangular handle. Provide eyewash and stay-open ball valve operated by foot treadle or push handle.

2.4.23 Emergency Eye and Face Wash

ANSI/ISEA Z358.1, wall-mounted self-cleaning, nonclogging eye and face wash with quick opening, full-flow valves, stainless steel eye and face wash receptor. Unit shall deliver 3 gpm of aerated water at 30 psig flow pressure, with eye and face wash nozzles 33 to 45 inches above finished floor. Provide copper alloy control valves. Provide an air-gap with the lowest potable eye and face wash water outlet located above the overflow rim by not less than the International Plumbing Code minimum.

2.5 BACKFLOW PREVENTERS

Backflow prevention devices must be approved by the State or local regulatory agencies. If there is no State or local regulatory agency requirements, the backflow prevention devices must be listed by the Foundation for Cross-Connection Control & Hydraulic Research, or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention devices and assemblies.

Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be meet the above requirements.

Backflow preventers with intermediate atmospheric vent shall conform to ASSE 1012. Reduced pressure principle backflow preventers shall conform to ASSE 1013. Hose connection vacuum breakers shall conform to ASSE 1011. Pipe applied atmospheric type vacuum breakers shall conform to ASSE 1001. Pressure vacuum breaker assembly shall conform to ASSE 1020. Air gaps in plumbing systems shall conform to ASME A112.1.2.

2.6 DRAINS

2.6.1 Floor and Shower Drains

Floor and shower drains shall consist of a galvanized body, integral seepage pan, and adjustable perforated or slotted chromium-plated bronze, nickel-bronze, or nickel-brass strainer, consisting of grate and threaded collar. Floor drains shall be cast iron except where metallic waterproofing membrane is installed. Drains shall be of double drainage pattern for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drainpipe. The strainer shall be adjustable to floor thickness. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane shall be provided when required. Drains shall be provided with threaded connection. Between the drain outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Floor and shower drains shall conform to ASME A112.6.3. Provide drain with trap primer connection, trap primer, and connection piping. Primer shall meet ASSE 1018.

2.6.1.1 Metallic Shower Pan Drains

Where metallic shower pan membrane is installed, polyethylene drain with corrosion-resistant screws securing the clamping device shall be provided. Polyethylene drains shall have fittings to adapt drain to waste piping. Polyethylene for floor drains shall conform to ASTM D1248. Drains shall have separate cast-iron "P" trap, circular body, seepage pan, and strainer, unless otherwise indicated.

2.6.1.2 Drains and Backwater Valves

Drains and backwater valves installed in connection with waterproofed floors or shower pans shall be equipped with bolted-type device to securely clamp flashing.

2.6.2 Bathtub and Shower Faucets and Drain Fittings

Provide single control pressure equalizing bathtub and shower faucets with body mounted from behind the wall with threaded connections. Provide ball joint self-cleaning shower heads. Provide WaterSense labeled showerhead with a maximum flow rate of (1.75 gpm). Provide data identifying WaterSense label for showerhead. Provide tubing mounted from behind the wall between bathtub faucets and shower heads and bathtub diverter spouts. Provide separate globe valves or angle valves with union connections in each supply to faucet. Provide trip-lever pop-up drain fittings for above-the-floor drain installations. The top of drain pop-ups, drain outlets, tub overflow outlet, and; control handle for pop-up drain shall be chromium-plated or polished stainless steel. Linkage between drain pop-up and pop-up control handle at bathtub overflow outlet shall be copper alloy or stainless steel. Provide 1.5 inch copper alloy adjustable tubing with slip nuts and gaskets between bathtub overflow and drain outlet; chromium-plated finish is not required.

2.6.3 Area Drains

Area drains shall be plain pattern with polished stainless steel perforated or slotted grate and bottom outlet. The drain shall be circular or square with a 12 inch nominal overall width or diameter and 10 inch nominal overall depth. Drains shall be cast iron with manufacturer's standard coating. Grate shall be easily lifted out for cleaning. Outlet shall be suitable for inside caulked connection to drain pipe. Drains shall conform to ASME A112.6.3.

2.6.4 Floor Sinks

Floor sinks shall be square, with 12 inch nominal overall width or diameter and 10 inch nominal overall depth. Floor sink shall have an acid-resistant enamel interior finish with cast-iron body, sediment bucket, and perforated grate of cast iron in industrial areas and stainless steel in finished areas. The outlet pipe size shall be as indicated or of the same size as the connecting pipe.

2.6.5 Boiler Room Drains

Boiler room drains shall have combined drain and trap, hinged grate, removable bucket, and threaded brass cleanout with brass backwater valve. The removable galvanized cast-iron sediment bucket shall have rounded corners to eliminate fouling and shall be equipped with hand grips. Drain shall have a minimum water seal of 4 inches. The grate area shall be not less than 100 square inches.

2.6.6 Pit Drains

Pit drains shall consist of a body, integral seepage pan, and nontilting perforated or slotted grate. Drains shall be of double drainage pattern suitable for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drain pipe. Membrane or flashing clamping device shall be provided when required. Drains shall be cast iron with manufacturer's standard coating. Drains shall be circular and provided with bottom outlet suitable for inside caulked connection, unless otherwise indicated. Drains shall be provided with separate cast-iron "P" traps, unless otherwise indicated.

2.6.7 Sight Drains

Sight drains shall consist of body, integral seepage pan, and adjustable strainer with perforated or slotted grate and funnel extension. The strainer shall have a threaded collar to permit adjustment to floor thickness. Drains shall be of double drainage pattern suitable for embedding in the floor construction. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or membrane shall be provided for other than concrete construction. Drains shall have a galvanized heavy cast-iron body and seepage pan and chromium-plated bronze, nickel-bronze, or nickel-brass strainer and funnel combination. Drains shall be provided with threaded connection and with a separate cast-iron "P" trap, unless otherwise indicated. Drains shall be circular, unless otherwise indicated. The funnel shall be securely mounted over an opening in the center of the strainer. Minimum dimensions shall be as follows:

Area of strainer and collar:	36 square inches
Height of funnel:	3-3/4 inches
Diameter of lower portion:	2 inches of funnel
Diameter of upper portion:	4 inches of funnel

2.6.8 Roof Drains and Expansion Joints

Roof drains shall conform to ASME A112.6.4, with dome and integral flange, and shall have a device for making a watertight connection between roofing and flashing. The whole assembly shall be galvanized heavy pattern cast iron. For aggregate surface roofing, the drain shall be provided with a gravel stop. On roofs other than concrete construction, roof drains shall be complete with underdeck clamp, sump receiver, and an extension for the insulation thickness where applicable. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or membrane shall be provided when required to suit the building construction. Strainer openings shall have a combined area equal to twice that of the drain outlet. The outlet shall be equipped to make a proper connection to threaded pipe of the same size as the downspout. An expansion joint of proper size to receive the conductor pipe shall be provided. The expansion joint shall consist of a heavy cast-iron housing, brass or bronze sleeve, brass or bronze fastening bolts and nuts, and gaskets or packing. The sleeve shall have a nominal thickness of not less than 0.134 inch. Gaskets and packing shall be close-cell neoprene, O-ring packing shall be close-cell neoprene of 70 durometer. Packing shall be held in place by a packing gland secured with bolts.

2.6.9 Swimming Pool Suction Fittings

Pool water suction fittings in swimming pools shall comply with ANSI/APSP-16. The compliance of the fitting shall include of the associated drain cover, sump, and hardware. The fitting shall be permanently marked to indicate compliance with the ASME standard, or permanently marked with the symbol "VGB 2008".

2.7 SHOWER PAN

Shower pan may be copper, or nonmetallic material.

2.7.1 Sheet Copper

Sheet copper shall be 16 ounce weight.

2.7.2 Plasticized Polyvinyl Chloride Shower Pan Material

Material shall be sheet form. The material shall be 0.040 inch minimum thickness of plasticized polyvinyl chloride or chlorinated polyethylene and shall be in accordance with ASTM D4551.

2.7.3 Nonplasticized Polyvinyl Chloride (PVC) Shower Pan Material

Material shall consist of a plastic waterproofing membrane in sheet form. The material shall be 0.040 inch minimum thickness of nonplasticized PVC and shall have the following minimum properties:

a. or ASTM D638:

Ultimate Tensile Strength:	2600 psi
Ultimate Elongation:	398 percent
100 Percent Modulus:	445 psi

b. ASTM D1004:

Tear Strength:	300 pounds per inch

c. ASTM E96/E96M:

Permeance:	0.008 perms

d. Other Properties:

Specific Gravity:	1.29
PVC Solvent:	Weldable
Cold Crack:	minus 53 degrees F
Dimensional stability	212 degrees F minus 2.5 percent
Hardness, Shore A:	89

2.8 TRAPS

Unless otherwise specified, traps shall be plastic per ASTM F409 or copper-alloy adjustable tube type with slip joint inlet and swivel. Traps shall be without a cleanout.Tubes shall be copper alloy with walls not less than 0.032 inch thick within commercial tolerances, except on the outside of bends where the thickness may be reduced slightly in manufacture by usual commercial methods. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level. Swivel joints shall be below the discharge level and shall be of metal-to-metal or metal-to-plastic type as required for the application. Nuts shall have flats for wrench grip. Outlets shall have internal pipe thread, except that when required for the application, the outlets shall have sockets for solder-joint connections. The depth of the water seal shall be not less than 2 inches. The interior diameter shall be not more than 1/8 inch over or under the nominal size, and interior surfaces shall be reasonably smooth throughout. A copper alloy "P" trap assembly consisting of an adjustable "P" trap and threaded trap wall nipple with cast brass wall flange shall be provided for lavatories. The assembly shall be a standard manufactured unit and may have a rubber-gasketed swivel joint.

2.9 INTERCEPTORS

2.9.1 Grease Interceptor

Grease interceptor of the size indicated shall be of reinforced concrete, or precast concrete construction or equivalent capacity commercially available steel grease interceptor with removable three-section, 3/8 inch checker-plate cover, and shall be installed outside the building. Steel grease interceptor shall be installed in a concrete pit and shall be epoxy-coated to resist corrosion as recommended by the manufacturer. Interceptors shall be tested and rated in accordance with PDI G 101. Concrete shall have 3,000 psi minimum compressive strength at 28 days. Provide flow control fitting.

2.9.2 Oil Interceptor

Cast iron or welded steel, coated inside and outside with white acid resistant epoxy, with internal air relief bypass, bronze cleanout plug, double wall trap seal, removable combination pressure equalizing and flow diffusing baffle and sediment bucket, horizontal baffle, adjustable oil draw-off and vent connections on either side, gas and watertight gasketed nonskid cover, and flow control fitting.

2.9.3 Sand Interceptors

Sand interceptor of the size indicated shall be of reinforced concrete, or precast concrete construction with manufacturer's standard checker-plate cover, and shall be installed outside the building. Steel sand interceptor shall be installed in accordance with manufacturer's recommendations and shall be coated to resist corrosion as recommended by the manufacturer. Concrete shall have 3,000 psi minimum compressive strength at 28 days.

2.10 WATER HEATERS

Water heater types and capacities shall be as indicated. Each water heater shall have replaceable anodes. Each primary water heater shall have controls with an adjustable range that includes 90 to 160 degrees F. Each gas-fired water heater and booster water heater shall have controls with an adjustable range that includes 120 to 180 degrees F. Hot water systems utilizing recirculation systems shall be tied into building off-hour controls. The thermal efficiencies and standby heat losses shall conform to TABLE III in PART 3 of this Section for each type of water heater specified. The only exception is that storage water heaters and hot water storage tanks having more than 500 gallons storage capacity need not meet the standard loss requirement if the tank surface area is insulated to R-12.5 and if a standing light is not used. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. A factory pre-charged expansion tank shall be installed on the cold water supply to each water heater. Expansion tanks shall be specifically designed for use on potable water systems and shall be rated for 200 degrees F water temperature and 150 psi working pressure. The expansion tank size and acceptance volume shall be as indicated.

2.10.1 Automatic Storage Type

Heaters shall be complete with control system, control system, temperature gauge, and pressure gauge, and shall have ASME rated combination pressure and temperature relief valve.

2.10.1.1 Oil-Fired Type

Oil-fired type water heaters shall conform to UL 732.

2.10.1.2 Gas-Fired Type

Gas-fired water heaters shall conform to ANSI Z21.10.1/CSA 4.1 when input is 75,000 BTU per hour or less or ANSI Z21.10.3/CSA 4.3 for heaters with input greater than 75,000 BTU per hour.

2.10.1.3 Electric Type

Electric type water heaters shall conform to UL 174 with dual heating elements. Each element shall be 4.5 KW. The elements shall be wired so that only one element can operate at a time.

2.10.1.4 Indirect Heater Type

Steam and high temperature hot water (HTHW) heaters with storage system shall be the assembled product of one manufacturer, and be ASME tested and "U" stamped to code requirements under ASME BPVC SEC VIII D1. The storage tank shall be as specified in paragraph HOT-WATER STORAGE TANKS. The heat exchanger shall be double wall type that separates the potable water from the heat transfer medium with a space vented to the atmosphere in accordance with ICC IPC.

a. HTHW Energy Source: The heater element shall have a working pressure of 400 psig with water at a temperature of 400 degrees F. The heating surface shall be based on 1 square foot of heating surface to heat 20 gallons or more of water in 1 hour from 40 to 180 degrees F using hot water at a temperature of 350 degrees F. Carbon steel heads shall be used. Tubing shall conform to ASTM B111/B111M, Copper Alloy No. 706 (90-10 copper-nickel). Heating elements shall withstand an internal hydrostatic pressure of 600 psig for not less than 15 seconds without leaking or any evidence of damage.

b. Steam Energy Source: The heater element shall have a working pressure of 150 pounds per square inchgauge (psig) with steam at a temperature of 365 degrees F. The heating surface shall be based on 1 square foot of heating surface to heat 20 gallons or more of water in 1 hour from 40 to 180 degrees F using steam at atmospheric pressure. Cast ironorbronze heads shall be used. Tubing shall be light-drawn copper tubing conforming to ASTM B75/B75M. Heating elements shall withstand an internal hydrostatic pressure of 225 psig for not less than 15 seconds without leaking or any evidence of damage.

2.10.2 Instantaneous Water Heater

Heater shall be crossflow design with service water in the coil and steam or hot water in the shell. An integral internal controller shall be provided, anticipating a change in demand so that the final temperature can be maintained under all normal load conditions when used in conjunction with pilot-operated temperature control system. Normal load conditions shall be as specified by the manufacturer for the heater. Unit shall be manufactured in accordance with ASME BPVC SEC VIII D1, and shall be certified for 150 psi working pressure in the shell and 150 psi working pressure in the coils. Shell shall be carbon steel with copper lining. Heads shall be carbon steel plate with copper lining. Coils shall be copper . Shell shall have metal sheathed fiberglass insulation, combination pressure and temperature relief valve, and thermometer. Insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. For gas service, provide Energy Star labeled gas instantaneous water heater. Provide data identifying Energy Star label for gas instantaneous water heater.

2.10.3 Electric Instantaneous Water Heaters (Tankless)

UL 499 and UL listed flow switch activated, tankless electric instantaneous water heater for wall mounting below sink or lavatory.

2.10.4 Phenolic Resin Coatings for Heater Tubes

The phenolic resin coating system shall be applied at either the coil or coating manufacturer's factory in accordance with manufacturer's standard proven production process. The coating system shall be a product specifically intended for use on the material the water heating tubes/coils are made of and shall be acceptable for use in potable water systems. The coating system shall be capable of withstanding temperatures up to 400 degrees F dry bulb; and meet the requirements of 21 CFR 175.

The entire exterior surface of each coil shall be coated with phenolic resin coating system.

2.10.4.1 Standard Product

Provide a phenolic resin coating system that is a standard product of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship.

Standard products are defined as components and equipment that have been in satisfactory commercial or industrial use in similar applications of similar size for at least two years before bid opening.

Prior to this two year period, these standard products were sold on the commercial market using advertisements in manufacturers' catalogs or brochures. These manufacturers' catalogs, or brochures shall have been copyrighted documents or be identified with a manufacturer's document number.

2.11 HOT-WATER STORAGE TANKS

Hot-water storage tanks shall be constructed by one manufacturer, ASME stamped for the working pressure, and shall have the National Board (ASME) registration. The tank shall be cement-lined or glass-lined steel type in accordance with AWWA D100. The heat loss shall conform to TABLE III in PART 3 of this Section as determined by the requirements of ASHRAE 90.1 - IP. Each tank shall be equipped with a thermometer, conforming to ASTM E1, Type I, Class 3, Range C, style and form as required for the installation, and with 7 inch scale. Thermometer shall have a separable socket suitable for a 3/4 inch tapped opening. Tanks shall be equipped with a pressure gauge 6 inch minimum diameter face. Insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Storage tank capacity shall be as shown.

2.12 PUMPS

2.12.1 Sump Pumps

Sump pumps shall be of capacities indicated. The pumps shall be of the automatic, electric motor-driven, submerged type, complete with necessary control equipment and with a split or solid cast-iron or steel cover plate. The pumps shall be direct-connected by an approved flexible coupling to a vertical electric motor having a continuous oiling device or packed bearings sealed against dirt and moisture. Motors shall be totally enclosed, fan-cooled of sizes as indicated and shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. Each pump shall be fitted with a high-grade thrust bearing mounted above the floor. Each shaft shall have an alignment bearing at each end, and the suction inlet shall be between 3 and 6 inches above the sump bottom. The suction side of each pump shall have a strainer of ample capacity. A float switch assembly, with the switch completely enclosed in a NEMA 250, Type 1 enclosure, shall start and stop each motor at predetermined water levels. Duplex pumps shall be equipped with an automatic alternator to change the lead operation from one pump to the other, and for starting the second pump if the flow exceeds the capacity of the first pump. The discharge line from each pump shall be provided with a union or flange, a nonclog swing check valve, and a stop valve in an accessible location near the pump.

2.12.2 Circulating Pumps

Domestic hot water circulating pumps shall be electrically driven, single-stage, centrifugal, with mechanical seals, suitable for the intended service. Pump and motor shall be integrally mounted on a cast-iron or steel subbase, close-coupled with an overhung impeller,]. The shaft shall be one-piece, heat-treated, corrosion-resisting steel with impeller and smooth-surfaced housing of bronze.

Motor shall be totally enclosed, fan-cooled and shall have sufficient horsepower for the service required. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in cover.

Integral size motors shall be premium efficiency type in accordance with NEMA MG 1. Pump motors smaller than 1 hp Fractional horsepower pump motors shall have integral thermal overload protection in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Guards shall shield exposed moving parts.

2.12.3 Booster Pumps

2.12.3.1 Centrifugal Pumps

Horizontal split-case centrifugal-type booster pumps shall be furnished. The capacities shall be as shown, and the speed shall not exceed 1800 rpm. Pumps shall have a casing of close-grained iron or steel with smooth water passages. A gasket shall be provided between the upper and lower halves of the casing. Suction and discharge connections shall be flanged. Impellers shall be nonoverloading, bronze, balanced to eliminate vibration, and shall be keyed to corrosion-resisting steel shafts. The casings shall be fitted with bronze wearing or sealing rings. Bearings shall be cartridge type, enabling the entire rotating element to be removed without disturbing alignment or exposing the bearings to dirt, water, and other foreign matter. Pumps shall be provided with mechanical seals. Seal boxes shall be machined in the pump casing and at both sides of the pump, and shall be of sufficient depth to include a conventional bronze seal ring and rows of shaft packing. Bedplates shall be close-grain cast iron or steel with ribs and lugs, complete with foundation bolts, and shall have a drip lip with drain hole. Each pump shall be tested at the manufacturer's plant for operating characteristics at the rated capacity and under specified operating conditions. Test curves shall be furnished showing capacity in gpm, head in feet, efficiency, brake horsepower, and operation in parallel with similar pumps. Multiple pump installations shall have pump characteristics compatible for operation in parallel with similar pumps. The electric motor shall be sized for non-overload when operating at any point along the characteristic curve of the pump. Guards shall shield exposed belts and moving parts.

2.12.3.2 Controls

Each pump motor shall be provided with enclosed across-the-line-type magnetic controller complete in a NEMA 250 Type 1 enclosure with three position, "HAND-OFF-AUTOMATIC," selector switch in cover. Pumps shall be automatically started and stopped by float or pressure switches, as indicated. The pumps shall start and stop at the levels and pressures indicated. A multiposition sequence selector switch shall be provided so that any two pumps may be operated simultaneously keeping a third pump as a standby.

2.12.4 Flexible Connectors

Flexible connectors shall be provided at the suction and discharge of each pump that is 1 hp or larger. Connectors shall be constructed of neoprene, rubber, or braided bronze, with Class 150 standard flanges. Flexible connectors shall be line size and suitable for the pressure and temperature of the intended service.

2.12.5 Sewage Pumps

Provide single type duplex type with automatic controls to alternate the operation from one pump to the other pump and to start the second pump in the event the first pump cannot handle the incoming flow. Provide high water alarm and check valve.

2.13 WATER PRESSURE BOOSTER SYSTEM

2.13.1 Constant Speed Pumping System

Constant speed pumping system with pressure-regulating valves shall employ one lead pump for low flows, and one or more lag pumps for higher flows. Pressure-regulating valves shall be provided with nonslam check feature. The factory prepiped and prewired assembly shall be mounted on a steel frame, complete with pumps, motors, and automatic controls. The system capacity and capacity of individual pumps shall be as indicated. Current sensing relays shall provide staging of the pumps. The pumps shall be protected from thermal buildup, when running at no-flow, by a common thermal relief valve. Pressure gauges shall be mounted on the suction and discharge headers. The control panel shall bear the UL listing label for industrial control panels and shall be in a NEMA 250, Type 1 enclosure. The control panel shall include the following: No-flow shutdown; 7-day time clock; audiovisual alarm; external resets; manual alternation; magnetic motor controllers; time delays; transformer; current relays; "HAND-OFF-AUTOMATIC" switches for each pump; minimum run timers; low suction pressure cutout; and indicating lights for power on, individual motor overload, and low suction pressure. The control circuit shall be interlocked so that the failure of any controller shall energize the succeeding controller.

2.13.2 Hydro-Pneumatic Water Pressure System

An ASME code constructed tank stamped for 125 psig water working pressure shall be provided. The tank shall have a flexible diaphragm made of material conforming to FDA requirements for use with potable water and shall be factory precharged to meet required system pressure.

2.13.3 Variable Speed Pumping System

Variable speed pumping system shall provide system pressure by varying speed and number of operating pumps. The factory prepiped and prewired assembly shall be mounted on a steel frame complete with pumps, variable speed drives, motors, and controls. The variable speed drives shall be the oil-filled type capable of power transmission throughout their complete speed range without vibration, noise, or shock loading. Each variable speed drive shall be run-tested by the manufacturer for rated performance, and the manufacturer shall furnish written performance certification. System shall have suppressors to prevent noise transmission over electric feed lines. Required electrical control circuitry and system function sensors shall be supplied by the variable speed drive manufacturer. The primary power controls and magnetic motor controllers shall be installed in the motor control center. The sensors shall be located in the system to control drive speed as a function of constant system pressure at location indicated. Connection between the sensors and the variable speed drive controls shall be accomplished with copper wiring]. Controls shall be in NEMA 250, Type 1 enclosures.

2.14 COMPRESSED AIR SYSTEM

2.14.1 Air Compressors

Air compressor unit shall be a factory-packaged assembly, including phase as indicated, volt motor controls as indicated, switches, wiring, accessories, and motor controllers, in a NEMA 250, Type 1 enclosure. Tank-mounted air compressors shall be manufactured to comply with UL listing requirements. Air compressors shall have manufacturer's name and address, together with trade name, and catalog number on a nameplate securely attached to the equipment. Each compressor shall start and stop automatically at upper and lower pressure limits of the system . Guards shall shield exposed moving parts. Each duplex compressor system shall be provided with automatic alternation system. Each compressor motor shall be provided with an across-the-line-type magnetic controller, complete with low-voltage release. An intake air filter and silencer shall be provided with each compressor. Aftercooler and moisture separator shall be installed between compressors and air receiver to remove moisture and oil condensate before the air enters the receiver. Aftercoolers shall be either air- or water-cooled, as indicated. The air shall pass through a sufficient number of tubes to affect cooling. Tubes shall be sized to give maximum heat transfer. Water to unit shall be controlled by a solenoid or pneumatic valve, which opens when the compressors start and closes when the compressors shut down. Cooling capacity of the aftercooler shall be sized for the total capacity of the compressors. Means shall be provided for draining condensed moisture from the receiver by an automatic float type trap. Capacities of air compressors and receivers shall be as indicated.

2.14.2 Lubricated Compressors

Compressors shall be two-stage, V-belt drive, capable of operating continuously against their designed discharge pressure, and shall operate at a speed not in excess of 1800 rpm. Compressors shall have the capacity and discharge pressure indicated. Compressors shall be assembled complete on a common subbase. The compressor main bearings shall be either roller or ball. The discharge passage of the high pressure air shall be piped to the air receiver with a copper pipe or tubing. A pressure gauge calibrated to 150 psi and equipped with a gauge cock and pulsation dampener shall be furnished for installation adjacent to pressure switches.

2.14.3 Air Receivers

Receivers shall be designed for 200 psi working pressure. Receivers shall be factory air tested to 1-1/2 times the working pressure. Receivers shall be equipped with safety relief valves and accessories, including pressure gauges and automatic and manual drains. The outside of air receivers may be galvanized or supplied with commercial enamel finish. Receivers shall be designed and constructed in accordance with ASME BPVC SEC VIII D1 and shall have the design working pressures specified herein. A display of the ASME seal on the receiver or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code shall be provided.

2.14.4 Intake Air Supply Filter

Dry type air filter shall be provided having a collection efficiency of 99 percent of particles larger than 10 microns. Filter body and media shall withstand a maximum 125 psi, capacity as indicated.

2.14.5 Pressure Regulators

The air system shall be provided with the necessary regulator valves to maintain the desired pressure for the installed equipment. Regulators shall be designed for a maximum inlet pressure of 125 psi and a maximum temperature of 200 degrees F. Regulators shall be single-seated, pilot-operated with valve plug, bronze body and trim or equal, and threaded connections. The regulator valve shall include a pressure gauge and shall be provided with an adjustment screw for adjusting the pressure differential from 0 to 125 psi. Regulator shall be sized as indicated.

2.15 DOMESTIC WATER SERVICE METER

The requirements for metering and submetering are specified in Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

Cold water meters 2 inches and smaller shall be positive displacement type conforming to AWWA C700. Cold water meters 2-1/2 inches and larger shall be turbine type conforming to AWWA C701. Meter register may be round or straight reading type. Meter shall be provided with a pulse generator, remote readout register and all necessary wiring and accessories.

Meters must be connected to the base wide energy and utility monitoring and control system (if this system exists) using the installation's advanced metering protocols.

2.16 POOL WATER PUMP SAFETY VACUUM RELEASE SYSTEM (SVRS)

Safety vacuum release system (SVRS) shall meet the requirements specified in ASME A112.19.17, or ASTM F2387, as modified and supplemented by this specification. System shall include:

Vacuum monitoring at least 60 times per second.
Power supply monitoring at least 50 times per second.
Capable of integration with existing timer box.
Low vacuum sensing and alarm.
Maintenance override.
Power back-up.
Display of error readout.
Turns off power to pump in milliseconds upon detecting sudden vacuum change.
Multiple audible alarm capabilities for multiple harmful situations.

2.17 ELECTRICAL WORK

Provide electrical motor driven equipment specified complete with motors, motor starters, and controls as specified herein and in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, corresponding to the applications in accordance with NEMA MG 11. In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide polyphase, squirrel-cage medium induction motors with continuous ratings, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Controllers and contactors shall have auxiliary contacts for use with the controls provided. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers, including the required monitors and timed restart.

Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.18 MISCELLANEOUS PIPING ITEMS

2.18.1 Escutcheon Plates

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Provide chromium-plated on copper alloy plates or polished stainless steel finish in finished spaces. Provide paint finish on plates in unfinished spaces.

2.18.2 Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade, except where penetrating a membrane waterproof floor.

2.18.2.1 Sleeves in Masonry and Concrete

Provide steel pipe sleeves or schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2.18.2.2 Sleeves Not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

2.18.3 Pipe Hangers (Supports)

Provide MSS SP-58 Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

2.18.4 Nameplates

Provide 0.125 inch thick melamine laminated plastic nameplates, black matte finish with white center core, for equipment, gages, thermometers, and valves; valves in supplies to faucets will not require nameplates. Accurately align lettering and engrave minimum of 0.25 inch high normal block lettering into the white core. Minimum size of nameplates shall be 1.0 by 2.5 inches. Key nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule.

2.18.5 Labels

Provide labels for sensor operators at flush valves and faucets. Include the following information on each label:

a. Identification of the sensor and its operation with written description.

b. Range of the sensor.

c. Battery replacement schedule.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Piping located in air plenums shall conform to NFPA 90A requirements. Piping located in shafts that constitute air ducts or that enclose air ducts shall be noncombustible in accordance with NFPA 90A. Installation of plastic pipe where in compliance with NFPA may be installed in accordance with PPFA Fire Man. The plumbing system shall be installed complete with necessary fixtures, fittings, traps, valves, and accessories. Water and drainage piping shall be extended 5 feet outside the building, unless otherwise indicated. A full port ball valve and drain shall be installed on the water service line inside the building approximately 6 inches above the floor from point of entry. Piping shall be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown. Exterior underground utilities shall be at least 12 inches below the average local frost depth or as indicated on the drawings. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, the location of the end of each plumbing utility shall be marked with a stake or other acceptable means. Valves shall be installed with control no lower than the valve body.

3.1.1 Water Pipe, Fittings, and Connections

3.1.1.1 Utilities

The piping shall be extended to fixtures, outlets, and equipment. The hot-water and cold-water piping system shall be arranged and installed to permit draining. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with integral stops, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to fixtures, faucets, hydrants, shower heads, and flushing devices shall be anchored to prevent movement.

3.1.1.2 Cutting and Repairing

The work shall be carefully laid out in advance, and unnecessary cutting of construction shall be avoided. Damage to building, piping, wiring, or equipment as a result of cutting shall be repaired by mechanics skilled in the trade involved.

3.1.1.3 Protection of Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated. Safety guards shall be provided for exposed rotating equipment.

3.1.1.4 Mains, Branches, and Runouts

Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Structural portions of the building shall not be weakened. Aboveground piping shall run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 1/2 inch between finished covering on the different services. Bare and insulated water lines shall not bear directly against building structural elements so as to transmit sound to the structure or to prevent flexible movement of the lines. Water pipe shall not be buried in or under floors unless specifically indicated or approved. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted except for use in situations in which standard factory fabricated components are furnished to accommodate specific accepted installation practice. Change in direction shall be made with fittings, except that bending of pipe 4 inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be acceptable.

3.1.1.5 Pipe Drains

Pipe drains indicated shall consist of 3/4 inch hose bibb with renewable seat and gateor full port ball valve ahead of hose bibb. At other low points, 3/4 inch brass plugs or caps shall be provided. Disconnection of the supply piping at the fixture is an acceptable drain.

3.1.1.6 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of water pipe. Each hot-water and hot-water circulation riser shall have expansion loops or other provisions such as offsets and changes in direction where indicated and required. Risers shall be securely anchored as required or where indicated to force expansion to loops. Branch connections from risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Horizontal runs of pipe over 50 feet in length shall be anchored to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends. Sufficient flexibility shall be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining. If mechanical grooved pipe coupling systems are provided, the deviation from design requirements for expansion and contraction may be allowed pending approval of Contracting Officer.

3.1.1.7 Thrust Restraint

Plugs, caps, tees, valves and bends deflecting 11.25 degrees or more, either vertically or horizontally, in waterlines 4 inches in diameter or larger shall be provided with thrust blocks, where indicated, to prevent movement. Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 2000 psi after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of the thrust block shall be poured against undisturbed earth. The side of the thrust block not subject to thrust shall be poured against forms. The area of bearing will be as shown. Blocking shall be placed so that the joints of the fitting are accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.1.8 Commercial-Type Water Hammer Arresters

Commercial-type water hammer arresters shall be provided on hot- and cold-water supplies and shall be located as generally indicated, with precise location and sizing to be in accordance with PDI WH 201. Water hammer arresters, where concealed, shall be accessible by means of access doors or removable panels. Commercial-type water hammer arresters shall conform to ASSE 1010. Vertical capped pipe columns will not be permitted.

3.1.2 Compressed Air Piping (Non-Oil Free)

Compressed air piping shall be installed as specified for water piping and suitable for 125 psig working pressure. Compressed air piping shall have supply lines and discharge terminals legibly and permanently marked at both ends with the name of the system and the direction of flow.

3.1.3 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints shall be made up with fittings of compatible material and made for the specific purpose intended.

3.1.3.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to ASME B1.20.1. Only male pipe threads shall be coated with graphite or with an approved graphite compound, or with an inert filler and oil, or shall have a polytetrafluoroethylene tape applied.

3.1.3.2 Mechanical Couplings

Mechanical couplings may be used in conjunction with grooved pipe for aboveground, ferrous or non-ferrous, domestic hot and cold water systems, in lieu of unions, brazed, soldered, welded, flanged, or threaded joints.

Mechanical couplings are permitted in accessible locations including behind access plates. Flexible grooved joints will not be permitted, except as vibration isolators adjacent to mechanical equipment. Rigid grooved joints shall incorporate an angle bolt pad design which maintains metal-to-metal contact with equal amount of pad offset of housings upon installation to ensure positive rigid clamping of the pipe.

Designs which can only clamp on the bottom of the groove or which utilize gripping teeth or jaws, or which use misaligned housing bolt holes, or which require a torque wrench or torque specifications will not be permitted.

Grooved fittings and couplings, and grooving tools shall be provided from the same manufacturer. Segmentally welded elbows shall not be used. Grooves shall be prepared in accordance with the coupling manufacturer's latest published standards. Grooving shall be performed by qualified grooving operators having demonstrated proper grooving procedures in accordance with the tool manufacturer's recommendations.

The Contracting Officer shall be notified 24 hours in advance of test to demonstrate operator's capability, and the test shall be performed at the work site, if practical, or at a site agreed upon. The operator shall demonstrate the ability to properly adjust the grooving tool, groove the pipe, and to verify the groove dimensions in accordance with the coupling manufacturer's specifications.

3.1.3.3 Unions and Flanges

Unions, flanges and mechanical couplings shall not be concealed in walls, ceilings, or partitions. Unions shall be used on pipe sizes 2-1/2 inches and smaller; flanges shall be used on pipe sizes 3 inches and larger.

3.1.3.4 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations.

3.1.3.5 Cast Iron Soil, Waste and Vent Pipe

Bell and spigot compression and hubless gasketed clamp joints for soil, waste and vent piping shall be installed per the manufacturer's recommendations.

3.1.3.6 Copper Tube and Pipe

a. Brazed. Brazed joints shall be made in conformance with AWS B2.2/B2.2M, ASME B16.50, and CDA A4015 with flux and are acceptable for all pipe sizes. Copper to copper joints shall include the use of copper-phosphorus or copper-phosphorus-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorus, copper-phosphorus-silver or a silver brazing filler metal.

b. Soldered. Soldered joints shall be made with flux and are only acceptable for piping 2 inches and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015. Soldered joints shall not be used in compressed air piping between the air compressor and the receiver.

c. Copper Tube Extracted Joint. Mechanically extracted joints shall be made in accordance with ICC IPC.

d. Press connection. Copper press connections shall be made in **strict** accordance with the manufacturer's installation instructions for manufactured rated size. The joints shall be pressed using the tool(s) approved by the manufacturer **of that joint**. Minimum distance between fittings shall be in accordance with the manufacturer's requirements.

3.1.3.7 Plastic Pipe

Acrylonitrile-Butadiene-Styrene (ABS) pipe shall have joints made with solvent cement. PVC and CPVC pipe shall have joints made with solvent cement elastomeric, threading, (threading of Schedule 80 Pipe is allowed only where required for disconnection and inspection; threading of Schedule 40 Pipe is not allowed), or mated flanged.

3.1.3.8 Glass Pipe

Joints for corrosive waste glass pipe and fittings shall be made with corrosion-resisting steel compression-type couplings with acrylonitrile rubber gaskets lined with polytetrafluoroethylene.

3.1.3.9 Corrosive Waste Plastic Pipe

Joints for polyolefin pipe and fittings shall be made by mechanical joint or electrical fusion coil method in accordance with ASTM D2657 and ASTM F1290. Joints for filament-wound reinforced thermosetting resin pipe shall be made in accordance with manufacturer's instructions. Unions or flanges shall be used where required for disconnection and inspection.

3.1.3.10 Polypropylene Pipe

Joints for polypropylene pipe and fittings shall be made by heat fusion welding socket-type or butt-fusion type fittings and shall comply with ASTM F2389.

3.1.3.11 Other Joint Methods

3.1.4 Dissimilar Pipe Materials

Connections between ferrous and non-ferrous copper water pipe shall be made with dielectric unions or flange waterways. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways. Connecting joints between plastic and metallic pipe shall be made with transition fitting for the specific purpose.

3.1.5 Corrosion Protection for Buried Pipe and Fittings

Ductile iron, cast iron, and steel pipe, fittings, and joints shall have a protective coating. Additionally, ductile iron, cast iron, and steel pressure pipe shall have a cathodic protection system and joint bonding. The cathodic protection system, protective coating system, and joint bonding for cathodically protected pipe shall be in accordance with Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM. Coatings shall be selected, applied, and inspected in accordance with NACE SP0169 and as otherwise specified. The pipe shall be cleaned and the coating system applied prior to pipe tightness testing. Joints and fittings shall be cleaned and the coating system applied after pipe tightness testing. For tape coating systems, the tape shall conform to AWWA C203 and shall be applied with a 50 percent overlap. Primer utilized with tape type coating systems shall be as recommended by the tape manufacturer.

3.1.6 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.6.1 Sleeve Requirements

Unless indicated otherwise, provide pipe sleeves meeting the following requirements:

a. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors.

b. A modular mechanical type sealing assembly may be installed in lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve using galvanized steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe and sleeve involved.

c. Sleeves shall not be installed in structural members, except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective floor, or roof, and shall be cut flush with each surface, except for special circumstances. Pipe sleeves passing through floors in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas shall extend a minimum of 4 inches above the finished floor.

d. Unless otherwise indicated, sleeves shall be of a size to provide a minimum of 1/4 inch clearance between bare pipe or insulation and inside of sleeve or between insulation and inside of sleeve. Sleeves in bearing walls and concrete slab on grade floors shall be steel pipe or cast-iron pipe. Sleeves in nonbearing walls or ceilings may be steel pipe, cast-iron pipe, galvanized sheet metal with lock-type longitudinal seam, or plastic.

e. Except as otherwise specified, the annular space between pipe and sleeve, or between jacket over insulation and sleeve, shall be sealed as indicated with sealants conforming to ASTM C920 and with a primer, backstop material and surface preparation as specified in Section 07 92 00 JOINT SEALANTS. The annular space between pipe and sleeve, between bare insulation and sleeve or between jacket over insulation and sleeve shall not be sealed for interior walls which are not designated as fire rated.

f. Sleeves through below-grade walls in contact with earth shall be recessed 1/2 inch from wall surfaces on both sides. Annular space between pipe and sleeve shall be filled with backing material and sealants in the joint between the pipe and concrete wall as specified above. Sealant selected for the earth side of the wall shall be compatible with dampproofing/waterproofing materials that are to be applied over the joint sealant. Pipe sleeves in fire-rated walls shall conform to the requirements in Section 07 84 00 FIRESTOPPING.

3.1.6.2 Flashing Requirements

Pipes passing through roof shall be installed through a 16 ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the roof or floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches. For cleanouts, the flashing shall be turned down into the hub and caulked after placing the ferrule. Pipes passing through pitched roofs shall be flashed, using lead or copper flashing, with an adjustable integral flange of adequate size to extend not less than 8 inches from the pipe in all directions and lapped into the roofing to provide a watertight seal. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Flashing for dry vents shall be turned down into the pipe to form a waterproof joint. Pipes, up to and including 10 inches in diameter, passing through roof or floor waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing-clamp device, and pressure ring with brass bolts. Flashing shield shall be fitted into the sleeve clamping device. Pipes passing through wall waterproofing membrane shall be sleeved as described above. A waterproofing clamping flange shall be installed.

3.1.6.3 Waterproofing

Waterproofing at floor-mounted water closets shall be accomplished by forming a flashing guard from soft-tempered sheet copper. The center of the sheet shall be perforated and turned down approximately 1-1/2 inches to fit between the outside diameter of the drainpipe and the inside diameter of the cast-iron or steel pipe sleeve. The turned-down portion of the flashing guard shall be embedded in sealant to a depth of approximately 1-1/2 inches; then the sealant shall be finished off flush to floor level between the flashing guard and drainpipe. The flashing guard of sheet copper shall extend not less than 8 inches from the drainpipe and shall be lapped between the floor membrane in a solid coating of bituminous cement. If cast-iron water closet floor flanges are used, the space between the pipe sleeve and drainpipe shall be sealed with sealant and the flashing guard shall be upturned approximately 1-1/2 inches to fit the outside diameter of the drainpipe and the inside diameter of the water closet floor flange. The upturned portion of the sheet fitted into the floor flange shall be sealed.

3.1.6.4 Optional Counterflashing

Instead of turning the flashing down into a dry vent pipe, or caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may be accomplished by utilizing the following:

a. A standard roof coupling for threaded pipe up to 6 inches in diameter.

b. A tack-welded or banded-metal rain shield around the pipe.

3.1.6.5 Pipe Penetrations of Slab on Grade Floors

Where pipes, fixture drains, floor drains, cleanouts or similar items penetrate slab on grade floors, except at penetrations of floors with waterproofing membrane as specified in paragraphs FLASHING REQUIREMENTS and WATERPROOFING, a groove 1/4 to 1/2 inch wide by 1/4 to 3/8 inch deep shall be formed around the pipe, fitting or drain. The groove shall be filled with a sealant as specified in Section 07 92 00 JOINT SEALANTS.

3.1.6.6 Pipe Penetrations

Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed to prevent infiltration of air, insects, and vermin.

3.1.7 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.1.8 Supports

3.1.8.1 General

Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run. Threaded sections of rods shall not be formed or bent.

3.1.8.2 Pipe Supports and Structural Bracing, Seismic Requirements

Piping and attached valves shall be supported and braced to resist seismic loads as specified in Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL as shown. Structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, shall be provided. Material used for supports shall be as specified in Section 05 12 00 STRUCTURAL STEEL.

3.1.8.3 Pipe Hangers, Inserts, and Supports

Installation of pipe hangers, inserts and supports shall conform to MSS SP-58 except as modified herein.

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued per MSS SP-58 and shall have both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Type 39 saddles shall be used on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Type 39 saddles shall be welded to the pipe.

h. Type 40 shields shall:

   (1) Be used on insulated pipe less than 4 inches.

   (2) Be used on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or less.

   (3) Have a high density insert for all pipe sizes. High density inserts shall have a density of 8 pcf or greater.

i. Horizontal pipe supports shall be spaced as specified in MSS SP-58 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves. Operating temperatures in determining hanger spacing for PVC or CPVC pipe shall be 120 degrees F for PVC and 180 degrees F for CPVC. Horizontal pipe runs shall include allowances for expansion and contraction.

j. Vertical pipe shall be supported at each floor, except at slab-on-grade, at intervals of not more than 15 feet nor more than 8 feet from end of risers, and at vent terminations. Vertical pipe risers shall include allowances for expansion and contraction.

k. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided to allow longitudinal pipe movement. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints shall be provided as needed. Where steel slides do not require provisions for lateral restraint the following may be used:

(1) On pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher, a Type 39 saddle, welded to the pipe, may freely rest on a steel plate.

(2) On pipe less than 4 inches a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

(3) On pipe 4 inches and larger carrying medium less that 60 degrees F a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

l. Pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation. The insulation shall be continuous through the hanger on all pipe sizes and applications.

m. Where there are high system temperatures and welding to piping is not desirable, the type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.

n. Hangers and supports for plastic pipe shall not compress, distort, cut or abrade the piping, and shall allow free movement of pipe except where otherwise required in the control of expansion/contraction.

3.1.8.4 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floor or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only.

3.1.9 Welded Installation

Plumbing pipe weldments shall be as indicated. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.10 Pipe Cleanouts

Pipe cleanouts shall be the same size as the pipe except that cleanout plugs larger than 4 inches will not be required. A cleanout installed in connection with cast-iron soil pipe shall consist of a long-sweep 1/4 bend or one or two 1/8 bends extended to the place shown. An extra-heavy cast-brass or cast-iron ferrule with countersunk cast-brass head screw plug shall be caulked into the hub of the fitting and shall be flush with the floor. Cleanouts in connection with other pipe, where indicated, shall be T-pattern, 90-degree branch drainage fittings with cast-brass screw plugs, except plastic plugs shall be installed in plastic pipe. Plugs shall be the same size as the pipe up to and including 4 inches. Cleanout tee branches with screw plug shall be installed at the foot of soil and waste stacks, at the foot of interior downspouts, on each connection to building storm drain where interior downspouts are indicated, and on each building drain outside the building. Cleanout tee branches may be omitted on stacks in single story buildings with slab-on-grade construction or where less than 18 inches of crawl space is provided under the floor. Cleanouts on pipe concealed in partitions shall be provided with chromium plated bronze, nickel bronze, nickel brass or stainless steel flush type access cover plates. Round access covers shall be provided and secured to plugs with securing screw. Square access covers may be provided with matching frames, anchoring lugs and cover screws. Cleanouts in finished walls shall have access covers and frames installed flush with the finished wall. Cleanouts installed in finished floors subject to foot traffic shall be provided with a chrome-plated cast brass, nickel brass, or nickel bronze cover secured to the plug or cover frame and set flush with the finished floor. Heads of fastening screws shall not project above the cover surface. Where cleanouts are provided with adjustable heads, the heads shall be cast iron.

3.2 WATER HEATERS AND HOT WATER STORAGE TANKS

3.2.1 Relief Valves

No valves shall be installed between a relief valve and its water heater or storage tank. The P&T relief valve shall be installed where the valve actuator comes in contact with the hottest water in the heater. Whenever possible, the relief valve shall be installed directly in a tapping in the tank or heater; otherwise, the P&T valve shall be installed in the hot-water outlet piping. A vacuum relief valve shall be provided on the cold water supply line to the hot-water storage tank or water heater and mounted above and within 6 inches above the top of the tank or water heater.

3.2.2 Installation of Gas- and Oil-Fired Water Heater

Installation shall conform to NFPA 54 for gas fired and NFPA 31 for oil fired. Storage water heaters that are not equipped with integral heat traps and having vertical pipe risers shall be installed with heat traps directly on both the inlet and outlet. Circulating systems need not have heat traps installed. An acceptable heat trap may be a piping arrangement such as elbows connected so that the inlet and outlet piping make vertically upward runs of not less than 24 inches just before turning downward or directly horizontal into the water heater's inlet and outlet fittings. Commercially available heat traps, specifically designed by the manufacturer for the purpose of effectively restricting the natural tendency of hot water to rise through vertical inlet and outlet piping during standby periods may also be approved.

3.2.3 Heat Traps

Piping to and from each water heater and hot water storage tank shall be routed horizontally and downward a minimum of 2 feet before turning in an upward direction.

3.2.4 Connections to Water Heaters

Connections of metallic pipe to water heaters shall be made with dielectric unions or flanges.

3.2.5 Expansion Tank

A pre-charged expansion tank shall be installed on the cold water supply between the water heater inlet and the cold water supply shut-off valve. The Contractor shall adjust the expansion tank air pressure, as recommended by the tank manufacturer, to match incoming water pressure.

3.2.6 Direct Fired and Domestic Water Heaters

Notify the Contracting Officer when any direct fired domestic water heater over 400,000 BTU/hour is operational and ready to be inspected and certified.

3.3 FIXTURES AND FIXTURE TRIMMINGS

Polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets shall be furnished and installed with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, a beading tool shall be used to mechanically deform the tubing above the compression fitting. Exposed traps and supply pipes for fixtures and equipment shall be connected to the rough piping systems at the wall, unless otherwise specified under the item. Floor and wall escutcheons shall be as specified. Drain lines and hot water lines of fixtures for handicapped personnel shall be insulated and do not require polished chrome finish. Plumbing fixtures and accessories shall be installed within the space shown.

3.3.1 Fixture Connections

Where space limitations prohibit standard fittings in conjunction with the cast-iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made gastight and watertight with a closet-setting compound or neoprene gasket and seal. Use of natural rubber gaskets or putty will not be permitted. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

3.3.2 Flushometer Valves

Flushometer valves shall be secured to prevent movement by anchoring the long finished top spud connecting tube to wall adjacent to valve with approved metal bracket. Flushometer valves for water closets shall be installed 39 inches above the floor, except at water closets intended for use by the physically handicapped where flushometer valves shall be mounted at approximately 30 inches above the floor and arranged to avoid interference with grab bars. In addition, for water closets intended for handicap use, the flush valve handle shall be installed on the wide side of the enclosure. Bumpers for water closet seats shall be installed on the wall flushometer stop or flushometer spud.

3.3.3 Height of Fixture Rims Above Floor

Lavatories shall be mounted with rim 31 inches above finished floor. Wall-hung drinking fountains and water coolers shall be installed with rim 42 inches above floor. Wall-hung service sinks shall be mounted with rim 28 inches above the floor. Installation of fixtures for use by the physically handicapped shall be in accordance with ICC A117.1.

3.3.4 Shower Bath Outfits

The area around the water supply piping to the mixing valves and behind the escutcheon plate shall be made watertight by caulking or gasketing.

3.3.5 Fixture Supports

Fixture supports for off-the-floor lavatories, urinals, water closets, and other fixtures of similar size, design, and use, shall be of the chair-carrier type. The carrier shall provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability shall be provided to locate the fixture at the desired height and in proper relation to the wall. Support plates, in lieu of chair carrier, shall be fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.

3.3.5.1 Support for Solid Masonry Construction

Chair carrier shall be anchored to the floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be imbedded in the masonry wall.

3.3.5.2 Support for Concrete-Masonry Wall Construction

Chair carrier shall be anchored to floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be fastened to the concrete wall using through bolts and a back-up plate.

3.3.5.3 Support for Steel Stud Frame Partitions

Chair carrier shall be used. The anchor feet and tubular uprights shall be of the heavy duty design; and feet (bases) shall be steel and welded to a square or rectangular steel tube upright. Wall plates, in lieu of floor-anchored chair carriers, shall be used only if adjoining steel partition studs are suitably reinforced to support a wall plate bolted to these studs.

3.3.5.4 Support for Wood Stud Construction

Where floor is a concrete slab, a floor-anchored chair carrier shall be used. Where entire construction is wood, wood crosspieces shall be installed. Fixture hanger plates, supports, brackets, or mounting lugs shall be fastened with not less than No. 10 wood screws, 1/4 inch thick minimum steel hanger, or toggle bolts with nut. The wood crosspieces shall extend the full width of the fixture and shall be securely supported.

3.3.5.5 Wall-Mounted Water Closet Gaskets

Where wall-mounted water closets are provided, reinforced wax, treated felt, or neoprene gaskets shall be provided. The type of gasket furnished shall be as recommended by the chair-carrier manufacturer.

3.3.6 Backflow Prevention Devices

Plumbing fixtures, equipment, and pipe connections shall not cross connect or interconnect between a potable water supply and any source of nonpotable water. Backflow preventers shall be installed where indicated and in accordance with ICC IPC at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. In addition backflow preventers shall be installed at all locations where the potable water outlet is below the flood level of the equipment, or where the potable water outlet will be located below the level of the nonpotable substance. Backflow preventers shall be located so that no part of the device will be submerged. Backflow preventers shall be of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Bypass piping shall not be provided around backflow preventers. Access shall be provided for maintenance and testing. Each device shall be a standard commercial unit.

3.3.7 Access Panels

Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced. Access panels shall be as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.3.8 Sight Drains

Sight drains shall be installed so that the indirect waste will terminate 2 inches above the flood rim of the funnel to provide an acceptable air gap.

3.3.9 Traps

Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped. Traps installed on cast-iron soil pipe shall be cast iron. Traps installed on steel pipe or copper tubing shall be recess-drainage pattern, or brass-tube type. Traps installed on plastic pipe may be plastic conforming to ASTM D3311. Traps for acid-resisting waste shall be of the same material as the pipe.

3.3.10 Shower Pans

Before installing shower pan, subfloor shall be free of projections such as nail heads or rough edges of aggregate. Drain shall be a bolt-down, clamping-ring type with weepholes, installed so the lip of the subdrain is flush with subfloor.

3.3.10.1 General

The floor of each individual shower, the shower-area portion of combination shower and drying room, and the entire shower and drying room where the two are not separated by curb or partition, shall be made watertight with a shower pan fabricated in place. The shower pan material shall be cut to size and shape of the area indicated, in one piece to the maximum extent practicable, allowing a minimum of 6 inches for turnup on walls or partitions, and shall be folded over the curb with an approximate return of 1/4 of curb height. The upstands shall be placed behind any wall or partition finish. Subflooring shall be smooth and clean, with nailheads driven flush with surface, and shall be sloped to drain. Shower pans shall be clamped to drains with the drain clamping ring.

3.3.10.2 Metal Shower Pans

When a shower pan of required size cannot be furnished in one piece, metal pieces shall be joined with a flintlock seam and soldered or burned. The corners shall be folded, not cut, and the corner seam shall be soldered or burned. Pans, including upstands, shall be coated on all surfaces with one brush coat of asphalt. Asphalt shall be applied evenly at not less than 1 gallon per 50 square feet. A layer of felt covered with building paper shall be placed between shower pans and wood floors. The joining surfaces of metal pan and drain shall be given a brush coat of asphalt after the pan is connected to the drain.

3.3.10.3 Plasticized Chlorinated Polyethylene Shower Pans

Corners of plasticized chlorinated polyethylene shower pans shall be folded against the upstand by making a pig-ear fold. Hot-air gun or heat lamp shall be used in making corner folds. Each pig-ear corner fold shall be nailed or stapled 1/2 inch from the upper edge to hold it in place. Nails shall be galvanized large-head roofing nails. On metal framing or studs, approved duct tape shall be used to secure pig-ear fold and membrane. Where no backing is provided between the studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding 1/2 inch from upper edge. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it will be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Surfaces to be solvent-welded shall be clean. Surfaces to be joined with xylene shall be initially sprayed and vigorously cleaned with a cotton cloth, followed by final coating of xylene and the joining of the surfaces by roller or equivalent means. If ambient or membrane temperatures are below 40 degrees F the membrane and the joint shall be heated prior to application of xylene. Heat may be applied with hot-air gun or heat lamp, taking precautions not to scorch the membrane. Adequate ventilation and wearing of gloves are required when working with xylene. Membrane shall be pressed into position on the drain body, and shall be cut and fit to match so that membrane can be properly clamped and an effective gasket-type seal provided. On wood subflooring, two layers of 15 pound dry felt shall be installed prior to installation of shower pan to ensure a smooth surface for installation.

3.3.10.4 Nonplasticized Polyvinyl Chloride (PVC) Shower Pans

Nonplasticized PVC shall be turned up behind walls or wall surfaces a distance of not less than 6 inches in room areas and 3 inches above curb level in curbed spaces with sufficient material to fold over and fasten to outside face of curb. Corners shall be pig-ear type and folded between pan and studs. Only top 1 inch of upstand shall be nailed to hold in place. Nails shall be galvanized large-head roofing type. Approved duct tape shall be used on metal framing or studs to secure pig-ear fold and membrane. Where no backing is provided between studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding at top inch of upstand. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it is to be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Trim for drain shall be exactly the size of drain opening. Bolt holes shall be pierced to accommodate bolts with a tight fit. Adhesive shall be used between pan and subdrain. Clamping ring shall be bolted firmly. A small amount of gravel or porous materials shall be placed at weepholes so that holes remain clear when setting bed is poured. Membrane shall be solvent welded with PVC solvent cement. Surfaces to be solvent welded shall be clean (free of grease and grime). Sheets shall be laid on a flat surface with an overlap of about 2 inches. Top edge shall be folded back and surface primed with a PVC primer. PVC cement shall be applied and surfaces immediately placed together, while still wet. Joint shall be lightly rolled with a paint roller, then as the joint sets shall be rolled firmly but not so hard as to distort the material. In long lengths, about 2 or 3 feet at a time shall be welded. On wood subflooring, two layers of 15 pound felt shall be installed prior to installation of shower pan to ensure a smooth surface installation.

3.4 VIBRATION-ABSORBING FEATURES

Mechanical equipment, including compressors and pumps, shall be isolated from the building structure by approved vibration-absorbing features, unless otherwise shown. Each foundation shall include an adequate number of standard isolation units. Each unit shall consist of machine and floor or foundation fastening, together with intermediate isolation material, and shall be a standard product with printed load rating. Piping connected to mechanical equipment shall be provided with flexible connectors. .

3.4.1 Tank- or Skid-Mounted Compressors

Floor attachment shall be as recommended by compressor manufacturer. Compressors shall be mounted to resist seismic loads as specified in Section 23 05 48.19 SEISMIC BRACING FOR HVAC.

3.4.2 Foundation-Mounted Compressors

Foundation shall be as recommended by the compressor manufacturer, except the foundation shall weigh not less than three times the weight of the moving parts. Compressors shall be mounted to resist seismic loads as specified in Section 23 05 48.19 SEISMIC BRACING FOR HVAC.

3.5 WATER METER REMOTE READOUT REGISTER

The remote readout register shall be mounted at the location indicated or as directed by the Contracting Officer.

3.6 IDENTIFICATION SYSTEMS

3.6.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on valves, except those valves installed on supplies at plumbing fixtures. Tags shall be 1-3/8 inch minimum diameter, and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

3.6.2 Pipe Color Code Marking

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6.3 Color Coding Scheme for Locating Hidden Utility Components

Scheme shall be provided in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of operable components which are not visible from the finished space and installed in the space directly above the suspended grid ceiling. The operable components shall include valves, dampers, switches, linkages and thermostats. The color coding scheme shall consist of a color code board and colored metal disks. Each colored metal disk shall be approximately 3/8 inch in diameter and secured to removable ceiling panels with fasteners. The fasteners shall be inserted into the ceiling panels so that the fasteners will be concealed from view. The fasteners shall be manually removable without tools and shall not separate from the ceiling panels when panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall have the approximate dimensions of 3 foot width, 30 inches height, and 1/2 inch thickness. The board shall be made of wood fiberboard and framed under glass or 1/16 inch transparent plastic cover. Unless otherwise directed, the color code symbols shall be approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters. The color code board shall be mounted and located in the mechanical or equipment room.

3.7 ESCUTCHEONS

Escutcheons shall be provided at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.8 PAINTING

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09 90 00 PAINTS AND COATINGS.

3.8.1 Painting of New Equipment

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

3.8.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

3.8.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

3.9 TESTS, FLUSHING AND DISINFECTION

3.9.1 Plumbing System

The following tests shall be performed on the plumbing system in accordance with ICC IPC, except that the drainage and vent system final test shall include the smoke test. The Contractor has the option to perform a peppermint test in lieu of the smoke test. If a peppermint test is chosen, the Contractor must submit a testing procedure and reasons for choosing this option in lieu of the smoke test to the Contracting Officer for approval.

a. Drainage and Vent Systems Test. The final test shall include a smoke test.

b. Building Sewers Tests.

c. Water Supply Systems Tests.

3.9.1.1 Test of Backflow Prevention Assemblies

Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies.

Backflow prevention assembly test gauges shall be tested annually for accuracy in accordance with the requirements of State or local regulatory agencies. If there is no State or local regulatory agency requirements, gauges shall be tested annually for accuracy in accordance with the requirements of University of Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14), or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention assembly test gauges. Report form for each assembly shall include, as a minimum, the following:

Data on Device	Data on Testing Firm
Type of Assembly	Name
Manufacturer	Address
Model Number	Certified Tester
Serial Number	Certified Tester No.
Size	Date of Test
Location	
Test Pressure Readings	Serial Number and Test Data of Gauges

If the unit fails to meet specified requirements, the unit shall be repaired and retested.

3.9.1.2 Shower Pans

After installation of the pan and finished floor, the drain shall be temporarily plugged below the weep holes. The floor area shall be flooded with water to a minimum depth of 1 inch for a period of 24 hours. Any drop in the water level during test, except for evaporation, will be reason for rejection, repair, and retest.

3.9.1.3 Compressed Air Piping (Nonoil-Free)

Piping systems shall be filled with oil-free dry air or gaseous nitrogen to

150 psig and hold this pressure for 2 hours with no drop in pressure.

3.9.2 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests shall be repeated. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes will not be acceptable.

3.9.3 System Flushing

3.9.3.1 During Flushing

Before operational tests or disinfection, potable water piping system shall be flushed with hot potable water. Sufficient water shall be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 4 fps through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) shall specify the number of fixtures to be operated during flushing. Contractor shall provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor shall be responsible for any flood damage resulting from flushing of the system. Flushing shall be continued until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration. All faucets and drinking water fountains, to include any device considered as an end point device by NSF/ANSI 61, Section 9, shall be flushed a minimum of 0.25 gallons per 24 hour period, ten times over a 14 day period.

3.9.3.2 After Flushing

System shall be drained at low points. Strainer screens shall be removed, cleaned, and replaced. After flushing and cleaning, systems shall be prepared for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system shall be repaired by the Contractor. When the system flushing is complete, the hot-water system shall be adjusted for uniform circulation. Flushing devices and automatic control systems shall be adjusted for proper operation according to manufacturer's instructions. Flow rates on fixtures must not exceed those stated in PART 2 of this Section. Unless more stringent local requirements exist, lead levels shall not exceed limits established by 40 CFR 141.80 (c)(1). The water supply to the building shall be tested separately to ensure that any lead contamination found during potable water system testing is due to work being performed inside the building.

3.9.4 Operational Test

Upon completion of flushing and prior to disinfection procedures, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory installation, connections, adjustments, and functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:

a. Time, date, and duration of test.

b. Water pressures at the most remote and the highest fixtures.

c. Operation of each fixture and fixture trim.

d. Operation of each valve, hydrant, and faucet.

e. Pump suction and discharge pressures.

f. Temperature of each domestic hot-water supply.

g. Operation of each floor and roof drain by flooding with water.

h. Operation of each vacuum breaker and backflow preventer.

i. Complete operation of each water pressure booster system, including pump start pressure and stop pressure.

j. Compressed air readings at each compressor and at each outlet. Each indicating instrument shall be read at 1/2 hour intervals. The report of the test shall be submitted in quadruplicate. The Contractor shall furnish instruments, equipment, and personnel required for the tests; the Government will furnish the necessary water and electricity.

3.9.5 Disinfection

After all system components are provided and operational tests are complete, the entire domestic hot- and cold-water distribution system shall be disinfected. Before introducing disinfecting chlorination material, entire system shall be flushed with potable water until any entrained dirt and other foreign materials have been removed.

Water chlorination procedure shall be in accordance with AWWA C651 and AWWA C652 as modified and supplemented by this specification. The chlorinating material shall be hypochlorites or liquid chlorine. The chlorinating material shall be fed into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). Feed a properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or inject liquid chlorine into the system through a solution-feed chlorinator and booster pump until the entire system is completely filled.

Test the chlorine residual level in the water at 6 hour intervals for a continuous period of 24 hours. If at the end of a 6 hour interval, the chlorine residual has dropped to less than 25 ppm, flush the piping including tanks with potable water, and repeat the above chlorination procedures. During the chlorination period, each valve and faucet shall be opened and closed several times.

After the second 24 hour period, verify that no less than 25 ppm chlorine residual remains in the treated system. The 24 hour chlorination procedure must be repeated until no less than 25 ppm chlorine residual remains in the treated system.

Upon the specified verification, the system including tanks shall then be flushed with potable water until the residual chlorine level is reduced to less than one part per million. During the flushing period, each valve and faucet shall be opened and closed several times.

Take additional samples of water in disinfected containers, for bacterial examination, at locations specified by the Contracting Officer. Test these samples for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA 10084. The testing method used shall be EPA approved for drinking water systems and shall comply with applicable local and state requirements.

Disinfection shall be repeated until bacterial tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.10 POSTED INSTRUCTIONS

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.11 PERFORMANCE OF WATER HEATING EQUIPMENT

Standard rating condition terms are as follows:

EF = Energy factor, minimum overall efficiency.

ET = Minimum thermal efficiency with 70 degrees F delta T.

SL = Standby loss is maximum (Btu/h) based on a 70 degrees F temperature difference between stored water and ambient requirements.

V = Rated volume in gallons

Q = Nameplate input rate in kW (Btu/h)

3.11.1 Storage Water Heaters

3.11.1.1 Electric

a. Storage capacity of 60 gallons shall have a minimum energy factor (EF) of 0.93 or higher per FEMP requirements.

b. Storage capacity of 60 gallons or more shall have a minimum energy factor (EF) of 0.91 or higher per FEMP requirements.

3.11.1.2 Gas

a. Storage capacity of 50 gallons or less shall have a minimum energy factor (EF) of 0.67 or higher per FEMP requirements.

b. Storage capacity of 20 gallons - or more and input rating of 75,000

Btu/h or less: minimum EF shall be 0.62 - 0.0019V per 10 CFR 430.

c. Rating of less than 22980 W: (75,000 Btu/h) ET shall be 80 percent; maximum SL shall be (Q/800+110x(V^^1/2)), per ANSI Z21.10.3/CSA 4.3

3.11.1.3 Oil

a. Storage capacity of 20 gallons or more and input rating of 105,000 Btu/h or less: minimum EF shall be 0.59-0.0019V per 10 CFR 430.

b. Rating of less than 4,000 Btu/h/gallon or input rating more than 105,000 Btu/h: ET shall be 78 percent; maximum SL shall be (Q/800+100x(V^^1/2)), per ANSI Z21.10.3/CSA 4.3.

3.11.2 Unfired Hot Water Storage

All volumes and inputs: shall meet or exceed R-12.5.

3.11.3 Instantaneous Water Heater

3.11.3.1 Gas

a. Rating of 4,000 Btu/h/gal and greater and less than 2 gallons with an input greater than 50,000 Btu/h and less than 200,000 Btu/h shall have a minimum energy factor (EF) of 0.62-0.0019V per 10 CFR 430.

b. Rating of 4,000 Btu/h/gal and greater and less than 10 gallons with an input of 200,000 Btu/h and greater shall have a minimum thermal efficiency (ET) of 80 percent per ANSI Z21.10.3/CSA 4.3

c. Rating of 4,000 BTU/h/gal and greater and 10 gallons and greater with an input of 200,000 Btu/h and greater shall have a minimum thermal efficiency (ET) of 80 percent and the maximum SL shall be Q/800+110x(V^^1/2)) per ANSI Z21.10.3/CSA 4.3

3.11.3.2 Oil

a. Rating of 4,000 Btu/h/gal and greater and less than 2 gallons with an input of 210,000 Btu/h and less shall have an energy factor (EF) of 0.59-0.0019V per 10 CFR 430

b. Rating of 4,000 Btu/h/gal and greater and less than 10 gallons with an input greater than 210,000 Btu/h shall have a minimum thermal efficiency (ET) of 80 percent per ANSI Z21.10.3/CSA 4.3

c. Rating of 4,000 Btu/h/gal and 10 gallons and greater with an input of greater than 210,000 Btu/h shall have a minimum thermal efficiency (ET) of 78 percent and the maximum SL shall be Q/800+110x(V^^1/2)) per ANSI Z21.10.3/CSA 4.3

3.11.4 Pool Heaters

a. Gas/oil fuel, capacities and inputs: ET shall be 78 percent per ASHRAE 146.

b. Heat Pump, All capacities and inputs shall meet a COP of 4.0 per ASHRAE 146

3.12 TABLES

TABLE I								
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS								
It #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F	SERVICE G
1	Cast iron soil pipe and fittings, hub and spigot, ASTM A74 with compression gaskets. Pipe and fittings shall be marked with the CISPI	X	X	X	X	X		
2	Cast iron soil pipe and fittings hubless, CISPI 301 and ASTM A888. Pipe and fittings shall be marked with the CISPI trademark.		X	X	X	X		
3	Cast iron drainage fittings, threaded, ASME B16.12 for	X		X	X			
4	Cast iron screwed fittings (threaded) ASME B16.4 for use with Item 10				X	X		
5	Grooved pipe couplings, ferrous and non-ferrous pipe ASTM A536 And ASTM A47/A47M	X	X		X	X		
6	Ductile iron grooved joint fittings for ferrous pipe ASTM A536 and ASTM A47/A47M for use with Item 5	X	X		X	X		
7	Bronze sand casting grooved joint pressure fittings for non-ferrous pipe ASTM B584, for use with Item 5	X	X		X	X		

TABLE I								
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS								
It #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F	SERVICE G
8	Wrought copper grooved joint pressure fittings for non-ferrous pipe ASTM B75/B75M C12200, ASTM B152/B152M, C11000, ASME B16.22 ASME B16.22 for use with Item 5	X	X					
9	Malleable-iron threaded fittings, galvanized ASME B16.3 for use with Item 10				X	X		
10	Steel pipe, seamless galvanized, ASTM A53/A53M, Type S, Grade B	X			X	X		
11	Seamless red brass pipe, ASTM B43				X	X		X
12	Bronzed flanged fittings, ASME B16.24 for use with Items 11 and 14				X	X		X
13	Cast copper alloy solder joint pressure fittings, ASME B16.18for use with Item 14				X	X		X
14	Seamless copper pipe, ASTM B42						X	X
15	Cast bronze threaded fittings, ASME B16.15				X	X		
16	Copper drainage tube, (DWV), ASTM B306	X*	X	X*	X	X		X

TABLE I

PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS

It #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F	SERVICE G
17	Wrought copper and wrought alloy solder-joint drainage fittings. ASME B16.29	X	X	X	X	X		X
18	Cast copper alloy solder joint drainage fittings, DWV, ASME B16.23	X	X	X	X	X		X
19	Acrylonitrile-Butad (ABS) plastic drain, waste, and vent pipe and fittings ASTM D2661, ASTM F628	X	X	X	X	X	X	
20	Polyvinyl Chloride plastic drain, waste and vent pipe and fittings, ASTM D2665, ASTM F891, (Sch 40) ASTM F1760	X	X	X	X	X	X	X
21	Process glass pipe and fittings, ASTM C1053						X	
22	High-silicon content cast iron pipe and fittings (hub and spigot, and mechanical joint), ASTM A518/A518M		X			X	X	
23	Polypropylene (PP) waste pipe and fittings, ASTM D4101						X	
24	Filament-wound reinforced thermosetting resin (RTRP) pipe, ASTM D2996						X	

TABLE I

PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS

It #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F	SERVICE G

SERVICE:

A - Underground Building Soil, Waste and Storm Drain
B - Aboveground Soil, Waste, Drain In Buildings
C - Underground Vent
D - Aboveground Vent
E - Interior Rainwater Conductors Aboveground
F - Corrosive Waste And Vent Above And Belowground
G - Condensate Drain Aboveground

* - Hard Temper

TABLE II

PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
1	Malleable-iron threaded fittings:				
	a. Galvanized, ASME B16.3 for use with Item 4a	X	X	X	X
	b. Same as "a" but not galvanized for use with Item 4b			X	
2	Grooved pipe couplings, ferrous pipe ASTM A536 and ASTM A47/A47M non-ferrous pipe, ASTM A536 and ASTM A47/A47M	X	X	X	
3	Ductile iron grooved joint fittings for ferrous pipe ASTM A536 and ASTM A47/A47M, for use with Item 2	X	X	X	
4	Steel pipe:				
	a. Seamless, galvanized, ASTM A53/A53M, Type S, Grade B	X	X	X	X
	b. Seamless, black, ASTM A53/A53M, Type S, Grade B			X	

TABLE II					
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS					
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
5	Seamless red brass pipe, ASTM B43	X	X		X
6	Bronze flanged fittings, ASME B16.24 for use with Items 5 and 7	X	X		X
7	Seamless copper pipe, ASTM B42	X	X		X
8	Seamless copper water tube, ASTM B88, ASTM B88M	X**	X**	X**	X***
9	Cast bronze threaded fittings, ASME B16.15 for use with Items 5 and 7	X	X		X
10	Wrought copper and bronze solder-joint pressure fittings, ASME B16.22 for use with Items 5, 7 and 8	X	X	X	X
11	Cast copper alloy solder-joint pressure fittings, ASME B16.18 for use with Item 8	X	X	X	X
12	Bronze and sand castings groovedjoint pressure fittings for non-ferrous pipe ASTM B584, for use with Item 2	X	X	X	
13	Polyethylene (PE) plastic pipe, Schedules 40 and 80, based on outside diameter	X			X
14	Polyethylene (PE) plastic pipe (SDR-PR), based on controlled outside diameter, ASTM D3035	X			X
15	Polyethylene (PE) plastic pipe (SIDR-PR), based on controlled inside diameter, ASTM D2239	X			X

TABLE II

PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
16	Butt fusion polyethylene (PE) plastic pipe fittings, ASTM D3261 for use with Items 14, 15, and 16	X			X
17	Socket-type polyethylene fittings for outside diameter-controlled polyethylene pipe, ASTM D2683 for use with Item 15	X			X
18	Polyethylene (PE) plastic tubing, ASTM D2737	X			X
19	Chlorinated polyvinyl chloride (CPVC) plastic hot and cold water distribution system, ASTM D2846/D2846M	X	X		X
20	Chlorinated polyvinyl chloride (CPVC) plastic pipe, Schedule 40 and 80, ASTM F441/F441M	X	X		X
21	Chlorinated polyvinyl chloride (CPVC) plastic pipe (SDR-PR) ASTM F442/F442M	X	X		X
22	Threaded chlorinated polyvinyl chloride (chloride CPVC) plastic pipe fittings, Schedule 80, ASTM F437, for use with Items 20, and 21	X	X		X
23	Socket-type chlorinated polyvinyl chloride (CPVC) plastic pipe fittings, Schedule 40, ASTM F438 for use with Items 20, 21, and 22	X	X		X
24	Socket-type chlorinated polyvinyl chloride (CPVC) plastic pipe fittings Schedule 80, ASTM F439 for use with Items 20, 21, and 22	X	X		X

TABLE II					
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS					
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
25	Polyvinyl chloride (PVC) plastic pipe, Schedules 40, 80, and 120, ASTM D1785	X			X
26	Polyvinyl chloride (PVC) pressure-rated pipe (SDR Series), ASTM D2241	X			X
27	Polyvinyl chloride (PVC) plastic pipe fittings, Schedule 40, ASTM D2466	X			X
28	Socket-type polyvinyl chloride (PVC) plastic pipe fittings, schedule 80, ASTM D2467 for use with Items 26 and 27	X			X
29	Threaded polyvinyl chloride (PVC) plastic pipe fittings, schedule 80, ASTM D2464	X			X
30	Joints for IPS PVC pipe using solvent cement, ASTM D2672	X			X
31	Polypropylene (PP) plastic pipe and fittings; ASTM F2389	X	X		X
32	Steel pipeline flanges, MSS SP-44	X	X		
33	Fittings: brass or bronze; ASME B16.15, and ASME B16.18 ASTM B828	X	X		
34	Carbon steel pipe unions, socket-welding and threaded, MSS SP-83	X	X	X	
35	Malleable-iron threaded pipe unions ASME B16.39	X	X		
36	Nipples, pipe threaded ASTM A733	X	X	X	

TABLE II					
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS					
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
37	Crosslinked Polyethylene (PEX) Plastic Pipe ASTM F877	X	X		X
38	Press Fittings	X	X		
	SERVICE: A - Cold Water Service Aboveground B - Hot and Cold Water Distribution 180 degrees F Maximum Aboveground C - Compressed Air Lubricated D - Cold Water Service Belowground Indicated types are minimum wall thicknesses. ** - Type L - Hard *** - Type K - Hard temper with brazed joints only or type K-soft temper without joints in or under floors **** - In or under slab floors only brazed joints				

TABLE III				
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT				
FUEL	STORAGE CAPACITY GALLONS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
A. STORAGE WATER HEATERS				
Elect.	60 max.		10 CFR 430	EF = 0.93
Elect.	60 min.		10 CFR 430	EF = 0.91
Elect.	20 min.	12 kW max.	10 CFR 430	EF = 0.93-0.00132V minimum
Elect.	20 min.	12 kW max.	ANSI Z21.10.3 (Addenda B)	SL = 20+35x(V^^1/2) maximum
Elect. Heat Pump		24 Amps or less and 250 Volts or less	10 CFR 430	EF = 0.93-0.00132V
Gas	50 max.		10 CFR 430	EF = 0.67
Gas	20 min.	75,000 Btu/h max.	10 CFR 430	EF = [0.67][80]-0.0019V min.
Gas	1,000 (Btu/h)/gal max.	75,000 Btu/h	ANSI Z21.10.3	ET = 80 percent min. SL = 1.3+38/V max.
Oil	20 min.	105,000 Btu/h max.	10 CFR 430	EF = 0.80-0.0019V min.
Oil	4,000 (Btu/h)/gal max	105,000 Btu/h min.	ANSI Z21.10.3	ET = 78 percent; SL = 1.3+38/V max.
B. Unfired Hot Water Storage, R-12.5 min.				
C. Instantaneous Water Heater				
Gas	4,000 (btu/h)/gal and 2 gal max.	50,000 Btu/h min 200,000 Btu/h max.	10 CFR 430	EF = 0.62-0.0019V
Gas	4,000 (btu/h)/gal and 2 gal max.	200,000 Btu/h min.	ANSI Z21.10.3	ET = 80 percent

TABLE III

STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT

FUEL	STORAGE CAPACITY GALLONS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
Gas	4,000 (btu/h)/gal and 2 gal max.	200,000 Btu/h min.	ANSI Z21.10.3	ET = 80 percent SL = (Q/800+110x(V^^1/2))
Oil	4,000 (btu/h)/gal and 2 gal max.	50,000 Btu/h min. 210,000 Btu/h max.	10 CFR 430	EF = 0.59-0.0019V SL = (Q/800+110x(V^^1/2))
Oil	4,000 (btu/h)/gal and 10 gal max.	210,000 Btu/h min.	ANSI Z21.10.3	ET = 80 percent
Oil	4,000 (btu/h)/gal and 10 gal max.	210,000 Btu/h min.	ANSI Z21.10.3	ET = 78 percent SL = (Q/800+110x(V^^1/2)) max.
D. Pool Heater				
Gas or Oil	All	All	ASHRAE 146	ET = 78 percent
Heat Pump All	All	All	ASHRAE 146	COP = 4.0

TERMS:

EF = Energy factor, minimum overall efficiency.
ET = Minimum thermal efficiency with 70 degrees F delta T.
SL = Standby loss is maximum Btu/h based on a 70 degree F temperature difference between stored water and ambient requirements.
V = Rated storage volume in gallons
Q = Nameplate input rate in Btu/h

-- End of Section --

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SECTION 22 00 70

PLUMBING FOR HEALTHCARE FACILITIES
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.10.1/CSA 4.1	(2019) Gas Water Heaters Vol. I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less
ANSI Z21.10.3/CSA 4.3	(2019) Gas-Fired Water Heaters Vol.III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous
ANSI Z21.22/CSA 4.4	(2015; R 2020) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-6 2021; Addenda AS-BF 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems
ASME A112.1.2	(2012; R 2017; R 2022) Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)
ASME A112.6.1M	(1997; R 2017) Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use
ASME A112.6.3	(2019) Standard for Floor and Trench Drains
ASME A112.6.4	(2003: R 2012) Roof, Deck and Balcony Drains
ASME A112.14.1	(2003; R 2017; R 2022) Backwater Valves

ASME A112.19.2/CSA B45.1	(2018; ERTA 2018) Standard for Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals
ASME A112.19.3/CSA B45.4	(2017; Errata 2017) Stainless Steel Plumbing Fixtures
ASME A112.36.2M	(1991; R 2017) Cleanouts
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.23	(2021) Cast Copper Alloy Solder Joint Drainage Fittings - DWV
ASME B16.29	(2017) Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings - DWV
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B31.1	(2020) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME CSD-1	(2021) Control and Safety Devices for Automatically Fired Boilers

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1001	(2021) Performance Requirements for Atmospheric Type Vacuum Breakers
ASSE 1003	(2020) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1010	(2021) Performance Requirements for Water Hammer Arresters
ASSE 1011	(2017) Performance Requirements for Hose Connection Vacuum Breakers
ASSE 1012	(2021) Performance Requirements for Backflow Preventer with an Intermediate Atmospheric Vent
ASSE 1013	(2021) Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies
ASSE 1017	(2009) Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems - (ANSI approved 2010)
ASSE 1018	(2001; R 2021) Performance Requirements for Trap Seal Primer Valves - Potable Water Supplied (ANSI Approved 2002
ASSE 1019	(2011; R 2016) Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance
ASSE 1020	(2020) Performance Requirements for Pressure Vacuum Breaker Assemblies
ASSE 1037	(2015; R 2020) Performance Requirements for Pressurized Flushing Devices for Plumbing Fixtures
ASSE 1070	(2015) Performance Requirements for Water Temperature Limiting Devices

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(2018) Hypochlorites
AWWA B301	(2018) Liquid Chlorine
AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C606	(2015) Grooved and Shouldered Joints

AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C652	(2019) Disinfection of Water-Storage Facilities
AWWA C700	(2020) Cold-Water Meters - Displacement Type, Metal Alloy Main Case
AWWA C701	(2019) Cold-Water Meters - Turbine Type for Customer Service
AWWA D100	(2021) Welded Steel Tanks for Water Storage

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.1/B2.1M	(2021) Specification for Welding Procedure and Performance Qualification
AWS B2.2/B2.2M	(2016) Specification for Brazing Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A74	(2021) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A312/A312M	(2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A403/A403M	(2022) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM A515/A515M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for

	Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A518/A518M	(1999; R 2018) Standard Specification for Corrosion-Resistant High-Silicon Iron Castings
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A755/A755M	(2018) Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products
ASTM A815/A815M	(2021) Standard Specification for Wrought Ferritic, Ferritic/Austenitic, and Martensitic Stainless Steel Piping Fittings
ASTM A861	(2004; R 2017) Standard Specification for High-Silicon Iron Pipe and Fittings
ASTM A888	(2021a) Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B36/B36M	(2018) Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B111/B111M	(2018) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B306	(2020) Standard Specification for Copper Drainage Tube (DWV)

ASTM B370	(2022) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B584	(2014; R 2022) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM C564	(2020a) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C1053	(2000; R 2010) Standard Specification for Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications
ASTM D635	(2018) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007; R 2015) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2729	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D2846/D2846M	(2019) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems

ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3311	(2017) Standard Specification for Drain, Waste, and Vent (DWV) Plastic Fittings Patterns
ASTM D4101	(2017) Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials
ASTM D4586/D4586M	(2007; E 2012; R 2012) Asphalt Roof Cement, Asbestos-Free
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM F402	(2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F656	(2021) Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM F1290	(2019) Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings
ASTM F1412	(2016) Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems
ASTM F2618	(2021) Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Fittings for Chemical Waste Drainage Systems

CAST IRON SOIL PIPE INSTITUTE (CISPI)

CISPI 301	(2018) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
CISPI 310	(2012) Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and

	Vent Piping Applications

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2016; 14/17) Copper Tube Handbook

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR Manual	(10th Edition) Manual of Cross-Connection Control

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO Z124.5	(2013; E 2013; R 2018) Plastic Toilet Seats

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities
ICC IPC	(2018) International Plumbing Code

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)

ANSI/ISEA Z358.1	(2014) American National Standard for Emergency Eyewash and Shower Equipment

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2017; Errata 1 2017) Butterfly Valves
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NACE INTERNATIONAL (NACE)

NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA Z535.1	(2017) Safety Colors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2020) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2021) National Fuel Gas Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2021) Plastics Piping System Components and Related Materials
NSF/ANSI 42	(2021) Drinking Water Treatment Units - Aesthetic Effects
NSF/ANSI 53	(2019) Drinking Water Treatment Units
NSF/ANSI 61	(2020) Drinking Water System Components - Health Effects
NSF/ANSI 372	(2016) Drinking Water System Components - Lead Content

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

PPFA Fire Man	(2016) Firestopping: Plastic Pipe in Fire Resistive Construction

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI G 101	(2010) Testing and Rating Procedure for Hydro Mechanical Grease Interceptors with

Appendix of Installation and Maintenance

PDI WH 201	(2010) Water Hammer Arresters Standard

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1508	(2009) Hose Clamp Specifications

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

PL 93-523	(1974; A 1999) Safe Drinking Water Act

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 430	Energy Conservation Program for Consumer Products
29 CFR 1910.144	Safety Color Code for Marking Physical Hazards
40 CFR 141.74	(2019) National Primary Drinking Water Regulations
40 CFR 143	National Secondary Drinking Water Regulations

UNDERWRITERS LABORATORIES (UL)

UL 174	(2004; Reprint Dec 2021) UL Standard for Safety Household Electric Storage Tank Water Heaters
UL 399	(2017; Reprint May 2019) UL Standard for Safety Drinking Water Coolers
UL 499	(2014; Reprint Jun 2022) UL Standard for Safety Electric Heating Appliances
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 732	(2018; Reprint Aug 2018) UL Standard for Safety Oil-Fired Storage Tank Water Heaters
UL 778	(2016; Reprint Jun 2021) UL Standard for Safety Motor-Operated Water Pumps
UL 1951	(2011; Reprint Jun 2020) UL Standard for Safety Electric Plumbing Accessories

1.2 SYSTEM DESCRIPTION

Provide complete and operable plumbing systems including sanitary and storm drainage, domestic water, plumbing fixtures, valves, pumps, water heaters, supports, and all associated appurtenances.

1.2.1 Performance Requirements

1.2.1.1 Cathodic Protection and Pipe Joint Bonding

Provide cathodic protection and pipe joint bonding systems in accordance with Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM.

1.2.2 Accessibility of Equipment

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, and equipment requiring access, in locations freely accessible through access doors.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Environmental Data; G

SD-02 Shop Drawings

Plumbing System; G

Domestic Water Systems Flushing Program; G

SD-03 Product Data

Pipe and Fittings; G

Pipe Hangers, Inserts, and Supports; G

Valves; G

Plumbing Fixtures; G

Backflow Preventers; G

Drains and Backwater Valves; G

Cleanouts; G

Interceptors; G

Water Heaters; G

Storage Tanks; G

Pumps; G

Water Pressure Booster System; G

Water Service Meter; G

Copper-Silver Ionization System; G

Potable Water Monitoring System; G

Vibration-Absorbing Features;

Recycled content for cast iron pipe; S

Recycled content for steel pipe; S

WaterSense label for shower head; S

Energy Star label for electric water cooler; S

WaterSense label for urinal; S

WaterSense label for water closet; S

Energy Star label for gas storage water heater; S

Energy Star label for gas instantaneous water heater; S

Plumbing System

SD-06 Test Reports

Tests, Flushing and Disinfection

Test of Backflow Prevention Assemblies

SD-07 Certificates

Materials and Equipment

Welding

Bolts

Pressure-Seal (Press-Fit) System Installation Training

Pressure-Seal (Press-Fit) Tools Calibration

EPA Registration for Copper-Silver Ionization

NSF Certification for Copper-Silver Ionization

SD-10 Operation and Maintenance Data

Plumbing System; G

Maintenance Data Package; 2

Submit in accordance with Section 01 78 23 OPERATIONS AND MAINTENANCE DATE; G.

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

1.4.1.1 Manufacturer Qualifications

Engage manufacturers regularly manufacturing, supplying, and servicing of specified products and equipment, as well as, providing engineering and/or start-up services as specified. Provide evidence demonstrating compliance for a minimum of 5 years, and on 5 projects of similar complexity.

1.4.1.2 Installer Qualifications

Installer must be licensed, and must provide evidence of the successful completion of at least five projects of equal or greater size and complexity. Provide tradespeople skilled in the appropriate trade. Installation of the following items/systems must be done by authorized representatives of respective manufacturers:

a. Water Pressure Booster Pump System.

b. Copper-silver Ionization System.

1.4.2 Welding

Weld piping in accordance with qualified procedures using performance-qualified welders and welding operators. Submit a list of names and identification symbols of qualified welders and welding operators. Provide documentation that welders, and welding operators are certified in accordance with American Welding Society Standard AWS B2.1/B2.1M. Qualify procedures and welders in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests, and perform the tests at the work site if practicable. Welders or welding operators must apply their assigned symbols near each weld they make as a permanent record. Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

1.4.3 Regulatory Requirements

1.4.3.1 International Code Council (ICC) Codes

Unless otherwise required herein, perform plumbing work in accordance with the ICC IPC.

a. For ICC Codes, interpret reference to the "code official" to mean the "Contracting Officer." For Government-owned property, interpret references to the "owner" to mean the "Contracting Officer." For leased facilities, interpret references to the "owner" to mean the "lessor." Interpret references to the "permit holder" to mean the "Contractor."

b. For ICC Codes referenced in the Contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this Contract and by the authority granted to the Officer in Charge of Construction] to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by their administrative cognizance and the FAR.

1.4.4 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.4.5 Service Support

The equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the Contract. Provide Maintenance Data Package 2. Submit manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 MAINTENANCE

Provide extra materials as follows:

a. Four additional cartridges for each waterless urinal installed along with any tools needed to remove/install the cartridge. Provide an additional quart of biodegradable liquid for each urinal installed.

b. One spare electrode cell for the copper-silver ionization system.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products. Specified equipment must essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening. Provide standard products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

2.2 MANUFACTURER'S NAMEPLATE

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. See also paragraph "Nameplates" in PART 3.

2.3 MATERIALS AND EQUIPMENT

Submit manufacturer's catalog data with highlighting to show model, size, options, and other features, that are intended for consideration. Provide adequate data to demonstrate compliance with Contract requirements. Submit certificate stating that the design, fabrication, and installation conform to the code, where equipment is specified to conform to requirements of the ASME Boiler and Pressure Vessel Code.

a. Provide NSF/ANSI 14 and NSF listed plastic pipe, fittings, and solvent cement for the service intended. Provide plastic pipe, fittings, and solvent cement used for potable hot and cold water service bearing the NSF seal "NSF-PW." Provide polypropylene pipe and fittings conforming to dimensional requirements of Schedule 40, Iron Pipe size. Do not install plastic pipe in air plenums. Do not install plastic pipe in pressure piping systems in buildings greater than three stories including any basement levels.

b. Hubless cast-iron soil pipe installed underground, under concrete floor slabs, or in crawl spaces below kitchen floors is not acceptable.

c. Provide cement pipe containing recycled content as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

d. Provide steel pipe containing a minimum of 25 percent recycled content, with a minimum of 16 percent post-consumer recycled content. Provide data identifying percentage of recycled content for steel pipe. Select pipe schedules based on service requirements. Provide pipe fittings compatible with the applicable pipe materials. Provide pipe threads (except dry seal) conforming to ASME B1.20.2M ASME B1.20.1. Provide grooved pipe couplings and fittings from the same manufacturer.

e. The use of lead containing materials or equipment in any potable water system is not acceptable. Comply with PL 93-523, NSF/ANSI 61, Section 8, and NSF/ANSI 372 for inline devices such as water meters, building valves, check valves, meter stops, valves, fittings and back flow preventers. Comply with NSF/ANSI 61, Section 9, and NSF/ANSI 372 for endpoint devices such as water coolers, lavatory faucets, kitchen and bar faucets, ice makers, supply stops and endpoint control valves used to dispense water for drinking.

2.4 PIPE AND FITTINGS

2.4.1 Domestic Water Piping

Domestic water piping at service entrance (from 1 foot inside building to 5 feet outside): Provide same as indicated for outside utilities.

a. 2 inches and smaller after service entrance above grade:

(1) Provide copper tube conforming to ASTM B88, type L, with soldered joints and wrought copper ASME B16.22 or cast brass ASME B16.18 fittings.

(2) Provide stainless steel pipe conforming to ASTM A312/A312M, Schedule 40, with threaded and butt weld joints. Provide stainless steel fittings conforming to ASTM A815/A815M, stainless steel

casting dimensions matching stainless steel pipe for threaded and butt weld connections.

(3) Pressure-seal (press-fit) fittings for Copper Pipe and Tube: Provide copper pressure-seal(press-fit) fittings conforming to the material and sizing requirements of ASME B16.18 or ASME B16.22. Provide EPDM, FKM, or HNBR sealing elements for copper pressure-seal (press-fit) fittings. Sealing elements must be factory installed or an alternative supplied fitting manufacturer. Select sealing elements based on manufacturer's approved application guidelines.

(4) Provide stainless steel pipe conforming to ASTM A312/A312M, Schedule 40, iron pipe size. Provide pressure-seal (press-fit) fittings for ASTM A312/A312M Schedule 40 stainless steel IPS pipe and tube. Stainless steel pressure-seal (press-fit) fittings conforming to the material and sizing requirements of ASTM A312/A312M or ASTM A403/A403M; NSF/ANSI 61 listed. Provide EPDM or FKM sealing elements for stainless steel pressure-seal (press-fit) fittings. Sealing elements must be factory installed or an alternative supplied fitting manufacturer. Select sealing elements based on manufacturer's approved application guidelines.

b. 2 1/2-inch and larger after service entrance above grade:

(1) Provide copper tube conforming to ASTM B88, type L, with brazed joints and wrought copper ASME B16.22 or cast brass ASME B16.18 fittings.

(2) Provide stainless steel pipe conforming to ASTM A312/A312M, Schedule 40, with threaded and butt weld joints. Provide stainless steel fittings conforming to ASTM A815/A815M or ASTM A403/A403M, stainless steel casting dimensions matching stainless steel pipe for threaded and butt weld connections.

(3) Provide copper tube conforming to ASTM B88M ASTM B88, type L, with roll-groove joints and manufactured grooved fittings conforming to ASTM A755/A755M C12200 or ASTM B152/B152M C11000 and ASME B16.22 for wrought copper, or in accordance with ASTM B584 copper alloy CDA 836 (85-5-5-5) in accordance with ASME B16.18.

(4) Provide copper tube conforming to ASTM B88M ASTM B88, type L. Provide pressure-seal (press-fit) fittings for copper pipe and tube. Copper pressure-seal (press-fit) fittings conforming to the material and sizing requirements of ASME B16.18 or ASME B16.22. Provide EPDM, FKM, or HNBR sealing elements for copper pressure-seal (press-fit) fittings. Sealing elements must be factory installed or an alternative supplied fitting manufacturer. Select sealing elements based on manufacturer's approved application guidelines.

(5) Provide stainless steel pipe conforming to ASTM A312/A312M, Schedule 40, iron pipe size. Provide pressure-seal (press-fit) fittings for ASTM A312/A312M Schedule 40 stainless steel IPS pipe and tube. Stainless steel pressure-seal (press-fit) fittings conforming to the material and sizing requirements of ASTM A312/A312M or ASTM A403/A403M; NSF/ANSI 61 listed. Provide EPDM or FKM sealing elements for stainless steel pressure-seal (press-fit) fittings. Sealing elements must be factory installed

or an alternative supplied fitting manufacturer. Select sealing elements based on manufacturer's approved application guidelines.

(6) Provide stainless steel pipe conforming to ASTM A312/A312M, Schedule 10, with roll-groove joints and manufactured grooved fittings conforming to ASTM A815/A815M with stainless steel casting dimensions matching stainless steel pipe.

c. Below grade:

(1) Provide copper tube conforming to ASTM B88, type K soft, with brazed joints and wrought copper ASME B16.22 fittings.

(2) Where below-grade run of piping is shorter than 50 feet, below-grade joints are not acceptable.

d. Connections to Existing Galvanized Piping:

(1) Provide threaded, mechanical groove, mechanical plain-end, or flanged connections.

2.4.2 Deionized and Reverse Osmosis Water Piping

CPVC Plastic Pipe, Fittings, and Solvent Cement: Provide ASTM D2846/D2846M, Schedule 80 CPVC. Provide transition union connections or threaded gate valve between copper tubing and chlorinated polyvinyl chloride (CPVC) piping. Provide male threaded adapters with PTFE (polytetrafluoroethylene) pipe thread paste for threaded connections to valves, strainers, and equipment.

2.4.3 Drainage Piping (Soil, Waste, Vent, Indirect, and Storm)

a. Above grade:

(1) Provide cast-iron conforming to ASTM A74, hubbed pipe and fittings with ASTM C564 elastomeric push joints.

(2) Provide cast-iron conforming to CISPI 301 or ASTM A888, hubless pipe, fittings, and CISPI 310 elastomeric sealing sleeves with stainless-steel or cast iron clamps.

(3) Provide copper tube conforming to ASTM B306, type DWV or heavier, with soldered joints and wrought copper ASME B16.29 or cast brass ASME B16.23 drainage and vent fittings. Provide copper piping systems within MRI shielding assemblies.

(4) Provide seamless or welded, hot-dipped galvanized steel conforming to ASTM A53/A53M or ASTM B36/B36M, cast iron drainage type fittings, galvanized malleable vent fittings and threaded joints.

b. Below grade:

(1) Provide cast-iron conforming to ASTM A 74, hubbed pipe and fittings with ASTM C564 elastomeric push joints.

(2) Provide PVC solid-wall pipe, iron pipe size (IPS), conforming to ASTM D1785 and ASTM D2665. PVC socket fittings conforming to ASTM D2665, made to ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe. ASTM F656 adhesive primer and

ASTM D2564 solvent cement. Provide PVC pipe and fittings manufactured from ASTM D1784 PVC compound cell class of 12454 and conforming to NSF/ANSI 14.

c. Foundation Drain:

(1) Provide PVC solid-wall pipe, iron pipe size (IPS), 4 inches in diameter, perforated, conforming to ASTM D2729. PVC socket fittings conforming to ASTM D2665, made to ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe. ASTM F656 adhesive primer and ASTM D2564 solvent cement. Provide PVC pipe and fittings manufactured from ASTM D1784 PVC compound cell class of 12454 and conforming to NSF/ANSI 14.

2.4.4 Drainage Piping (Corrosive Waste)

a. Above grade:

(1) Provide corrosive waste borosilicate glass conforming to ASTM C1053, with mechanical joints and borosilicate glass fittings.

(2) Provide corrosive waste cast iron (14 percent silica) pipe and fittings conforming to ASTM A518/A518M and ASTM A861. Mechanical joints, and bell and spigot joints are acceptable in exposed (accessible) locations. Bell and spigot joints only are acceptable in concealed (non-accessible) locations.

(3) Provide corrosive waste Schedule 40 fire retardant polypropylene DWV pipe and fittings conforming to ASTM D4101, ASTM F1412, ASTM D635, and ASTM D3311. Mechanical joints, and fused joints are acceptable in exposed (accessible) locations. Fused joints only are acceptable in concealed (non-accessible) locations.

(4) Provide CPVC drainage pipe and drainage pattern fittings conforming to ASTM F2618. ASTM F656 adhesive primer and ASTM D2564 solvent cement. Provide CPVC pipe and fittings manufactured from ASTM D1784 CPVC Type IV compound cell class of 23447 and conforming to NSF/ANSI 14.

b. Below grade:

(1) Corrosive waste cast iron (14 percent silica) pipe and fittings conforming to ASTM A518/A518M and ASTM A861, with bell and spigot joints.

(2) Corrosive waste Schedule 80 polypropylene DWV pipe and fittings conforming with ASTM D4101 and ASTM D3311 with fused joints.

(3) Provide CPVC drainage pipe and drainage pattern fittings conforming to ASTM F2618. ASTM F656 adhesive primer and ASTM D2564 solvent cement. Provide CPVC pipe and fittings manufactured from ASTM D1784 CPVC Type IV compound cell class of 23447 and conforming to with National Sanitation Foundation (NSF) Standard 14..

2.4.5 Pressure Drainage Piping

a. Cast iron pressure pipe and fittings, with mechanical joints.

b. Galvanized steel, cast iron drainage fittings with threaded joints.

2.4.6 Exposed Piping in Finished Areas

a. Chrome or nickel plated brass to wall or floor.

b. Piping 2 inches and larger may be provided with chrome or nickel plated brass sleeves to cover pipe and fittings in lieu of plating.

2.4.7 Trap Primer Pipe Between Primer Device and Drain

a. Above grade: Copper tube conforming to ASTM B88, type K or L, with soldered joints and wrought copper ASME B16.22 or cast brass ASME B16.18 fittings.

b. Below grade: Copper tube conforming to ASTM B88, type K soft, with soldered joints and wrought copper ASME B16.22 or cast brass ASME B16.18 fittings.

2.5 PIPE JOINT MATERIALS

The use of grooved pipe and hubless cast-iron soil pipe underground is not acceptable. Mark cast iron soil pipe and fittings with the collective trademark of the Cast Iron Soil Pipe Institute. Provide joints and gasket materials conforming to the following:

a. Coupling for Cast-Iron Pipe: for hub and spigot type ASTM A74, AWWA C606. For hubless type: CISPI 310

b. Couplings for Stainless Steel Pipe: AWWA C606.

c. Couplings for Grooved Pipe: Ductile Iron ASTM A536 (Grade 65-45-12) Malleable Iron ASTM A47/A47M, Grade 32510. Copper ASTM A536.

d. Flange Gaskets: Provide gaskets of non-asbestos material in accordance with ASME B16.21. Provide flat gaskets, 1/16 inch thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Provide full face or self centering flat ring type gaskets. Provide gaskets bonded with NBR for hydrocarbon service.

e. Brazing Material: Conform to AWS A5.8/A5.8M, BCuP-5.

f. Brazing Flux: Provide flux in paste or liquid form appropriate for use with brazing material. Provide flux as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides; and contain fluorides.

g. Solder Material: Solder metal conforming to ASTM B32 and Code approved "Lead Free" having a chemical composition equal to or less than 0.2 percent lead.

h. Solder Flux: Liquid form, non-corrosive, Code approved "Lead Free" and conforming to ASTM B813, Standard Test 1.

i. PTFE Tape: PTFE Tape, for use with Threaded Metal or Plastic Pipe.

j. Rubber Gaskets for Cast-Iron Soil-Pipe and Fittings (hub and spigot type and hubless type): ASTM C564.

k. Rubber Gaskets for Grooved Pipe: ASTM D2000, rated for a maximum temperature of not less than 230 degrees F.

l. Flexible Elastomeric Seals: ASTM D3139, ASTM D3212 or ASTM F477.

m. Bolts and Nuts for Grooved Pipe Couplings: Heat-treated carbon steel, ASTM A183.

n. Flanged fittings including flanges, bolts, nuts, bolt patterns, and related features, in accordance with ASME B16.5 class 150 and having the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material conforming to ASTM A105/A105M. Blind flange material conforming to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Provide high strength or intermediate strength bolts with material conforming to ASTM A193/A193M. Submit written certification by the bolt manufacturer that the bolts furnished comply with the specified requirements.

2.6 MISCELLANEOUS MATERIALS

Miscellaneous materials conforming to the following:

a. Water Hammer Arrester: PDI WH 201.

b. Copper, Sheet, and Strip for Building Construction: ASTM B370.

c. Asphalt Roof Cement: ASTM D4586/D4586M.

d. Hose Clamps: SAE J1508.

e. Supports for Off-The-Floor Plumbing Fixtures: ASME A112.6.1M.

f. Metallic Cleanouts: ASME A112.36.2M.

g. Plumbing Fixture Setting Compound: A preformed flexible ring seal molded from hydrocarbon wax material. The seal material must be nonvolatile nonasphaltic and contain germicide and provide watertight, gastight, odorproof, and verminproof properties.

h. Coal-Tar Protective Coatings and Linings for Steel Water Pipelines: AWWA C203.

i. Hypochlorites: AWWA B300.

j. Liquid Chlorine: AWWA B301.

k. Gauges - Pressure Indicating Dial Type - Elastic Element: ASME B40.100.

l. Thermometers: ASTM E1. Mercury in thermometers is not acceptable.

2.7 PIPE INSULATION MATERIAL

Provide insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.8 PIPE HANGERS, INSERTS, AND SUPPORTS

Provide pipe hangers, inserts, and supports conforming to MSS SP-58. Provide non-ferrous (copper, aluminum, stainless steel hangers in MRI

Suites.

2.9 VALVES

Provide valves on supplies to equipment and fixtures. Valves 2-1/2 inches and smaller must be bronze with threaded bodies for pipe and solder-type connections for tubing. Valves 3 inches and larger must have flanged iron bodies and bronze trim. Base valve pressure ratings on the application. Grooved end valves may be provided if the manufacturer certifies that the valves meet the performance requirements of applicable MSS standard. Provide valves conforming to the following standards:

Description	Standard
Butterfly Valves	MSS SP-67
Cast-Iron Gate Valves, Flanged and Threaded Ends	MSS SP-70
Cast-Iron Swing Check Valves, Flanged and Threaded Ends	MSS SP-71
Ball Valves with Flanged Butt-Welding Ends for General Service	MSS SP-72
Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends	MSS SP-110
Cast-Iron Plug Valves, Flanged and Threaded Ends	MSS SP-78
Bronze Gate, Globe, Angle, and Check Valves	MSS SP-80
Steel Valves, Socket Welding and Threaded Ends	ASME B16.34
Cast-Iron Globe and Angle Valves, Flanged and Threaded Ends	MSS SP-85
Backwater Valves	ASME A112.14.1
Vacuum Relief Valves	ANSI Z21.22/CSA 4.4
Water Pressure Reducing Valves	ASSE 1003
Water Heater Drain Valves	ASME BPVC SEC IV, Part HLW-810
Trap Seal Primer Valves	ASSE 1018
Temperature and Pressure Relief Valves for Hot Water Supply Systems	ANSI Z21.22/CSA 4.4
Temperature and Pressure Relief Valves for Automatically Fired Hot Water Boilers	ASME CSD-1 Safety Code, Part CW, Article 5

2.9.1 Thermostatic Mixing Valves

2.9.1.1 Master Mixing Valve Assemblies

ASSE 1017. Provide lead-free high/low type mixing valve assembly with large type thermostatic water mixing valve and intermediate type thermostatic water mixing valve. Provide union angle strainers, checkstops on inlets outlets, and ball valves on outlets of mixing valves. Provide pilot actuated regulating valve with pressure gage, thermostat, adjustable limit stop, and dial thermometer (range) (range 0 to 200 degrees F). Provide mixing valve components with rough bronze finish and mount on welded strut with corrosion resistant wall support and inlet piping manifold. Provide entire assembly factory assembled and tested. Pipe mixing valve assembly and domestic hot water return according to manufacturer's recommended piping method. Set mixing valve outlet temperature as indicated on Contract Drawings. Provide mixing valves which maintain water temperature within 4 degrees F of setpoint.

2.9.1.2 Lavatory and Sink Mixing Valves

ASSE 1070. Provide line size mixing valves for each lavatory and/or sink faucet in restrooms. Provide mixing valves, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced constructed with rough or finish bodies either with or without plating. Each valve must be constructed to control the mixing of hot and cold water and to deliver water at a desired temperature regardless of pressure or input temperature changes. Provide heavy cast bronze body, and interior parts of brass, bronze, corrosion-resisting steel or copper materials. Equip the valve with stop valves, check valves, unions, and sediment strainers on the inlets. Set mixing valves at 105 degrees F. Mixing valves must maintain water temperature within 4 degrees F of setpoint.

2.10 PLUMBING FIXTURES

2.10.1 General

Provide water conservation type fixtures. Provide fixtures for use by the physically handicapped in accordance with ICC A117.1. Provide vitreous china fixtures that are nonabsorbent, hard-burned, and vitrified throughout the body. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws. Equip fixtures with appurtenances such as traps, faucets, stop valves, and drain fittings. Equip each fixture and piece of equipment requiring connections to the drainage system with a trap. Provide brass expansion or toggle bolts capped with acorn nuts for supports, and provide polished chromium-plated pipe, valves, and fittings where exposed to view. Equip fixtures with the supply discharge below the rim with backflow preventers. Internal parts of flush and/or flushometer valves, shower mixing valves, shower head face plates, may contain acetal resin, fluorocarbon, nylon, acrylonitrile-butadiene-styrene (ABS) or other plastic material, if the material has provided satisfactory service under actual commercial or industrial operating conditions for not less than 2 years Maximum allowable lead content in wetted surfaces of pipes, pipe fittings, plumbing fittings and fixtures, as determined by a weighted average must not exceed 0.25 percent. Provide water closets, urinals, flush valves, lavatory faucets, bathroom sink faucets, and shower heads with WaterSense label .

2.10.2 Flushometer Valves

Provide flushometer valves with an ADA compliant, metal oscillating, non-hold-open handle, backcheck angle control stop, and vacuum breaker. Flushometer valves must be either a large diaphragm, or fixed volume piston type with filtered metering bypass. Valve must not be able to be converted externally or internally to exceed a low consumption flush. Provide handle packing, main seat, stop seat and vacuum breaker molded from a chloramine resistant rubber compound. Provide valve body, cover, tailpiece and control stop in conformance with ASTM Alloy Classification for semi-red brass. Provide all exposed surfaces chrome plated. Provide handle with factory applied antimicrobial coating. Provide flushometer valves conforming to ASSE 1037.

2.10.3 Automatic Controls

Where specified with a fixture, provide automatic, sensor operated faucets complying with ASSE 1037 and UL 1951. Provide faucet systems consisting of solenoid-activated valves with light beam sensors.

2.10.4 Fixture Descriptions

2.10.4.1 Electric Water Coolers

Provide self-contained, mechanically refrigerated electric water coolers with more than a single thickness of metal between the potable water and the refrigerant in the heat exchanger, wall-hung, bubbler style, air-cooled condensing unit, stainless steel splash receptor and basin, and stainless steel cabinet. Provide 8 gph minimum capacity of 50 degrees F water when supplied with 80 degrees F inlet water and a 90 degrees F room temperature. Control bubblers by push levers or push bars, front mounted or side mounted near the front edge of the cabinet. Mount bubbler spouts at a maximum of 36 inches above floor and at front of unit basin with 27 inch minimum knee clearance from bottom of unit to finished floor. Spouts must direct water flow at least 4 inches above unit basin and trajectory parallel or nearly parallel to the front of unit. Provide chrome plated 3/8 inch OD soft-copper tube supplies with set-screw escutcheons, and loose key stops. Provide chrome plated 1-1/4 by 1-1/2 inch semi-cast P-trap with cleanout with 17 gage by 1-1/2 inch chrome plated copper tube trap arm with set-screw escutcheon. Provide filters for chlorine in supply piping to faucets. Provide ASME A112.6.1M concealed steel pipe chair carriers. Provide electric water cooler that is Energy Star labeled. Provide data identifying Energy Star label for electric water cooler. Mount electric water coolers for use by the physically handicapped at heights in accordance with ICC A117.1.

2.10.4.1.1 EWC-1 (JSN R2200)

In-wall recessed bottle filling station. Provide stainless steel construction with plastic ABS alcove and lower hinged grille panel for access and servicing. Sensor-activation with an auto 20-second shut-off timer. Provide display indicating count of plastic bottles saved from waste. Provide bottle filler with a flow rate of 1.1-1.5 gpm and laminar flow to minimize splashing. Provide 3000-gallon capacity filter, certified to NSF/ANSI 42 and NSF/ANSI 53, with visual monitor to indicate when replacement is necessary. Provide integrated silver ion anti-microbial protection in key areas. Provide unit in conformance with ABA guidelines. Provide unit with lead free design certified to NSF/ANSI 61 and NSF/ANSI 372 and meets Federal and State low-lead requirements. Provide unit certified to UL 399.

2.10.4.1.2 EWC-2 (JSN R2201)

Self-contained, wall hung, mechanically refrigerated, dual-level, brushed stainless steel finish, top mounted bottle filler on non-accessible water cooler, receptors designed to eliminate splashing and standing waste water. Control bubblers by push levers or push bars, front mounted and side mounted near the front edge of the cabinet.

2.10.4.1.3 EWC-3 (Similar to JSN R2202)

Self-contained, wall hung, mechanically refrigerated, single-level, accessible, brushed stainless steel finish, top mounted bottle filler, receptor designed to eliminate splashing and standing waste water. Control bubbler by push levers or push bars, front mounted and side mounted near the front edge of the cabinet.

2.10.4.1.4 EWC-4 (JSN R2203)

Accessible (forward facing), dual-level, recessed, brushed stainless steel, recessed refrigeration unit, dual level extensions with oval receptors, recessed bottle filler, access panel cover, rounded corners, rounded edges, designed to eliminate splashing and standing waste water. Provide self-closing, semi-circular push bars with full 180 degree activation.

2.10.4.2 Emergency Fixtures

Provide copper alloy control valves. Provide an air-gap with the lowest potable eye and face wash water outlet located above the overflow rim by not less than the International Plumbing Code minimum. Provide a pressure-compensated tempering valve, with leaving water temperature setpoint adjustable throughout the range 60 to 95 degrees F. Provide packaged, UL listed, alarm system; including an amber strobe lamp, horn with externally adjustable loudness and horn silencing switch, mounting hardware, and waterflow service within NEMA Type 3 or 4 enclosures and for explosion proof service within NEMA Type 7 or 9 enclosures.

2.10.4.2.1 EW-1 (Similar to JSN P1965)

Eye/face wash, ANSI/ISEA Z358.1, deck-mounted, swing down, self-cleaning, non-clogging eye and face wash with quick opening, full-flow valve. Spray heads swing down from storage to operational position activating water flow. Coordinate configuration with sink faucet location. Provide eye/face wash with a minimum flow rate of 3 gpm of aerated water at 30 psig flow pressure.

2.10.4.2.2 EW-2 (JSN P2000)

Eye/face wash, ANSI/ISEA Z358.1, wall-mounted self-cleaning, non-clogging eye and face wash with quick opening, full-flow valves, corrosion-resisting steel eye and face wash receptor. Provide unit with a minimum flow rate of 3 gpm of aerated water at 30 psig flow pressure, with eye and face wash nozzles 33 to 45 inches above finished floor. Provide 1-1/4 inch standard chrome drain fitting.

EW-3 (Similar to JSN P2000)

Eye/face wash, ANSI/ISEA Z358.1. Recessed eye/face wash assembly. Eye/face wash, swing down, self-cleaning, non-clogging eye and face wash with quick opening, full-flow valve. Spray heads swing down from storage to operational position activating water flow. Provide eye/face wash with a minimum flow rate of 3 gpm of aerated water at 30 psig flow pressure. Mount eye/face wash actuator in combined stainless steel fully recessed cabinet with flanged rim and suitable for installation in a 3 5/8 inch stud wall. Provide all exposed surfaces with stainless steel finishes. Provide unit suitable for and installed for handicap access.

2.10.4.2.3 ES-1 (Similar to JSN P5210)

Combination drench shower and eye/face wash, ANSI/ISEA Z358.1. Recessed eye/face wash and shower actuator assembly. Eye/face wash, swing down, self-cleaning, non-clogging eye and face wash with quick opening, full-flow valve. Spray heads swing down from storage to operational position activating water flow. Provide eye/face wash with a minimum flow rate of 3 gpm of aerated water at 30 psig flow pressure. Provide a minimum 8 inch diameter shower head designed for vertical supply piping. Provide 1 inch IPS brass stay-open shower valve with stainless steel "panic bar" actuator. Provide shower with a minimum flow rate of 20 gpm flow and 20 inch pattern at 60 inches above floor. Mount eye/face wash and shower actuator in combined stainless steel fully recessed cabinet with flanged rim and suitable for installation in a 3 5/8 inch stud wall. Provide all exposed surfaces with stainless steel finishes. Provide unit suitable for and installed for handicap access.

2.10.4.2.4 ES-2 (JSN P5210)

Combination drench shower and eye/face wash, ANSI/ISEA Z358.1. Mount components on a minimum 1-1/4 inch diameter stainless steel pipe stanchion with floor flange. Provide chrome plated split ring support to adjacent wall surface 12 inches below shower arm connection. Eye/face wash, swing down, self-cleaning, non-clogging eye and face wash with quick opening, 1/2 inch IPS chrome-plated brass full-flow push to activate stay-open valve. Provide eye/face wash with a minimum flow rate of 3 gpm of aerated water at 30 psig flow pressure. Provide a minimum 8 inch diameter shower head. Provide 1 inch IPS chrome-plated brass stay-open shower valve with stainless steel actuating arm and pull rod. Provide shower with a minimum flow rate of 20 gpm flow and 20 inch pattern at 60 inches above floor. Provide unit suitable for and installed for handicap access.

2.10.4.3 Lavatories

a. Provide ASME A112.19.2/CSA B45.1, white vitreous china, integral back type wall hung lavatories with supply openings for use with top mounted faucet, and openings for concealed arm carrier installation. Provide chrome plated 3/8 inch OD soft-copper tube supplies with set-screw escutcheons, and loose key stops. Provide chrome plated 1-1/4 by 1-1/2 inch semi-cast P-trap with cleanout with 17 gage by 1-1/2 inch chrome plated copper tube trap arm with set-screw escutcheon. Provide ASME A112.6.1M concealed chair carriers with vertical steel pipe supports and concealed arms for the lavatory. Mount lavatory with the front rim 31 inches above the floor, except 34 inches maximum above floor and with 29 inches minimum clearance from bottom of the front rim to floor for accessible lavatories.

   (1) L-1 (Similar to JSN P3200): 20 by 18 inches. Equip fixture with, electronic infra-red operated 4 inch centerset combination faucet with aerator, drain fitting with grid strainer, "P" trap, and angle or straight stop valves. Automatic water flow starts electronically by proximity of individual. Provide wiring box, 120/24 volt solenoid, remote mounted transformer. Transformer may be sized for multiple adjacent lavatories. Provide WaterSense labeled faucet with a maximum flow rate of 0.5 gpm at a flowing pressure of 60 psig. Limit water volume to a maximum of 0.25 gal per metering cycle.

   (2) L-2: Same as L-1 except accessible mounting height per ICC A117.1. Provide accessible protection on exposed water supplies and "P"

trap and drain piping.

(3) L-3 (Similar to JSN P3100): 20 by 18 inches. Equip fixture with combination faucet, elevated gooseneck spout with laminar flow outlet, 4 inch wrist action handles, drain fitting with grid strainer, "P" trap, and angle or straight stop valves. Faucet bodies with a pop-up drain rod hole are not acceptable. Plugged holes are not acceptable. Limit faucet flow rate to a maximum of 1.5 gpm at a flowing water pressure of 60 psig.

(4) L-4: Same as L-3 except accessible mounting height per ICC A117.1. Provide accessible protection on exposed water supplies and "P" trap and drain piping.

(5) L-5 (Similar to JSN P3100): 20 by 18 inches. Equip fixture with combination faucet, elevated gooseneck spout with laminar flow outlet, 4 inch wrist action handles, drain fitting with grid strainer, "P" trap, and angle or straight stop valves. Faucet bodies with a pop-up drain rod hole are not acceptable. Plugged holes are not acceptable. Limit faucet flow rate to a maximum of 1.5 gpm at a flowing water pressure of 60 psig. Accessible mounting height per ICC A117.1. Provide accessible protection on exposed water supplies and "P" trap and drain piping.

b. ASME A112.19.2/CSA B45.1, white vitreous china, self-rimming counter-mounted lavatories with supply openings for use with top mounted faucet. Furnish template and mounting kit by lavatory manufacturer. Provide chrome plated 3/8 inch OD soft-copper tube supplies with escutcheons, and loose key stops. Provide chrome plated 1-1/4 by 1-1/2 inch semi-cast P-trap with cleanout with 17 gage by 1-1/2 inch chrome plated copper tube trap arm with escutcheon.

(1) L-6 (Similar to JSN P3070): 20 by 18 inches. Equip fixture with, electronic infra-red operated 4 inch centerset combination faucet with spray outlet, drain fitting with grid strainer, "P" trap, and angle or straight stop valves. Automatic water flow starts electronically by proximity of individual. Provide wiring box, 120/24 volt solenoid, remote mounted transformer. Transformer may be sized for multiple adjacent lavatories. Limit faucet flow rate to a maximum of 0.5 gpm at a flowing pressure of 60 psig. Limit water volume to a maximum of 0.25 gal per metering cycle.

(2) L-7: Same as L-6 except provide accessible protection on exposed water supplies and "P" trap and drain piping.

(3) L-8 (Similar to JSN P3070): 20 by 18 inches. Equip fixture with 4 inch centerset combination faucet, elevated gooseneck spout with laminar flow outlet, 4 inch wrist action handles, drain fitting with grid strainer, "P" trap, and angle or straight stop valves. Faucet body must not have a pop-up drain rod hole. Plugged holes are not acceptable. Flow must be limited to 1.5 gpm at a flowing pressure of 60 psig. Accessible mounting height per ICC A117.1. Provide accessible protection on exposed water supplies and "P" trap and drain piping.

2.10.4.4 Mop Service Basin

a. Provide terrazzo mop sinks made of marble chips cast in white portland cement to produce 3000 psig minimum compressive strength 7 days after casting. Provide floor or wall outlet copper alloy body drain cast integral with terrazzo, with polished stainless steel strainers.

b. MS-1 (JSN P4700): 36 by 24 by 12 inches, precast terrazzo with integral stainless steel caps with tiling flange, 3-inch cast brass drain with stainless strainer, lead caulk drain connection and 20 gage, type 304 stainless steel 12-inch high splash/wall guards. Provide chrome plated, 8-inch centers, wall mounted cast brass service sink faucet with rigid spout with integral vacuum breaker, 3/4-inch hose threads, pale hook, wall brace, indexed lever handles, hose, hose bracket, and mop hanger. Provide ball type shutoff valves and check valves above ceiling in supply piping to mop sink faucet.

2.10.4.5 Plaster Traps

2.10.4.5.1 PT-1 (JSN P7600)

Large, 16 inches high by 14 inches wide by 14 inches long; heavy gray cast-iron body, white porcelain-enamel inside and outside; clamps, cage of heavy galvanized material, and brass screens; with 2 inch low inlet and 2 inch high outlet fitted with hood seal.

2.10.4.5.2 PT-2 (JSN P7650)

Small, 12 inches high by 6 inches wide by 6 inches long; cast aluminum, rectangular with solid top and hinged bottom having integral baffles and 1/4 inch drain plug; provide bolted bottom for easy access for removal of screens for cleaning and recovery of items in sediment bucket.

2.10.4.6 Showers

Provide single control pressure equalizing shower valves with body mounted from behind the wall with threaded connections. Provide tubing mounted from behind the wall between faucets and shower assembly. Provide separate globe valves or angle valves with union connections in each supply to faucet. Provide top of drain outlets of chromium-plated or polished stainless steel finish. Provide shower valve with ball type control handle. Provide precast terrazzo shower floors made of marble chips cast in white portland cement to produce 3000 psi minimum compressive strength 7 days after casting. Provide floor or wall outlet copper alloy body drain cast integral with terrazzo floor, with polished stainless steel strainers.

2.10.4.6.1 SH-1 (JSN P5040)

Wall mounted detachable spray assembly, 24 inch wall bar, elevated vacuum breaker, supply elbow and flange and valve. All external trim, chrome plated metal. Plastic shower head 5 foot length of rubber lined corrosion resistant steel, chrome plated metal flexible, or white vinyl reinforced hose and supply wall elbow. Provide WaterSense labeled shower head with a maximum flow rate of 1.5 gpm. Provide data identifying WaterSense label for shower head. Design showerhead to fit in palm of hand. Provide corrosion resistant steel or chrome plated metal wall bar with an adjustable swivel hanger for showerhead. Fasten wall bar securely to wall for hand support. Combination thermostatic and pressure anti-scald balancing valve, with chrome plated metal lever type operating handle adjustable for rough-in variations and chrome plated metal or corrosion resistant steel face plate. Provide copper alloy valve body. Internal parts must be copper, nickel alloy, corrosion resistant steel or thermoplastic material. Provide 1/2 inch IPS valve inlets and outlet. Provide external screwdriver check stops, vacuum breaker and temperature limit stops. Set stops for a maximum temperature of 105 degrees F. Provide vandal resistant exposed fasteners. Provide valve with a maximum flow rate of 1.5 gpm at a flowing pressure of 80 psig.

2.10.4.6.2 SH-2 (Similar to JSN P5040)

Wall mounted, shower head connected to shower arm. Provide all external trim of chrome plated metal. Chrome plated metal head, adjustable ball joint, self cleaning with automatic flow control device to limit discharge to not more than 1.5 gpm. Provide valve body, internal parts of shower head and flow control fittings of copper alloy or corrosion resistant steel. Install showerhead 72 inches above finished floor. Combination thermostatic and pressure anti-scald balancing valve, with chrome plated metal lever with adjustment for rough-in variations, type operating handle and chrome plated brass or corrosion resistant steel face plate. Provide copper alloy valve body. Provide copper, nickel alloy, corrosion resistant steel or thermoplastic material internal parts. Provide 1/2 inch IPS valve inlets and outlet. Provide external screwdriver check stops, and temperature limit stops. Set stops for a maximum temperature of 105 degrees F. Install valve 54 inches from bottom of shower receptor. Provide vandal resistant exposed fasteners. Provide valve with a maximum flow rate of 1.5 gpm at a flowing pressure of 80 psig.

2.10.4.6.3 SH-3 (JSN P5350)

Psychiatric patient, vandal-resistant with thermostatic valve in cabinet; provide shower head designed for prison use. Provide fixture with smooth surfaces with no projection that can be used as a catch or hook; provide flat back arranged for bolting directly to the wall; tapped for 1/2 inch pipe connection to tempered water line; provide tamperproof shower head with removable face not less than 3-1/2 inch diameter; install shower head not less than 6 feet above the floor and with spray delivery within a 3 foot circle. Limit flow to a maximum rate of 2.0 gpm at a flowing water pressure of 80 psig.

2.10.4.7 Sinks

Provide ASME A112.19.3/CSA B45.4, Type 302(18-8) or 304(18-8) stainless steel sinks with integral mounting rim for flush installation, with undersides fully sound deadened, with supply openings for use with top mounted faucet, and with 3.5 inch drain outlet. Provide 18 gage sinks for basin depths less than or equal to 10 inch. Provide 16 gage sinks for basin depths greater than 10 inch. Provide faucet with gooseneck spout with plain-end and laminar flow fitting in base of gooseneck spout. Aerators are not acceptable. Provide faucets with a maximum flow rate of 1.5 gpm when measured at a flowing water pressure of 60 psig. Provide chrome plated 3/8 inch OD soft-copper tube supplied with escutcheons, and loose key stops. Provide chrome plated 1-1/2 inch semi-cast P-trap with cleanout with 17 gage by 1-1/2 inch chrome plated copper tube trap arm with escutcheon. Provide separate 1.5 inch P-trap and drain piping to vertical vent piping from each compartment. Coordinate hole quantities, locations, and centerings with faucet types indicated in fixture descriptions. Provide exact numbers of holes necessary. Use of faucet hole covers is not acceptable. Dimensions given are overall, and bowl in the following order: front to back, left to right, depth. Provide sinks located in casework designated as handicap accessible same as specified except basin depths not greater than 6 inches and drain outlets located to the rear of basins.

2.10.4.7.1 S-1 (JSN CS010)

Single bowl, counter-mounted, 18 by 15 by 6-1/2 inches, bowl 12 by 12 by 6 inches. Locate drain outlet to the rear of the basin. Provide 4 inch centerset faucet with two 4 inch wristblades and 5 inch diameter fixed gooseneck spout.

2.10.4.7.2 S-2 (JSN CS080)

Single bowl, counter-mounted, 20 by 22 by 7-1/2 inches, bowl 14 by 18 by 7-1/2 inches. Faucet must be 4 inch centerset with two 4 inch wristblades and 5 inch diameter fixed gooseneck spout.

2.10.4.7.3 S-3 (JSN CS090)

Single bowl, counter-mounted, 22 by 22 by 7-1/2 inches, bowl 16 by 19 by 7-1/2 inches. Provide 4 inch centerset faucet with two 4 inch wristblades and 5 inch diameter fixed gooseneck spout.

2.10.4.7.4 S-4 (JSN CS140)

Single bowl, counter-mounted, 22 by 17 by 10 inches, bowl 16 by 14 by 10 inches. Provide 4 inch centerset faucet with two 4 inch wristblades and 5 inch diameter fixed gooseneck spout.

2.10.4.7.5 S-5 (JSN CS150)

Single bowl, counter-mounted, 22 by 22 by 10 inches, bowl 16 by 19 by 10 inches. Provide 4 inch centerset faucet with two 4 inch wristblades and 5 inch diameter fixed gooseneck spout.

2.10.4.7.6 S-6 (JSN CS180)

Single bowl, counter-mounted, 22 by 25 by 12 inches, bowl 16 by 22 by 12 inches. Provide 4 inch centerset faucet with two 4 inch wristblades and 5 inch diameter fixed gooseneck spout.

2.10.4.7.7 S-7 (JSN CS200)

Single bowl, counter-mounted, 22 by 31 by 12 inches, bowl 16 by 28 by 12 inches. Provide 4 inch centerset faucet with two 4 inch wristblades and 5 inch diameter fixed gooseneck spout.

2.10.4.7.8 S-8 (JSN CS230)

Double bowl, counter-mounted, 22 by 33 by 10 inches, each bowl 16 by 14 by 10 inches. Provide 8 inch spread faucet, single handle, swing spout.

2.10.4.7.9 S-9 (JSN CS250)

Single bowl, counter-mounted, 15 by 15 by 6 inches, bowl 9 by 12 by 6 inches. Provide 4 inch centerset faucet with two 4 inch wristblades and 5 inch diameter fixed gooseneck spout.

2.10.4.7.10 S-10 (JSN P3520)

Sink, plaster, 22 by 30 by 9-1/2 inches; vitreous china; faucet with 2 inch spray, 6 inch handles, screwdriver stops, grid drain 1-1/2 inch tailpieces, 2 inch O.D. drain connection to trap and wall; provide plaster-interceptor trap (PT-1), install plaster trap with manufacturer's recommended clearances above the unit for removal of screens. Provide with floor-mounted heavy-duty type sink carrier with acid-resisting white coated exposed arms and hanger support plate.

2.10.4.8 Sink, Flushing Rim SF-1 (JSN P6350)

Wall mounted flushing rim sink with stainless steel spring type front and side rim guards, 4 inch wall outlet, nominal dimensions of 25 by 21 by 17 1/2 inches; vitreous china with an integral flushing rim. Provide floor mounted carrier.] Provide faucet with fork brace 6 inch handles, 10-1/4 inches wall to spout outlet, and plain end spout with bucket hook. Provide 6.5 gpf flushometer valve.

2.10.4.9 Sink, Surgeons Scrub

2.10.4.9.1 SSS-1 (JSN P6980)

Three station, wall-mounted, gooseneck spouts, knee push controls. Provide seamless welded 16 gage construction, Type 304, stainless steel. Sound-deaden cabinet with a fire-resistant material. Provide wall mounted unit using a mounting carrier. Provide removable front panels for access to the water control valves, waste connections, stops and strainers. Provide sloped sink bottoms to minimize splashing and a 1-1/2 inch OD tailpiece with an 3 inch flat strainer drain. Provide each compartment (station) with a gooseneck assembly with a 1-1/2 inch sprayhead that can be removed for sterilization. Provide adjustable thermostatic mixing valve with anti-scald feature for each compartment and controlled from the top mounted control panel. Provide mechanical pilot type water control valves for each compartment actuated by one push of a knee-operated front panel and turned off by a second push. Provide plastic splash shield between each compartment. Provide knee-controlled soap dispensers at each compartment.

2.10.4.9.2 SSS-2 (Similar to JSN P6990)

Two station, wall-mounted, gooseneck spouts, electronically timed with long (10 minute) and short (3, 4, 5 minute) cycles. Provide seamless welded 16 gage construction, Type 304, stainless steel. Sound-deaden cabinet with a fire-resistant material. Provide wall mounted unit using a mounting carrier. Provide removable front panels for access to the water control valves, waste connections, stops and strainers. Provide sloped sink bottoms to minimize splashing and a 1-1/2 inch OD tailpiece with an 3 inch flat strainer drain. Provide each compartment (station) with a gooseneck assembly with a 1-1/2 inch sprayhead that can be removed for sterilization. Provide adjustable thermostatic mixing valve with anti-scald feature for each compartment and controlled from the top mounted control panel. Provide watertight and top mounted control panel. Provide internal timing device to reduce tampering. Provide plastic splash shield between each compartment. Provide foot-controlled soap dispensers at each compartment. Provide sink with 120 volt, 2 ampere power to an internal junction box.

2.10.4.10 Urinals

Provide ASME A112.19.2/CSA B45.1, white vitreous china, wall-mounted, wall outlet, urinals with integral trap, drain line connection, and extended side shields. Provide urinals with trap design complying with the IPC. Install urinal rim 24 inches above the floor at non-accessible locations. Mount urinals installed in compliance with ADA requirements with the rim 17 inches above the floor. Provide ASME A112.6.1M concealed chair carriers. Provide urinals equipped with flush valves with a flushing volume of the urinal and flush valve combination not exceeding the fixture design rating. Mount flush valves not less than 11 inches above the fixture.

2.10.4.10.1 U-1 (Similar to JSN P8150)

High efficiency washout for solenoid valve. Provide WaterSense labeled urinal with a maximum water use of 0.125 gpf. Provide data identifying WaterSense label for urinal. Flushing cycle must be activated by an electronic infrared sensor operated by proximity of individual. Provide wiring box, 120/24 volt solenoid, and transformer.

2.10.4.10.2 U-2

Same as U-1 except accessible mounting height per ICC A117.1.

2.10.4.10.3 U-3: (Similar to JSN P8150)

High efficiency washout for solenoid valve. Provide WaterSense labeled urinal with a maximum water use of 0.5 gpf. Provide data identifying WaterSense label for urinal. Flushing cycle must be activated by an electronic infrared sensor operated by proximity of individual. Provide wiring box, 120/24 volt solenoid, and transformer.

2.10.4.10.4 U-4

Same as U-3 except accessible mounting height per ICC A117.1.

2.10.4.11 Water Closets

Provide ASME A112.19.2/CSA B45.1, white vitreous china, elongated bowl, wall-hung water closets. Provide water closets with trap design complying with the IPC. Install top of toilet seat 14 to 15 inches, above the floor at non-accessible locations. Mount water closets installed in compliance with ADA requirements with the rim 17 to 19 inches above the floor. Provide water closets equipped with flush valves with a flushing volume of the water closet and flush valve combination not exceeding the fixture design rating. Provide water flushing volume of the water closet and flush valve combination not exceeding 1.28 gallons per flush unless indicated otherwise. Provide white solid plastic elongated open-front seat without cover, with check hinge. Provide seats conforming to IAPMO Z124.5. Mount flush valves not less than 11 inches above the fixture. Mounted height of flush valve must not interfere with the hand rail in ADA stalls. Provide ASME A112.6.1M heavy duty 500 pound capacity chair carriers.

2.10.4.11.1 WC-1 (Similar to JSN P9050)

Siphon-jet for direct flushometer valve. Flushing cycle must be activated by an electronic infrared sensor operated by proximity of individual. Provide wiring box 120/24 volt solenoid and transformer.] Provide WaterSense labeled water closet with a maximum water use of 1.28 gpf. Provide data identifying WaterSense label for water closet.

2.10.4.11.2 WC-2 (Similar to JSN P9050)

Same as WC-1 except accessible mounting height per ICC A117.1 Provide riser with grab bar offset.

2.10.4.11.3 WC-3 (Similar to JSN P9050)

High efficiency (HET), siphon-jet for flushometer valve. High efficiency washout for solenoid valve. Flushing cycle must be activated by an electronic infrared sensor operated by proximity of individual. Provide WaterSense labeled water closet with a maximum water use of 1.28 gpf. Provide data identifying WaterSense label for water closet. Provide wiring box, 120/24 volt solenoid, and transformer.

2.10.4.11.4 WC-4 (Similar to JSN P9050)

Same as WC-3 except accessible mounting height per ICC A117.1. Provide riser with grab bar offset.

2.10.4.11.5 WC-5 (Similar to JSN P9050)

Siphon jet with bowl provided with lugs or slots for holding bedpan. Provide bedpan cleaner (P1150) for mounting on exposed water closet flush valves; provide with wall support bracket; and brass valve body having a taper machined type leakproof, raise and lower spray arm; and using one-third of flush water volume to rinse pan, balance to flush waste. Water flushing volume of the water closet and flush valve/bedpan washer combination must not exceed 1.6 gallons per flush.

2.10.4.11.6 WC-6 (Similar to JSN P9050)

Same as WC-5 except accessible mounting height per ICC A117.1. Provide riser with grab bar offset.

2.10.4.11.7 WC-7 (Similar to JSN P9050)

High efficiency (HET), siphon-jet for manual, lever operated flushometer valve, accessible mounting height per ICC A117.1. Provide riser with grab bar offset. Provide water closets with a maximum water use for the water closet and flush valve combination of 1.28 gallons per flush at a flowing water pressure of 80 psig. Provide WaterSense labeled water closet with a maximum water use of 1.28 gpf. Provide data identifying WaterSense label for water closet.

2.10.4.12 Hose Bibbs and Hydrants

2.10.4.12.1 HB-1

Hose bibb with vacuum-breaker backflow preventer, brass construction with 3/4 inch male inlet threads, hexagon shoulder, and 3/4 inch hose connection. Provide handle securely attached to stem.

2.10.4.12.2 HB-2

Wall hydrant (freezeproof) ASSE 1019 with vacuum-breaker backflow preventer and must have a nickel-brass or nickel-bronze wall plate or flange with nozzle and detachable key handle. Provide brass or bronze operating rod within a galvanized iron casing of sufficient length to extend through the wall so that the valve is inside the building, and the portion of the hydrant between the outlet and valve is self-draining. Provide brass or bronze valve with coupling and union elbow having metal-to-metal seat.

Valve rod and seat washer must be removable through the face of the hydrant. Provide hydrant with 3/4 inch exposed hose thread on spout and 3/4 inch male pipe thread on inlet.

2.10.4.12.3 HB-3

Yard hydrant (non-freezeproof) of brass construction, with either straight or angle bodies, and must be of the compression type. Provide body flange with internal pipe thread to suit 3/4 inch pipe. Provide bodies suitable for wrench grip. Provide faucet spout with 3/4 inch exposed hose threads. Provide faucet handle securely attached to stem.

2.10.4.12.4 HB-4

Yard hydrants (freezeproof), yard box or post hydrants with valve housings located below frost lines. Water from the casing must be drained after valve is shut off. Provide bronze hydrant with cast-iron box or casing guard. Provide "T" handle key.

2.11 BACKFLOW PREVENTERS

Provide backflow preventers approved and listed by the Foundation For Cross-Connection Control & Hydraulic Research. Provide reduced-pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers tested, approved, and listed in accordance with FCCCHR Manual. Provide backflow preventers with intermediate atmospheric vent conforming to ASSE 1012. Provide reduced pressure principle backflow preventers conforming to ASSE 1013. Provide hose connection vacuum breakers conforming to ASSE 1011. Provide pipe applied atmospheric type vacuum breakers conforming to ASSE 1001. Provide pressure vacuum breaker assembly conforming to ASSE 1020. Provide air gaps in plumbing systems conforming to ASME A112.1.2.

2.12 DRAINS AND BACKWATER VALVES

Provide drains and backwater valves installed in connection with waterproofed floors or shower pans equipped with bolted-type device to securely clamp flashing.

2.12.1 Area Drains

a. Provide area drains with coated galvanized cast iron bodies for embedding in the floor construction. Provide plain pattern perforated or slotted grate/strainer. Provide with threaded outlet connection. Between the outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Provide drains conforming to ASME A112.6.3. Grate/strainer weight loading classification is based on ASME A112.6.3. Dimensions are nominal.

b. AD-1: 12 inch overall diameter or width, 8 inch diameter grate, 6 inch depth, with removable, light-duty cast iron grate with minimal free area of 2 times free area of outlet pipe size. Provide with backwater valve.

2.12.2 Floor and Shower Drains

Provide floor and shower drains with coated galvanized cast iron bodies, double drainage pattern for embedding in the floor construction, and seepage pan having weep holes or channels for drainage to the drainpipe. Provide adjustable grate/strainers to compensate for floor thickness. Provide an integral clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane when required. Provide with threaded outlet connection. Between the outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Provide floor and shower drains conforming to ASME A112.6.3. Grate/strainer weight loading classification is based on ASME A112.6.3. Dimensions are nominal. Provide drain with trap primer connection, trap primer, and connection piping.

2.12.2.1 FD-1

12 inch diameter flashing collar, 4 inch deep body and 8 inch diameter removable, non-tilt heavy-duty cast iron grate with minimal free area of 1.5 times free area of outlet pipe size.

2.12.2.2 FD-2

10 inch diameter invertible flashing collar, 2 inch deep body, and minimum 6 inch square or diameter removable, secured, stainless steel strainer with minimum free area of 1.5 times free area of outlet pipe size.

2.12.2.3 FD-3

12 inch diameter flashing collar, 2 inch deep body, and 8 inch diameter non-tilt heavy-duty cast iron grate with minimal free area of 1.5 times free area of outlet pipe size.

2.12.2.4 FD-4

12 inch diameter invertible flashing collar, 7 inch deep body, stainless steel sediment basket with 3/16 inch perforations with lift handle, and minimum 12 inch square, removable, stainless steel strainer with minimum free area of 1.5 times free area of outlet pipe size.

2.12.3 Floor Sinks

Provide floor sinks with coated cast iron bodies, with acid-resisting interior, and double drainage pattern for embedding in the floor construction, and seepage pan having weep holes or channels for drainage to the drainpipe. Provide an integral clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane when required. Provide with threaded outlet connection. Between the outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Provide floor sinks conforming to ASME A112.6.3. Provide aluminum sediment bucket. Grate/strainer weight loading classification is based on ASME A112.6.3. Dimensions are nominal. Provide full grate free area a minimum of 1.5 times the free area of the outlet pipe size.

2.12.4 Roof Drains and Expansion Joints

Provide roof drains conforming to ASME A112.6.4, with dome and integral flange, with a device for making a watertight connection between roofing and flashing. Provide roof drains designated as secondary (emergency) overflow drains with 2 inch high dam. Provide galvanized heavy pattern cast iron assemblies, including the dome strainer. Provide drain with a gravel stop. On roofs other than concrete construction, provide drains complete with underdeck clamp, sump receiver, and an extension for the insulation thickness where applicable. Provide a clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or membrane when present. Provide trainer openings with a combined area equal to twice that of the drain outlet. Provide roof drains with outlets equipped to make a proper connection to threaded pipe of the same size as the rain leader. Provide an expansion joint of proper size to receive each rain leader. Provide heavy cast-iron housing expansion joint, brass or bronze sleeve, brass or bronze fastening bolts and nuts, and gaskets or packing. Provide sleeves with a nominal thickness of not less than 0.134 inch. Provide close-cell neoprene gaskets and packing, Provide 70 durometer close-cell neoprene O-ring packing. Provide packing held in place by a packing gland secured with bolts.

2.12.4.1 RD-1

16 to 19 inch diameter flashing clamp, 11 to 14 inch diameter by 5 inch high dome strainer.

2.12.4.2 RD-2

16 to 19 inch diameter flashing clamp, 11 to 14 inch diameter by 5 inch high dome strainer. Provide minimum 2 inch high internal or external water dam.

2.12.5 Sight Drains

a. Provide sight drains with coated galvanized cast iron bodies, double drainage pattern for embedding in the floor construction, and seepage pan having weep holes or channels for drainage to the drainpipe. Provide adjustable grate/strainer to compensate for floor thickness. Provide an integral clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane when required. Provide with threaded outlet connection. Between the outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Provide sight drains conforming to ASME A112.6.3. Grate/strainer weight loading classification is based on ASME A112.6.3. Dimensions are nominal.

b. SD-1: 10 inch diameter invertible flashing collar, 2 inch deep body, and minimum 6 inch square or diameter removable, secured, light-duty nickel bronze strainer with minimum free area of 1.5 times free area of outlet pipe size with funnel extension. Provide minimum funnel dimensions as follows:

    (1) Height of funnel 3-3/4 inches.

    (2) Diameter of lower portion of funnel 2 inches.

    (3) Diameter of upper portion of funnel 4 inches.

2.12.6 Backwater Valves

Provide backwater valves either separate from the floor drain or a combination floor drain, P-trap, and backwater valve, as shown. Provide backwater valves with cast-iron bodies and cleanouts large enough to permit removal of interior parts. Provide valves of the flap type, hinged or pivoted, with revolving disks. Provide hinge pivots, disks, and seats of nonferrous metal. Provide backwater valves with disks slightly open in a no-flow, no-backwater condition. Extend cleanouts to finished floor fit with threaded countersunk plugs.

2.13 CLEANOUTS

a. Provide cleanouts with coated cast-iron bodies (unless otherwise noted) with extra-heavy, threaded, tapered, brass plug with solid square nut and American Standard pipe threads. Provide flashing collars and clamps for cleanout bodies being installed in floors with finishes installed over waterproofing. Cleanouts on piping completely accessible from within pipe chases do not require covers. Cleanouts in exposed piping in equipment rooms do not require covers.

b. Provide interior floor-mounted cleanouts with a two-piece, threaded, adjustable housing. Provide top and cover based on floor finish:

(1) Resilient tile and sheet finish: Round flange top with scoriated cover.

(2) Ceramic tile finish: Square flange top with scoriated cover.

(3) Poured finish: Round, wide-flange top with scoriated cover.

(4) Carpet finish: Round top with standard top tapped for carpet-marker bolt.

(5) Terrazzo finish: Round top with recessed-for-terrazzo cover.

(6) Quarry tile finish: Square, heavy-duty top with heavy-duty scoriated cover.

(7) Concrete finish (unfinished areas): Heavy, round frame; satin-bronze, scoriated tractor top, ANSI heavy duty load class.

2.14 TRAPS

2.14.1 Fixture Traps

Unless otherwise specified, provide copper-alloy adjustable tube type traps with slip joint inlet and swivel. Provide traps without a cleanout. Provide tubes of copper alloy with walls not less than 0.032 inch thick within commercial tolerances, except on the outside of bends where the thickness may be reduced slightly in manufacture by usual commercial methods. Provide inlets with rubber washer and copper alloy nuts for slip joints above the discharge level. Provide swivel joints below the discharge level and must be of metal-to-metal type as required for the application. Provide nuts nuts flats for wrench grip. Provide outlets with internal pipe thread, except that when required for the application, the provide outlets with sockets for solder-joint connections. The depth of the water seal must be not less than 2 inches and not more than 4 inches. The interior diameter must be not more than 1/8 inch over or under the nominal size, and interior surfaces must be reasonably smooth throughout. Provide a copper alloy "P" trap assembly consisting of an adjustable "P" trap and threaded trap wall nipple with cast brass wall flange for lavatories. The assembly must be a standard manufactured unit and may have a rubber-gasketed swivel joint.

2.14.2 Drain Traps

Unless otherwise specified, provide cast iron traps, one piece pattern, deep seal with depth of water seal of 4 inches. The interior diameter must be not more than 1/8 inch over or under the nominal size, and interior surfaces must be reasonably smooth throughout. Provide standard manufactured trap assemblies. Traps for drains located in fan and plenum housings must maintain seal against the static pressure.

2.15 INTERCEPTORS

2.15.1 Grease Interceptor

Provide grease interceptor of the size indicated of reinforced concrete, or precast concrete construction with removable three-section, 3/8 inch checker-plate cover, and installed outside the building. Install steel grease interceptors concrete pits and provide epoxy-coating to resist corrosion as recommended by the manufacturer. Provide interceptors tested and rated in accordance with PDI G 101. Concrete must have 3,000 psi minimum compressive strength at 28 days. Provide flow control fitting.

2.15.2 Oil Interceptor

Cast iron or welded steel, coated inside and outside with white acid resistant epoxy, with internal air relief bypass, bronze cleanout plug, double wall trap seal, removable combination pressure equalizing and flow diffusing baffle and sediment bucket, horizontal baffle, adjustable oil draw-off and vent connections on either side, gas and watertight gasketed nonskid cover, and flow control fitting.

2.16 WATER HEATERS

Provide water heaters with replaceable anodes. Provide each primary water heater with controls having an adjustable range that includes 90 to 160 degrees F. Provide each gas-fired water heater and booster water heater with controls having an adjustable range that includes 120 to 180 degrees F. Connect hot water systems utilizing recirculation systems into building off-hour controls. The thermal efficiencies and standby heat losses must conform to or exceed the requirements of ASHRAE 90.1 - IP, or 10 CFR 430 whichever is the most stringent for each type of water heater specified. The only exception is that storage water heaters and hot water storage tanks having more than 500 gallons storage capacity need not meet the standard loss requirement if the tank surface area is insulated to R-12.5 and if a standing pilot-light is not used. Plastic materials, polyetherimide (PEI) and polyethersulfone (PES), are forbidden to be used for vent piping of combustion gases. Provide a factory pre-charged expansion tank on the cold water supply to each water heater. Provide expansion tanks specifically designed for use on potable water systems and rated for 200 degrees F water temperature and 150 psig working pressure.

2.16.1 Performance of Water Heating Equipment

Standard rating condition terms are as follows:

ET	Thermal efficiency with 70 degrees F delta T.
EC	Combustion efficiency, 100 percent - flue loss when smoke = 0 (trace is permitted).
SL	Standby loss in W/sq. ft. based on 80 degrees F delta T, or in percent per hour based on nominal 90 degrees F delta T.
HL	Heat loss of tank surface area.
V	Storage volume in liters

2.16.1.1 Storage Water Heaters

2.16.1.1.1 Electric

Storage Capacity or Input Rating of		Rating Condition
120 gallons or less	12 kW or less	minimum EF 0.93-0.00132V per 10 CFR 430
more than 120 gallons	more than 12 kW	maximum SL (0.3 + 27Vm) per ANSI Z21.10.3/CSA 4.3

2.16.1.1.2 Gas

Storage Capacity or Input Rating of		Rating Condition
100 gallons or less	75,000 Btu/h or less	minimum EF 0.67-0.0019V per 10 CFR 430
more than 100 gallons	more than 75,000 Btu/h	ET 80 percent; maximum SL Q/800+110 square root of V, Btu/h per ANSI Z21.10.3/CSA 4.3.

2.16.1.1.3 Oil

Storage Capacity or Input Rating of		Rating Condition
50 gallons or less	105,000 Btu/h or less	minimum EF 0.59-0.0019V per 10 CFR 430
more than 50 gallons or less	more than 105,000 Btu/h	ET 80 percent; maximum SL Q/800+110 square root of V, Btu/h per ANSI Z21.10.3/CSA 4.3.

2.16.1.2 Unfired Hot Water Storage

All volumes and inputs: Provide tank surface thermally insulated to a minimum of R12.5.

2.16.1.3 Instantaneous Water Heater

2.16.1.3.1 Gas

Input Rating	Rating Condition	In accordance with
50,000 to 200,000 Btu/h	EF 0.62-0.0019V	10 CFR 430
more than 200,000 Btu/h	ET 80 percent	ANSI Z21.10.3/CSA 4.3

2.16.1.3.2 Oil

Input Rating	Rating Condition	In accordance with
210,000 Btu/h or less	minimum EF 0.59-0.0019V	10 CFR 430
more than 210,000 Btu/h	ET 80 percent	ANSI Z21.10.3/CSA 4.3

2.16.2 Automatic Storage Type

Provide heaters complete with control system, temperature gauge, and pressure gauge, and ASME rated combination pressure and temperature relief valve.

2.16.2.1 Oil-Fired Type

Provide oil-fired type water heaters conforming to UL 732.

2.16.2.2 Gas-Fired Type

Provide gas-fired water heaters conforming to ANSI Z21.10.1/CSA 4.1 when input is 75,000 BTU per hour or less, or ANSI Z21.10.3/CSA 4.3 for heaters with input greater than 75,000 BTU per hour.

2.16.2.3 Electric Type

Provide electric type water heaters conforming to UL 174 with dual heating elements. Provide 4.5 kW elements. Provide elements wired for non-simultaneous operation so that only one element can operate at a time.

2.16.2.4 Indirect Heater Type

Steam and high temperature hot water (HTHW) heaters with storage system must be the assembled product of one manufacturer, and be ASME tested and "U" stamped to code requirements under ASME BPVC SEC VIII D1. Provide storage tank as specified in paragraph HOT-WATER STORAGE TANKS. Provide heat exchangers of the double wall type that separates the potable water from the heat transfer medium with a space vented to the atmosphere in accordance with ICC IPC.

2.16.2.4.1 HTHW Energy Source

Provide heater elements with a working pressure of 400 psig with water at a temperature of 400 degrees F. Base heating surface on 1 square foot of heating surface to heat 20 gallons or more of water in 1 hour from 40 to 180 degrees F using hot water at a temperature of 350 degrees F. Provide carbon steel heads. Provide tubing conforming to ASTM B111/B111M, Copper Alloy No. 706 (90-10 copper-nickel). Provide heating elements able to withstand an internal hydrostatic pressure of 600 psig for not less than 15 seconds without leaking or any evidence of damage.

2.16.2.4.2 Steam Energy Source

Provide heater elements with a working pressure of 150 psig with steam at a temperature of 365 degrees F. Base heating surface on 1 square foot of heating surface to heat 20 gallons or more of water in 1 hour from 40 to 180 degrees F using steam at atmospheric pressure. Provide bronze heads. Provide light-drawn copper tubing conforming to ASTM B75/B75M. Provide heating elements able to withstand an internal hydrostatic pressure of 225 psig for not less than 15 seconds without leaking or any evidence of damage.

2.16.3 Instantaneous Water Heater

Provide crossflow design type heater with service water in the coil and steam or hot water in the shell. Provide an integral internal controller, anticipating a change in demand so that the final temperature can be maintained under all normal load conditions when used in conjunction with pilot-operated temperature control system. Normal load conditions must be as specified by the manufacturer for the heater. Provide units manufactured in accordance with ASME BPVC SEC VIII D1, and certified for 150 psig working pressure in the shell and 150 psig working pressure in the coils. Provide carbon steel shell with copper lining. Provide carbon steel plate with copper lining heads. Provide copper or copper-nickel coils. Provide shell with metal sheathed fiberglass insulation, combination pressure and temperature relief valve, and thermometer. Provide insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. For gas service, provide Energy Star labeled gas instantaneous water heater. Provide data identifying Energy Star label for gas instantaneous water heater.

2.16.4 Electric Instantaneous Water Heaters (Tankless)

UL 499 and UL listed flow switch activated, tankless electric instantaneous water heater for wall mounting below sink or lavatory.

2.16.5 Relief Valves

Provide water heaters and hot water storage tanks with a combination pressure and temperature (P&T) relief valve. The pressure relief element of a P&T relief valve must have adequate capacity to prevent excessive pressure buildup in the system when the system is operating at the maximum rate of heat input. The temperature element of a P&T relief valve must have a relieving capacity which is at least equal to the total input of the heaters when operating at their maximum capacity. Provide relief valves rated according to ANSI Z21.22/CSA 4.4. Provide relief valves for systems where the maximum rate of heat input is less than 200,000 Btuh with 3/4 inch minimum inlets, and 3/4 inch outlets. Provide relief valves for systems where the maximum rate of heat input is greater than 200,000 Btuh with 1 inch minimum inlets, and 1 inch outlets. Provide discharge pipe from the relief valve full size of the valve outlet to the termination point.

2.17 HOT-WATER STORAGE TANKS

Provide hot-water storage tanks constructed by one manufacturer, ASME stamped for the working pressure, and having the National Board (ASME) registration. Provide cement-lined or glass-lined steel type tanks in accordance with AWWA D100. Provide tanks with heat losses conforming to TABLE III as determined by the requirements of ASHRAE 90.1 - IP. Equip each tank with a thermometer, conforming to ASTM E1, Type I, Class 3, Range C, style and form as required for the installation, and with 7 inch scale. Provide thermometers having a separable socket suitable for a 3/4 inch tapped opening. Equip tanks with a pressure gauge 6 inch minimum diameter face. Provide insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Provide storage tanks capacities as shown.

2.18 PUMPS

2.18.1 Sump Pumps

Provide sump pumps of the automatic, electric motor-driven, submerged type, complete with necessary control equipment and with a split or solid cast-iron or steel cover plate. Provide pumps direct-connected by an approved flexible coupling to a vertical electric motor having a continuous oiling device or packed bearings sealed against dirt and moisture. Provide totally enclosed motors, fan-cooled of sizes as indicated and equipped with an across-the-line magnetic controller in a NEMA 250, Type 4 enclosure. Provide each pump fitted with a high-grade thrust bearing mounted above the floor. Provide each shaft with an alignment bearing at each end, and suction inlets between 3 and 6 inches above the sump bottom. Provide the suction side of each pump with a strainer of ample capacity and bronze or stainless steel pump impeller. Provide a float switch assembly, with the switch completely enclosed in a NEMA 250, Type 4 enclosure, to start and stop each motor at predetermined water levels. Equip duplex pumps with an automatic alternator to change the lead operation from one pump to the other, and for starting the second pump if the flow exceeds the capacity of the first pump. Provide the discharge line from each pump with a union or flange, a nonclog swing check valve, and a stop valve in an accessible location near the pump.

2.18.2 Hydraulic Elevator Sump Pumps

Provide sump pump and control system capable of pumping water while containing oil. The system must function automatically and provide an alarm in the event of the presence of oil in the sump, high liquid in the sump, or high amps or a locked rotor condition. An alarm that sounds only in the event of a high liquid condition is not acceptable. Provide submersible type pump. Provide pumps conforming to UL 778 standards and include thermal and overload protection. Provide motor capable of operating continuously or intermittently. Provide motor housing constructed of 304 stainless steel, and mechanical seals housed in a separate oil-filled compartment. Provide controls approved to UL 508 standards and housed in a NEMA 4X enclosure with stainless steel hinged hardware. Provide controls with dual relays with variable sensitivity settings, magnetic contactor with separate over-current relay, self-cleaning stainless steel sensor probe, high decibel warning horn with illuminated red light and alarm silencing switch, dual floats, clearly marked terminal board and remote monitoring contact. Provide all cables between the pump and control unit a minimum of 16 feet long and the cable and plug from the control unit a minimum of 8 feet long. Provide control unit, pump, floats, and sensor probe factory assembled as a complete, ready to use system and tested and approved by a nationally recognized testing laboratory such as ENTELA.

2.18.3 Sewage Pumps

Provide duplex type with automatic controls to alternate the operation from one pump to the other pump and to start the second pump in the event the first pump cannot handle the incoming flow. Provide high water alarm and check valve.

2.18.4 Circulating Pumps

Provide electrically driven, single-stage, centrifugal domestic hot water circulating pumps with mechanical seals, suitable for the intended service and capacities not less than indicated. Provide pumps with revolutions per minute not exceeding 3600. Provide pump and motor integrally mounted on a cast-iron or steel subbase, close-coupled with an overhung impeller, or supported by the piping on which it is installed. Provide one-piece, heat-treated, corrosion-resisting steel shaft with bronze or stainless steel impeller, sleeve bearings and glands of bronze to accommodate mechanical seals and the housing of close-grained cast iron. Provide pump seals capable of withstanding 240 degrees F temperature without external cooling. Provide motors with sufficient horsepower for the service required, of a type approved by the manufacturer of the pump, and suitable for the available electric service. Provide pump motors smaller than 1 horsepower with integral thermal overload protection in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide guards to shield exposed moving parts.

2.18.5 Booster Pumps

2.18.5.1 Centrifugal Pumps

Provide horizontal split-case centrifugal-type booster pumps. Provide pumps with revolutions per minute not exceeding 1800. Provide pump casings of close-grained iron or steel with smooth water passages. Provide a gasket between the upper and lower halves of the casing. Provide flanged suction and discharge connections. Provide nonoverloading, bronze impellers, balanced to eliminate vibration, and keyed to corrosion-resisting steel shafts. Provide casings fitted with bronze wearing or sealing rings. Provide cartridge type bearings, enabling the entire rotating element to be removed without disturbing alignment or exposing the bearings to dirt, water, and other foreign matter. Provide pumps with mechanical seals. Provide seal boxes machined in the pump casing and at both sides of the pump, and of sufficient depth to include a conventional bronze seal ring and rows of shaft packing. Provide close-grain cast iron or steel bedplates with ribs and lugs, complete with foundation bolts, and a drip lip with drain hole. Provide pumps tested at the manufacturer's plant for operating characteristics at the rated capacity and under specified operating conditions. Provide test curves showing capacity in gpm, head in feet, efficiency, brake horsepower, and operation in parallel with similar pumps. Provide multiple pump installations with pump characteristics compatible for operation in parallel with similar pumps. Provide electric motors sized for non-overload when operating at any point along the characteristic curve of the pump. Provide guards to shield exposed belts and moving parts.

2.18.5.2 Controls

Provide each pump motor with enclosed across-the-line-type magnetic controller complete in a NEMA 250 Type 1 enclosure with three position, "HAND-OFF-AUTOMATIC," selector switch in cover. Pumps must be automatically started and stopped by float or pressure switches. The pumps must start and stop at the levels and pressures indicated. Provide a multiposition sequence selector switch so that any two pumps may be operated simultaneously keeping a third pump as a standby.

2.18.6 Flexible Connectors

Provide flexible connectors at the suction and discharge of each pump that is 1 horsepower or larger. Provide connectors constructed of neoprene, rubber, or braided bronze, with Class 150 standard flanges. Provide line size flexible connectors and suitable for the pressure and temperature of the intended service.

2.19 WATER PRESSURE BOOSTER SYSTEM

2.19.1 Constant Speed Pumping System

Provide constant speed pumping system with pressure-regulating valves employing one lead pump for low flows, and one or more lag pumps for higher flows. Provide pressure-regulating valves with nonslam check feature. Provide factory prepiped and prewired assembly mounted on a steel frame, complete with pumps, motors, automatic controls, and ASME code constructed hydro-pneumatic tank. Provide current sensing relays to stage the pumps. Protect pumps from thermal buildup, when running at no-flow, by a common thermal relief valve. Provide pressure gauges mounted on the suction and discharge headers. Provide control panels bearing the UL listing label for industrial control panels and in a NEMA 250, Type 1 enclosure. Provide control panels with the following: no-flow shutdown; 7-day time clock; audiovisual alarm; external resets; manual alternation; magnetic motor controllers; time delays; transformer; current relays; "HAND-OFF-AUTOMATIC" switches for each pump; minimum run timers; low suction pressure cutout; and indicating lights for power on, individual motor overload, and low suction pressure. Interlock control circuits so that the failure of any controller must energize the succeeding controller. Provide an ASME code constructed hydro-pneumatic tank stamped for 125 psig water working pressure. Provide the tank with a flexible diaphragm made of material conforming to FDA requirements for use with potable water and factory precharged to meet required system pressure.

2.19.2 Variable Speed Pumping System

Provide variable speed pumping system to provide system pressure by varying speed and number of operating pumps. Provide factory prepiped and prewired assembly mounted on a steel frame complete with pumps, variable speed drives, motors, automatic controls, and ASME code constructed hydro-pneumatic tank. Provide oil-filled type variable speed drives, capable of power transmission throughout their complete speed range without vibration, noise, or shock loading. Provide variable speed drives run-tested by the manufacturer for rated performance, and manufacturer furnished written performance certification. Provide system with suppressors to prevent noise transmission over electric feed lines. Required electrical control circuitry and system function sensors must be supplied by the variable speed drive manufacturer. The primary power controls and magnetic motor controllers must be installed in the motor control center. Locate sensors in the system to control drive speed as a function of constant system pressure at location indicated. Provide connection between the sensors and the variable speed drive controls with copper wiring. Provide controls in NEMA 250, Type 1 enclosures. Provide an ASME code constructed hydro-pneumatic tank stamped for 125 psig water working pressure. Provide tank with a flexible diaphragm made of material conforming to FDA requirements for use with potable water and factory precharged to meet required system pressure.

2.20 DOMESTIC WATER SERVICE METER

Provide positive displacement type cold water meters 2 inches and smaller conforming to AWWA C700. Provide turbine type cold water meters 2-1/2 inches and larger conforming to AWWA C701. Meter register may be round or straight reading type. Provide meters with pulse generators, remote readout registers and all necessary wiring and accessories.

2.21 COPPER-SILVER IONIZATION SYSTEM

a. Provide a complete copper-silver ionization system consisting of a controller, electrode cell(s), and flow meter.

b. Provide a microprocessor-based controller that automatically controls the rate of copper and silver ion release. Provide controllers able to generate a minimum concentration of 25 ug/L copper on a continuous basis. Controller must perform under all types of water conditions without limiting its current due to lack of voltage. Provide controller which operate primarily in proportional copper and silver ion level control mode to prevent over or under ionization, and capable of operating in secondary control modes, to include continuous, timer, and flow switch. Provide controllers which incorporate anti-scaling features.

c. Provide on-board and remote alarm connection capabilities. Provide auxiliary contacts for remote monitoring capability. Provide controllers conforming to UL 508 for Industrial Control Panels.

d. Provide electrode cell(s) incorporating reduced scaling features. Provide CPVC, epoxy coated aluminum, or Schedule 40 stainless steel housing. Provide with electrical quick connections. Provide sacrificial electrodes of an extruded alloy of 99.99 percent pure copper and 99.99 percent pure medical grade silver, with minimum ratio of 30 percent silver to 70 percent copper.

e. Provide a flow meter with a transmitter that displays the flow rate and total water usage. Provide clamp on transducers (non pipe invasive) with a flow response time of 0.3 seconds and flow sensitivity 0.001 fps.

f. Submit EPA registration for Copper-Silver Ionization as pesticide product (disinfectant).

g. Submit written NSF certification for Copper-Silver Ionization that the system (or components in contact with potable water) are certified.

2.22 POTABLE WATER MONITORING SYSTEM

For each potable cold-water and hot-water system, provide the following:

a. Skid mounted system for automatic monitoring of free or total chlorine residuals, temperature, pH, and pressure. The system must continuously monitor potable water systems. Provide components in direct contact with water conforming to NSF/ANSI 61 approved. Provide pre-wired and pre-plumbed unit on a single skid in a NEMA 4X enclosure.

b. Chlorine monitor minimum requirements:

(1) Measure free residual oxidant or total residual oxidant in potable water systems using the EPA accepted DPD colorimetric test method for measuring chlorine.

(2) Measure chlorine residuals at configurable frequencies as short as 110 seconds.

(3) Support water sample temperatures directly of up to 131 degree F, and up to 150 degree F using a sample cooler.

(4) Comply with US EPA regulation, 40 CFR 141.74 Standard Method 4500-CLG, and US EPA method 334.0 "Determination of Residual Chlorine in Drinking Water Using an Online Chlorine Analyzer."

(5) Support a Modbus interface.

c. Temperature, pH, and pressure sensors minimum requirements:

(1) Compact and Programmable sensors with built-in transmitters programmed by a computer.

(2) 4 mA to 20 mA output signals.

(3) 1/2-inch to 1-inch probe lengths.

(4) Type 316L stainless steel bodies.

(5) Operational temperature range of -58 degrees F to 248 degrees F for each sensor.

(6) Provide cables for hard wiring of sensors to Potable Water Monitoring System.

d. Data logging device minimum requirement:

(1) Automatically collect and log data at user selected intervals.

(2) Log device data date/time stamps and store in non-volatile memory.

(3) Store interval data locally until the next scheduled upload.

(4) Support a Modbus interface plus eight additional analog or pulse input signals.

e. Provide a minimum of one sampling point from each potable cold-water and hot-water system.

2.23 ELECTRICAL WORK

a. Provide electrical motor driven equipment specified complete with motors, motor starters, and controls as specified herein and in Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, corresponding to the applications in accordance with NEMA MG 11. In addition to the requirements of Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM, provide polyphase, squirrel-cage medium induction motors with continuous ratings, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

b. Provide motors rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor bearings fitted with grease supply fittings and grease relief to outside of the enclosure.

c. Provide controllers and contactors with auxiliary contacts for use with the controls provided. Provide manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown. For packaged equipment, the manufacturer must provide controllers, including the required monitors and timed restart.

d. Power wiring and conduit for field installed equipment must be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.24 FACTORY PAINTING

a. Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 1/8 inch on either side of the scratch mark.

b. The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system must be designed for the temperature service.

2.25 IDENTIFICATION MATERIALS

General: Provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.25.1 Plastic Pipe Markers

Provide snap-on or adhesive type pipe markers with nomenclature that closely matches Contract Drawings. Comply with designations indicated on Contract Drawings for piping system nomenclature and abbreviate only as necessary for each application length. Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as a separate unit of plastic.

a. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ASME A13.1.

b. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ASME A13.1.

c. Application: For exterior diameters greater than 2-inch (including insulation if any), provide continuous directional flow arrow tape around pipe circumference; two places, before and after pipe marker. Provide adhesive plastic pipe markers. For external diameters less than 2-inch (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:

(1) Snap-on application of pre-tensioned semi-rigid plastic pipe marker.

(2) Adhesive lap joint in pipe marker overlap.

(3) Laminated or bonded application of pipe marker to pipe (or insulation).

2.25.2 Valve Tags

Provide 19 gage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4-inch high letters and sequenced valve numbers 1/2-inch high, and with hole for fastener, or engraved plastic laminate valve tags, with piping system abbreviation in 1/4-inch high letters and sequenced valve numbers 1/2-inch high, and with hole for fastener. Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose. Compile valve schedule for each service. For each page of valve schedule, provide laminated plastic coated cardboard stock sheets.

a. Provide 1 1/2-inch diameter tags, except as otherwise indicated.

b. Provide size and shape as specified or scheduled for each piping system.

c. Fill tag engraving with black enamel.

2.25.3 Engraved Plastic Laminate Signs

Provide engraving stock melamine plastic laminate, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.25.4 Plasticized Tags

Provide pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing, approximately, 2-inch by 6-inch with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

2.25.5 Lettering and Graphics

Coordinate names, abbreviations and other designations used in plumbing identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of plumbing systems and equipment. Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Mixing Valve No. 2, Pump No. 1).

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 GENERAL INSTALLATION REQUIREMENTS

a. Provide piping located in air plenums conforming to NFPA 90A requirements. Installation of plastic pipe in air plenums is prohibited. Piping located in shafts that constitute air ducts or that enclose air ducts must be noncombustible in accordance with NFPA 90A. Installation of plastic pipe where in compliance with NFPA may be installed in accordance with PPFA Fire Man. Install the plumbing system complete with necessary fixtures, fittings, traps, valves, and accessories. Piping must be concealed wherever possible. Under no circumstances reduce pipe size on Contract Documents without written consent of Contracting Officer. Extend water and drainage piping 5 feet outside the building, unless otherwise indicated. Provide a full port ball valve and drain on the water service line inside the building approximately 6 inches above the floor from point of entry. Piping must be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Lay sewer and water pipes in separate trenches, except when otherwise shown. Exterior underground utilities must be at least 12 inches below the average local frost depth or 18 inches below finish grade whichever is greater. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, mark the location of the end of each plumbing utility with a stake or other acceptable means. Install valves with control no lower than the valve body.

b. Provide piping to fixtures, outlets, and equipment requiring drainage, vent, and water utilities. Arrange and install hot-water and cold-water piping systems to permit draining. Equip the supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with integral stops, with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Anchor supply piping to fixtures, faucets, hydrants, shower heads, and flushing devices to prevent movement.

c. The work must be carefully laid out in advance, and unnecessary cutting of construction must be avoided. Repair damage to building, piping, wiring, or equipment as a result of cutting by mechanics skilled in the trade involved.

d. Close pipe openings with caps or plugs during installation. Fixtures and equipment must be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, thoroughly clean, adjust and operate the fixtures, materials, and equipment. Provide safety guards for exposed rotating equipment.

e. Branch sizes to individual fixtures must be as scheduled. Consult manufacturer's data, Architectural drawings, and/or Plumbing drawings of rooms containing equipment and plumbing fixtures prior to roughing in piping. Stub piping through wall directly behind equipment item, or fixture being served. Connect equipment furnished by Owner or other divisions of the specification in accordance with this section.

f. Piping must not be routed over communications, electrical and server rooms unless dedicated to serving the room.

3.3 DOMESTIC WATER PIPING SYSTEMS

3.3.1 General

Accurately cut and work piping into place without springing or forcing. Weakening of structural portions of the building is not acceptable. Run aboveground piping parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings must be kept a sufficient distance from other work and other services to permit not less than 1/2 inch between finished covering on the different services. Bare and insulated water lines must not bear directly against building structural elements so as to transmit sound to the structure or to prevent flexible movement of the lines. Do not bury water pipe in or under floors unless specifically indicated or approved. Make changes in pipe sizes with reducing fittings. Use of bushings will not be permitted except for use in situations in which standard factory fabricated components are furnished to accommodate specific accepted installation practice. Make changes in direction with fittings.

3.3.2 Service Entrance

Provide service entrance installation through below grade exterior wall with water-stop pipe sleeves.

3.3.3 Pipe Drains

Provide pipe drains consisting of 3/4 inch hose bibb with renewable seat and full port ball valve ahead of hose bibb. At other low points, provide 3/4 inch brass plugs or caps. Disconnection of the supply piping at the fixture is an acceptable drain.

3.3.4 Valves

Provide manual isolation valves at base of risers, on branch runouts from piping mains, on each branch serving a rest room, on each branch serving an equipment item, and on each branch to hose bibb or wall hydrant. Wire isolation valves on emergency fixture supply open and tag "Do Not Close". Balance hot water circulation system.

3.3.5 Expansion and Contraction of Piping

Allowance must be made throughout for expansion and contraction of water pipe. Provide each hot-water and hot-water circulation riser with expansion loops or other provisions such as offsets, changes in direction, or manufactured expansion fittings. Securely anchor risers to force expansion to loops. Make branch connections from risers with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Anchor horizontal runs of pipe over 50 feet in length to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends. Sufficient flexibility must be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility must be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining. If mechanical grooved pipe coupling systems are provided, the deviation from design requirements for expansion and contraction may be allowed pending approval of Contracting Officer.

3.3.6 Thrust Restraint

Provide thrust blocks at plugs, caps, tees, valves and bends deflecting 11.25 degrees or more, either vertically or horizontally, in waterlines 4 inches in diameter or larger to prevent movement. Provide thrust blocking concrete of a mix not leaner than: 1 cement, 2.5 sand, 5 gravel; and having a compressive strength of not less than 2000 psi after 28 days. Place blocking between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, pour the base and thrust bearing sides of the thrust block against undisturbed earth. Pour t side of the thrust block not subject to thrust against forms. The area of bearing will be as shown. Place blocking so that the joints of the fitting are accessible for repair. Provide steel rods and clamps, protected by galvanizing or by coating with bituminous paint, to anchor vertical down bends into gravity thrust blocks.

3.3.7 Commercial-Type Water Hammer Arresters

Provide commercial-type water hammer arresters on hot- and cold-water supplies. Locate arresters as generally indicated, with precise location and sizing to be in accordance with PDI WH 201 Sizing and Placement Data. Water hammer arresters, where concealed, must be accessible by means of access doors or removable panels. Provide commercial-type water hammer arresters conforming to ASSE 1010. Vertical capped pipe columns (air chambers) are not be permitted.

3.3.8 Water Meter Remote Readout Register

a. Provide true absolute remote readout encoder register providing direct electronic transfer of meter reading information from water meter to automatic meter reading device. Mount the remote register at the location indicated, or as directed by the Contracting Officer.

b. Provide permanently sealed register to exclude dirt and/or moisture infiltration. Provide with a straight reading odometer-type display, and 360 degree test circle with center sweep hand and low flow (leak) detector. Provide tamperproof locking feature to resist tampering with the register. Provide factory potted moisture resistant wire assembly for pit applications.

c. Provide registers with full 6-wheel encoding, and a 6-wheel odometer assembly for direct manual reading. The register must transmit data using open architecture variable length protocol in ASCII format (American Standard Code for Information Interchange). Provide with capacity of remote installation up to 300 feet to an outside wall mounted touch pad.

d. The register must use an absolute encoder to directly read the actual position of the index odometer wheels, when interrogated by a reading device. The reading device must provide all necessary power. Pulse outputs and/or memory must not require programming. Battery powered registers are not acceptable. When a reading device interrogates the register, the translator encoder must communicate to the device in ASCII computer language the absolute meter reading, and an eight-digit identification number. Any error or nonread must be immediately indicated by the meter reading equipment.

3.3.9 Backflow Prevention Devices

Do not cross connect or interconnect plumbing fixtures, equipment, and pipe connections between a potable water supply and any source of nonpotable water. Install backflow preventers where indicated and in accordance with ICC IPC at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. In addition, install backflow preventers at all locations where the potable water outlet is below the flood level of the equipment, or where the potable water outlet will be located below the level of the nonpotable substance. Locate backflow preventers so that no part of the device will be submerged. Provide backflow preventers of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Do not provide bypass piping around backflow preventers. Maintain backflow preventers manufacturers access clearances for maintenance and testing. Each device must be a standard commercial unit. Install reduced pressure principle backflow prevention devices horizontally and located in an accessible location not more than 4 feet above finished floor. Pipe drain from reduced pressure principle backflow prevention devices to the exterior, or a floor drain of adequate capacity, or a mop sink.

3.3.10 Copper-Silver Ionization Systems

3.3.10.1 System Bypass

Provide 3 valve bypass around system.

3.3.10.2 System Startup

Start-up and activation of the copper-silver ionization system must include testing and documenting the baseline (pre-activation) water quality and ionization levels and the post-activation ionization levels. These tests must be performed by an independent laboratory in addition to any field testing required/performed by the manufacturer. A plan for on-going distal flushing and monitoring of ion levels must be established in accordance with the manufacturer's recommendations and implemented immediately upon system activation (prior to turnover or building occupancy). The plan must initially be implemented by the construction contractor and then integrated into the facility's ongoing maintenance plans.

3.3.10.3 Testing

After the facility has been turned over to the Government, provide one year of laboratory testing from distal sites for copper and silver ion levels to demonstrate appropriate levels for copper and silver. Copper level must be 0.2 to 0.4 mg/L over baseline not to exceed Safe Drinking Water Act (40 CFR 143) level of 1.0 mg/L (1.3 mg/L is enforceable limit by EPA unless the applicable State has established a lower level). Silver level must be 0.03 to 0.05 mg/L over baseline not to exceed Safe Drinking Water Act (40 CFR 143) of 0.1 mg/L (no maximum enforceable limit). Provide one test per quarter during the first year following Government acceptance of the facility. Provide factory test certifications attesting unit performance is meeting the requirements of this specification.

3.3.11 Potable Water Monitoring System

Install equipment on concrete housekeeping pads. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor base-mounted accessories to substrate. Provide interconnecting control wiring for sensors and Potable Water Monitoring System. Provide sensors in piping circuits. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installation, including connections.

3.4 DRAINAGE AND VENT PIPING SYSTEMS

3.4.1 General

a. Provide wye fittings and eighth bends, or combination wye and eighth fittings at changes of direction and junctions. Provide sanitary tee fittings only in vertical pipe. Sanitary crosses are not permitted. Provide P-trap for each direct waste-pipe connection to equipment. Provide ice makers with an indirect drain consisting of either a floor sink or a dedicated, under-counter P-trap. Provide air gaps at indirect drains.

b. Install horizontal soil, waste, and storm piping with the following minimum slopes; 3 inch and smaller pipes must be 1/4 inch per foot; 4 inch to 6 inch must be 1/8 inch per foot; 8 inch and larger pipes: 1/16 inch per foot. Slopes indicated on plans override those indicated here.

c. Provide vent stacks parallel to soil and waste stacks to receive branch vents from fixtures. Each vent stack must originate from a soil or waste stack at its base. To permit proper flashing, offset through-the-roof piping away from walls on roof before passing through roof. Carry vent stacks 4 inch and larger full size through roof. Install vent lines so they will drain and not trap water. Where possible, combine soil, waste or vent stacks before passing through roof to minimize roof openings. Where minimum vent-through-roof size is larger than vent size, provide an increaser a minimum of 12 inch below roof line.

d. Provide drip pans under drainage piping installed over critical areas to include but not limited to: operating rooms, recovery rooms, delivery rooms, nurseries, food preparation areas, food serving areas, food storage areas, central service areas, and electronic data processing areas. Provide drain piping from drip pans. Discharge drain piping to drain in exposed area.

e. Do not insulate, conceal, or fur around installed piping until it has been tested to satisfaction of the Contracting Officer. If inspection or test indicates defects, replace such defective work or material and repeat inspection and tests. Make repairs with new materials. Peening and chiseling of holes or screwed joints is not allowed.

f. Install underground PVC piping according to ASTM D2321. Clean and dry joining surfaces of PVC piping. Join PVC piping according to ASTM D2855 and ASTM D2665 appendixes. Comply with ASTM D2564 for solvent cements. Comply with ASTM F656 for PVC primers. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Provide all pipe and fittings produced by a single manufacturer and install in accordance with manufacturer's recommendations. Do not test with or transport/store compressed air or gas in PVC pipe or fittings.

g. Install PVC waste piping underground or below slab. PVC piping installed aboveground or slab is not acceptable.

h. Install foundation drainage piping as indicated. Lay perforated drain pipe with perforations facing down.

3.4.2 Pipe Cleanouts

Provide pipe cleanouts of the same size as the pipe except that cleanout plugs larger than 4 inches will not be required. Provide cleanouts installed in connection with cast-iron soil pipe consisting of a long-sweep 1/4 bend or one or two 1/8 bends extended to the location shown. Caulk an extra-heavy cast-brass or cast-iron ferrule with countersunk cast-brass head screw plug into the hub of the fitting and flush with the floor. Cleanouts in connection with other pipe must be T-pattern, 90-degree branch drainage fittings with cast-brass screw plugs, except install plastic plugs in plastic pipe. Provide plugs of the same size as the pipe up to and including 4 inches. Provide cleanout tee branches with screw plug at the foot of soil and waste stacks, at the foot of interior downspouts, on each connection to building storm drains where interior downspouts are indicated, and on each building drain outside the building. Cleanout tee branches may be omitted on stacks in single story buildings with slab-on-grade construction or where less than 18 inches of crawl space is provided under the floor. Provide cleanouts on pipe concealed in partitions with chromium plated bronze, nickel bronze, nickel brass or stainless steel flush type access cover plates. Provide round access covers secured to plugs with securing screw. Square access covers may be provided with matching frames, anchoring lugs and cover screws. Cleanouts in finished walls must have access covers and frames installed flush with the finished wall. Provide cleanouts installed in finished floors subject to foot traffic with a chrome-plated cast brass,nickel brass, or nickel bronze cover secured to the plug or cover frame and set flush with the finished floor. Heads of fastening screws must not project above the cover surface. Where cleanouts are provided with adjustable heads, provide cast iron heads. Provide cleanout extensions through floor above where cleanouts are required in piping above critical areas, or to an accessible location outside of critical area.

3.4.3 Sight Drains

Install sight drains so that the indirect waste will terminate a minimum of 2 inches above the flood rim of the funnel to provide an acceptable air gap.

3.4.4 Traps

Place traps as near the fixture as possible, and no fixture must be double-trapped. Provide cast-iron traps on cast-iron soil pipe. Traps installed on steel pipe or copper tubing must be recess-drainage pattern, or brass-tube type. Traps for acid-resisting waste must be of the same material as the pipe.

3.5 JOINTS

Install pipe and fittings in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees is not be permitted. Make joints with fittings of compatible material and made for the specific purpose intended.

3.5.1 Threaded

Provide threaded joints with American Standard taper pipe threads conforming to ASME B1.20.1. Coat only male pipe threads with graphite or with an approved graphite compound, or with an inert filler and oil, or have polytetrafluoroethylene tape applied.

3.5.2 Mechanical Couplings

Prepare grooved mechanical joints according to the coupling manufacturer's instructions. Pipe and groove dimensions must comply with the tolerances specified by the coupling manufacturer. Measure the diameter of grooves made in the field using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer. Measure and record groove width and dimension of groove from end of the pipe for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Do not use grooved joints in concealed locations. Grooved joints are only permissible in mechanical rooms.

3.5.3 Unions and Flanges

Do not conceal unions, flanges and mechanical couplings in walls, ceilings, or partitions. Provide unions on pipe sizes 2-1/2 inches and smaller; provide flanges on pipe sizes 3 inches and larger.

3.5.4 Grooved Mechanical Joints

Prepare grooves according to the coupling manufacturer's instructions. Provide grooved fittings, couplings, and grooving tools of the same manufacturer. Pipe and groove dimensions must comply with the tolerances specified by the coupling manufacturer. Measure the diameter of grooves made in the field using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Measure and record groove width and dimension of groove from end of pipe for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Do not use grooved joints. Grooved joints are only permissible in mechanical rooms.

3.5.5 Cast Iron Soil Pipe

Install bell and spigot compression and hubless gasketed clamp joints for soil, waste and vent piping per the manufacturer's recommendations.

3.5.6 Copper Tube and Pipe

3.5.6.1 Brazed Joint

In conformance with AWS B2.2/B2.2M and CDA A4015 with flux and are acceptable for all pipe sizes. Copper to copper joints must include the use of copper-phosphorus or copper-phosphorus-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) must include the use of flux with either a copper-phosphorus, copper-phosphorus-silver or a silver brazing filler metal.

3.5.6.2 Soldered Joint

Make with flux. Provide soldered joints conforming to ASME B31.5 and CDA A4015.

3.5.6.3 Pressure-Seal (Press-Fit) Connections

Calibrate pressure-seal (press-fit) tools within 24 months of pipe installation. Submit calibration certification prior to commencing with pressure-seal (press-fit) piping system installation. Maintain 24-month pressure-seal (press-fit) tools calibration certification during installation of piping systems. Pressure-seal (press-fit) piping system installers must be trained by the manufacturer of the pressure-seal (press-fit) system to be installed. Submit pressure-seal (press-fit) system installation training certificates prior to commencing with pressure-seal (press-fit) piping system installation. Make copper pressure-seal (press-fit) connections in strict accordance with the manufacturer's installation instructions for manufactured rated size. Press joints using the tool(s) approved by the manufacturer of that joint. Maintain minimum distances between fittings in accordance with the manufacturer's requirements.

3.5.7 Glass Pipe

Make joints for corrosive waste glass pipe and fittings with corrosion-resisting steel compression-type couplings with acrylonitrile rubber gaskets lined with polytetrafluoroethylene.

3.5.8 Corrosive Waste Plastic Pipe

Make joints for polypropylene pipe and fittings by mechanical joint or electrical fusion coil method in accordance with ASTM D2657 and ASTM F1290.

3.5.9 Other Joint Methods

Make connections between ferrous and non-ferrous copper water pipe with dielectric unions or flange waterways. Provide dielectric waterways with temperature and pressure rating equal to or greater than that specified for the connecting piping. Provide waterways with metal connections on both ends suited to match connecting piping. Provide dielectric waterways internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges must meet the performance requirements described herein for dielectric waterways. Make connecting joints between plastic and metallic pipe with transition fitting for the specific purpose.

3.6 CORROSION PROTECTION FOR BURIED PIPE AND FITTINGS

Ductile iron, cast iron, and steel pipe, fittings, and joints must have a protective coating. Additionally, provide ductile iron, cast iron, and steel pressure pipe with a cathodic protection system and joint bonding. Provide the cathodic protection system, protective coating system, and joint bonding for cathodically protected pipe in accordance with Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM and Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM. Select, apply, and inspect coatings in accordance with NACE SP0169 and as otherwise specified. Clean piping and apply the coating system prior to pipe tightness testing. Clean joints and fittings and apply the coating system after pipe tightness testing. For tape coating systems, provide tape conforming to AWWA C203 and apply with a minimum 50 percent overlap. Provide primer utilized with tape type coating systems as recommended by the tape manufacturer.

3.7 PIPE SLEEVES AND FLASHING

Provide pipe sleeves set in their proper and permanent location.

3.7.1 Sleeve Requirements

Provide pipes passing through concrete or masonry walls or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Sleeves are not required for supply, drainage, waste and vent pipe passing through concrete slab on grade, except where penetrating a membrane waterproof floor. A modular mechanical type sealing assembly may be installed in lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve. The seals must consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve using galvanized steel bolts, nuts, and pressure plates. The links must be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt must cause the rubber sealing elements to expand and provide a watertight seal between the pipe and the sleeve. Size each seal assembly as recommended by the manufacturer to fit the pipe and sleeve involved. Do not install sleeves in structural members, except where indicated or approved. Rectangular and square openings must be as detailed. Extend each sleeve through its respective floor, or roof, and cut flush with each surface, except for special circumstances. Extend pipe sleeves passing through floors, exposed or within partitions, in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas a minimum of 4 inches above the finished floor. Unless otherwise indicated, provide sleeves of a size to provide a minimum of 1/4 inch clearance between bare pipe or insulation and inside of sleeve or between insulation and inside of sleeve. Provide steel pipe or cast-iron pipe sleeves in bearing walls and concrete slab on grade floors. Sleeves in nonbearing walls or ceilings may be steel pipe, cast-iron pipe, galvanized sheet metal with lock-type longitudinal seam, or plastic. Except as otherwise specified, seal the annular space between pipe and sleeve, or between jacket over insulation and sleeve, with sealants conforming to ASTM C920 and with a primer, backstop material and surface preparation as specified in Section 07 92 00 JOINT SEALANTS. Do not seal the annular space between pipe and sleeve, between bare insulation and sleeve or between jacket over insulation and sleeve for interior walls which are not designated as fire rated. Recess sleeves through below-grade walls in contact with earth 1/2 inch from wall surfaces on both sides. Fill annular space between pipe and sleeve with backing material and sealants in the joint between the pipe and wall as specified above. Sealant selected for the earth side of the wall must be compatible with dampproofing/waterproofing materials that are to be applied over the joint sealant. Pipe sleeves in fire-rated walls must conform to the requirements in Section 07 84 00 FIRESTOPPING.

3.7.2 Flashing Requirements

Install pipes passing through roof through a 16 ounce copper flashing, each within an integral skirt or flange. Flashing must be suitably formed, and extend the skirt or flange not less than 8 inches from the pipe and set over the roof or floor membrane in a solid coating of bituminous cement. Extend the flashing up the pipe a minimum of 10 inches. For cleanouts, the turn down the flashing into the hub and caulked after placing the ferrule. Flash pipes passing through pitched roofs, using lead or copper flashing, with an adjustable integral flange of adequate size to extend not less than 8 inches from the pipe in all directions and lapped into the roofing to provide a watertight seal. Seal the annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation as indicated. Turn down flashing for dry vents into the pipe to form a waterproof joint. Pipes, up to and including 10 inches in diameter, passing through roof or floor waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing-clamp device, and pressure ring with brass bolts. Fit flashing shield into the sleeve clamping device. Sleeve pipes passing through wall waterproofing membranes as described above. Install a waterproofing clamping flange.

3.7.3 Optional Counterflashing

Instead of turning the flashing down into a dry vent pipe, or caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may be accomplished by utilizing the following:

a. A standard roof coupling for threaded pipe up to 6 inches in diameter.

b. A tack-welded or banded-metal rain shield around the pipe.

3.7.4 Pipe Penetrations of Slab on Grade Floors

Where pipes, fixture drains, floor drains, cleanouts or similar items penetrate slab on grade floors, except at penetrations of floors with waterproofing membrane as specified in paragraphs Flashing Requirements and Waterproofing, form a groove 1/4 to 1/2 inch wide by 1/4 to 3/8 inch deep around the pipe, fitting or drain. Fill the groove with a sealant as specified in Section 07 92 00 JOINT SEALANTS.

3.7.5 Pipe Penetrations

Provide sealants for all pipe penetrations. Seal all pipe penetrations to prevent infiltration of air, insects, and vermin.

3.7.6 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, provide a fire seal as specified in Section 07 84 00 FIRESTOPPING.

3.8 PIPE HANGERS, INSERTS, AND SUPPORTS

Install pipe hangers, inserts and supports conforming to MSS SP-58, except as modified herein.

a. Type 1, provide with adjustable type steel support rods.

b. Types 5, 12, and 26 are not be permitted.

c. Type 3 is not permitted on insulated pipe.

d. Secure Type 18 inserts to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

e. Provide Type 19 and 23 C-clamps for attachment to steel joists and torque per MSS SP-58. Provide both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

f. Provide Type 20 attachments on steel angles and vertical web steel channels and furnish with an added malleable-iron heel plate or adapter. Attach to horizontal web steel channel with drilled hole on centerline and double nut and washer.

g. Provide Type 21, 28, 29, and 30 clamps for attachment to steel W or S beams.

h. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

i. Provide Type 39 saddles on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Provide Type 39 saddles welded to the pipe.

j. Provide Type 40 shields:

(1) On insulated pipe less than 4 inches.

(2) On insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or less.

(3) Have a high density insert for all pipe sizes. High density inserts must have a density of 8 pcf or greater.

k. Space horizontal pipe supports as specified in MSS SP-58 and install a support not over 1 foot from the pipe fitting joint at each change in direction of the piping. Space pipe supports not over 5 feet apart at valves. Operating temperatures in determining hanger spacing for PVC or CPVC pipe must be 120 degrees F for PVC and 180 degrees F for CPVC. Include allowances for expansion and contraction in horizontal pipe runs.

l. Support vertical pipe at each floor, except at slab-on-grade, at intervals of not more than 15 feet nor more than 8 feet from end of risers, and at vent terminations. Include allowances for expansion and contraction in vertical pipe risers.

m. Provide Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides to allow longitudinal pipe movement. Slide materials must be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints must be provided as needed. Where steel slides do not require provisions for lateral restraint the following may be used:

(1) On pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher, a Type 39 saddle, welded to the pipe, may freely rest on a steel plate.

(2) On pipe less than 4 inches a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

(3) On pipe 4 inches and larger carrying medium less than 60 degrees F a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

n. Pipe hangers on horizontal insulated pipe must be the size of the outside diameter of the insulation. The insulation must be continuous through the hanger on all pipe sizes and applications.

o. Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide must include a pipe cradle, welded to the guide structure and strapped securely to the pipe. Separate the pipe from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.

p. Hangers and supports for plastic pipe must not compress, distort, cut or abrade the piping, and must allow free movement of pipe except where otherwise required in the control of expansion/contraction.

q. Hangers used to support piping 2 inches and larger must be fabricated to permit adequate adjustment after erection while still supporting the load. Install pipe guides and anchors to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Support piping subjected to vertical movement when operating temperatures exceed ambient temperatures by variable spring hangers and supports or by constant support hangers. In the support of multiple pipe runs on a common base member, provide a clip or clamp where each pipe crosses the base support member. Spacing of the base support members must not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run. Formed or bent threaded sections of rods are not permitted.

3.8.1 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads as specified in Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL . Structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, must be provided. Provide materials used for supports as specified in Section 05 12 00 STRUCTURAL STEEL.

3.8.2 Structural Attachments

Provide attachment to building structure concrete and masonry by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Provide inserts and anchors with a safety factor not less than 5. Supports attached to metal decking is not permitted. Supports to the underside of concrete filled floor or concrete roof decks is not permitted, unless approved by the Contracting Officer. Construct masonry anchors for overhead applications of ferrous materials only.

3.9 FIXTURES AND FIXTURE TRIMMINGS

Provide polished chromium-plated pipe, valves, and fittings where exposed to view. Provide angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, use a beading tool to mechanically deform the tubing above the compression fitting. Connect exposed traps and supply pipes for fixtures and equipment to the rough piping systems at the wall, unless otherwise specified under the item. Insulate drain lines and hot water lines of fixtures for handicapped/accessible fixtures and do not require polished chrome finish. Install plumbing fixtures and accessories within the space shown.

3.9.1 Fixture Connections

Make connections between earthenware fixtures and flanges on soil pipe gastight and watertight with a closet-setting compound or neoprene gasket and seal. Use of natural rubber gaskets or putty is not be permitted. Set fixtures with outlet flanges the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

3.9.2 Flushometer Valves

Secure flushometer valves to prevent movement by anchoring the long finished top spud connecting tube to wall adjacent to valve with approved metal bracket. Arrange flushometer valves for water closets to avoid interference with grab bars. In addition, for water closets intended for handicap use, install the flush valve handle on the wide side of the enclosure. Install bumpers for water closet seats on the wall.

3.9.3 Height of Fixture Rims Above Floor

Unless otherwise noted, mounting heights must be as indicated. Comply with ICC A117.1 for the installation of fixtures for use by the physically handicapped.

3.9.4 Shower Bath Outfits

The area around the water supply piping to the mixing valves and behind the escutcheon plate must be made watertight by caulking or gasketing.

3.9.5 Fixture Supports

Provide fixture supports for off-the-floor lavatories, urinals, water closets, and other fixtures of similar size, design, and use, of the chair-carrier type. The carrier must provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability must be provided to locate the fixture at the desired height and in proper relation to the wall. The use of support plates, in lieu of chair carrier, fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.

3.9.5.1 Support for Solid Masonry Construction

Anchor chair carrier to the floor slab. Where a floor-anchored chair carrier cannot be used, imbed a suitable wall plate in the masonry wall.

3.9.5.2 Support for Concrete-Masonry Wall Construction

Anchor chair carrier to floor slab. Where a floor-anchored chair carrier cannot be used, fasten a suitable wall plate to the concrete wall using through-bolts and a back-up plate.

3.9.5.3 Support for Steel Stud Frame Partitions

Provide chair carriers. The anchor feet and tubular uprights must be of the heavy duty design; and feet (bases) must be steel and welded to a square or rectangular steel tube upright. The use of wall plates, in lieu of floor-anchored chair carriers, are permitted only if adjoining steel partition studs are suitably reinforced to support a wall plate bolted to these studs.

3.9.5.4 Support for Wood Stud Construction

Where floor is a concrete slab, provide a floor-anchored chair carrier. Where entire construction is wood, install wood crosspieces. Fasten fixture hanger plates, supports, brackets, or mounting lugs with not less than No. 10 wood screws, 1/4 inch thick minimum steel hanger, or toggle bolts with nut. Extend wood crosspieces the full width of the fixture and securely support.

3.9.5.5 Wall-Mounted Water Closet Gaskets

Where wall-mounted water closets are provided, provide reinforced wax, treated felt, or neoprene gaskets. Provide gasket type as recommended by the chair-carrier manufacturer.

3.9.6 Access Panels

Provide access panels for concealed valves and controls, or any item requiring inspection or maintenance. Provide access panels of sufficient size and located so that the concealed items may be serviced, maintained, or replaced. Provide access panels as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

3.9.7 Escutcheons

Provide escutcheons at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Fasten escutcheons securely to pipe or pipe covering and must be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Provide one-piece escutcheons held in place by silicon caulk.

3.10 WATER HEATERS AND HOT WATER STORAGE TANKS

3.10.1 Relief Valves

Valves installed between a relief valve and its water heater or storage tank are not permitted. Install pressure and temperature relief valves where the valve actuator comes in contact with the hottest water in the heater. Whenever possible, install the relief valve directly in a tapping in the tank or heater; otherwise, install the pressure and temperature valve in the hot-water outlet piping. Provide a vacuum relief valve on the cold water supply line to the hot-water storage tank or water heater and mounted above and within 6 inches above the top of the tank or water heater.

3.10.2 Connections to Water Heaters

Make connections of metallic pipe to water heaters with dielectric unions or flanges.

3.10.3 Expansion Tank

Install a pre-charged expansion tank on the cold water supply between the water heater inlet and the cold water supply shut-off valve. Adjust the expansion tank air pressure, as recommended by the tank manufacturer, to match incoming water pressure.

3.10.4 Gas- and Oil-Fired Water Heaters

Install in accordance with NFPA 54 for gas fired and NFPA 31 for oil fired.

3.11 IDENTIFICATION SYSTEMS

Identify piping and physical hazards in accordance with 29 CFR 1910.144, ASME A13.1, NEMA Z535.1. Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment. Identify each piping system and item of equipment indicated on contract drawings.

3.11.1 Piping System Identification

Install plastic pipe markers on each system, and include arrows to show normal direction of flow. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, crawl spaces) and exterior non-concealed locations.

a. Near each valve and control device.

b. Near each branch; mark each pipe at branch, where there could be question of flow pattern.

c. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.

d. At access doors, manholes and similar access points which permit view of concealed piping.

e. Near major equipment items and other points of origination and termination.

f. Spaced intermediately at maximum spacing of 20 feet along each piping run, except reduce spacing to 10 feet in congested areas of piping and equipment. Provide a minimum of one pipe label in each space where partitions extend to structure.

3.11.2 Valves

Provide valve tag on every valve, cock and control device in each piping system. List each tagged valve in valve schedule for each piping system. Mount laminated valve schedules under glass in mechanical equipment rooms. Coordinate location with Contracting Officer. Provide 1/2-inch red adhesive identification dots on ceiling tiles located immediately below balancing valves and shutoff valves.

3.11.3 Plumbing Equipment

Install engraved plastic laminate sign or plastic equipment marker on or near each major item of plumbing equipment and each operational device. Provide minimum 1/4-inch high lettering for name of unit where viewing distance is less than 3 feet; 1/2-inch high for distances up to 6 feet, and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering. In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.11.4 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number must be installed on valves, except those valves installed on supplies at plumbing fixtures. Tags must be 1-3/8 inch minimum diameter, with stamped or engraved marking. Provide black indentations, for reading clarity. Attach tags to valves with No. 12 AW, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

3.11.5 Nameplates

Provide 1/8 inch thick melamine laminated plastic nameplates, black matte finish with white center core, for equipment, gages, thermometers, and valves; valves in supplies to faucets will not require nameplates. Accurately align lettering and engrave minimum of 1/4 inch high normal block lettering into the white core. Minimum size of nameplates must be 1 by 2-1/2 inches. Key nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule.

3.11.6 Labels

Provide labels for sensor operators at flush valves and faucets. Include the following information on each label:

a. Identification of the sensor and its operation with written] description.

b. Range of the sensor.

c. Battery replacement schedule.

3.11.7 Pipe Color Code Marking

Provide color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS.

3.11.8 Color Coding Scheme for Locating Hidden Utility Components

Provide scheme in buildings having suspended grid ceilings. The color coding scheme must identify points of access for maintenance and operation of operable components which are not visible from the finished space and installed in the space directly above the suspended grid ceiling. Operable components include valves. The color coding scheme must consist of a color code board and colored metal disks. Each colored metal disk must be approximately 3/8 inch in diameter and secured to removable ceiling panels with fasteners. Insert fasteners into the ceiling panels so that the fasteners will be concealed from view. The fasteners must be manually removable without tools and must not separate from the ceiling panels when panels are dropped from ceiling height. Installation of colored metal disks must follow completion of the finished surface on which the disks are to be fastened. Provide the color code board with approximate dimensions of 3 foot width, 30 inches height, and 1/2 inch thickness. Provide board made of wood fiberboard and framed under glass or 1/16 inch transparent plastic cover. Unless otherwise directed, the color code symbols must be approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters. Mount and locate the color code board in the mechanical or equipment room.

3.12 PAINTING

3.12.1 General

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09 90 00 PAINTS AND COATINGS. Provide new equipment with factory applied or shop applied paint, and as specified herein or in PART 2 paragraph FACTORY PAINTING, and provided under each individual section.

3.12.2 Shop Painting Systems for Metal Surfaces

a. Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F must be cleaned to bare metal.

b. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat must be aluminum or light gray.

(1) 120 Degrees F: Immediately after cleaning, the metal surfaces must receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

(2) Temperatures Between 120 and 400 Degrees F: Metal surfaces must receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

(3) Temperatures Greater Than 400 Degrees F: Metal surfaces must receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

3.13 VIBRATION-ABSORBING FEATURES

Isolate mechanical equipment, including pumps, from the building structure by approved vibration-absorbing features, unless otherwise shown. Each foundation must include an adequate number of standard isolation units. Each unit must consist of machine and floor or foundation fastening, together with intermediate isolation material, and must be a standard product with printed load rating. Provide piping connected to mechanical equipment with flexible connectors. Isolation unit installation must limit vibration to 20 percent of the lowest equipment rpm. Submit details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

3.14 TRAINING

a. Provide the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work.

b. Provide instruction during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished must be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

c. When significant changes or modifications in the equipment or system are made under the terms of the Contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

3.15 POSTED INSTRUCTIONS

Post framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system where directed. Prepare condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. Post the framed instructions before acceptance testing of the systems.

3.16 TESTS, FLUSHING AND DISINFECTION

Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Indicate the final position of controls in each test report.

3.16.1 Plumbing System

Perform the following tests on the plumbing system in accordance with the ICC IPC , except that the drainage and vent system final test must include the smoke test. The Contractor has the option to perform a peppermint test in lieu of the smoke test. If a peppermint test is chosen, submit a testing procedure to the Contracting Officer for approval.

a. Drainage and Vent Systems Test. Include a smoke test in the final test.

b. Building Sewers Tests.

c. Water Supply Systems Tests.

3.16.1.1 Test of Backflow Prevention Assemblies

Test backflow prevention assemblies using gauges specifically designed for the testing of backflow prevention assemblies. Certification of proper operation must be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. Submit written documentation of the tests performed and signed by the individual performing the tests. Gauges must be tested annually for accuracy in accordance with the University of Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14). Report form for each assembly must include, as a minimum, the following:

Data on Device	Data on Testing Firm
Type of Assembly	Name
Manufacturer	Address

Model Number	Certified Tester
Serial Number	Certified Tester No.
Size	Date of Test
Location	
Test Pressure Readings	Serial Number and Test Data of Gauges

If the unit fails to meet specified requirements, the unit must be repaired and retested.

3.16.1.2 Submittal Requirements

Submit the following:

a. Detail drawings for the complete plumbing system including piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams and wiring diagrams or connection and interconnection diagrams. Indicate clearances required for maintenance and operation on the detail drawings. Where piping and equipment are to be supported other than as indicated, include loadings and proposed support methods details. Draw plan, elevation, view, and detail drawings to scale.

b. Diagrams, instructions, and other sheets proposed for posting. Manufacturer's recommendations for the installation of bell and spigot and hubless joints for cast iron soil pipe.

c. Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

3.16.2 Defective Work

If inspections or test shows defects, replace or repair such defective work or material as necessary and repeat inspections and tests. Make repairs to piping with new materials. Caulking of screwed joints or holes is not acceptable.

3.16.3 Pressure-Seal (Press-Fit) Fittings Connection Tests

Perform a step-test on all piping systems containing pressure-seal (press-fit) connections. Test may utilize air, water, or dry nitrogen, to pressurize the system at a pressure not to exceed 85 psig. Examine and check each joint in the pressurized piping system for leaks. If a leaking joint is identified, relieve the pressure from the system, ensure the tube is full inserted into the fitting and proceed to press the fitting. Remove and replace any fitting that has already been pressed but is identified as leaking. Repeat the step-test until the system is determined to be leak-free.

3.16.4 System Flushing

3.16.4.1 During Flushing

Before operational tests or disinfection, flush potable water piping system with hot potable water. Sufficient water must be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 4 fps through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) must specify the number of fixtures to be operated during flushing. Provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor is responsible for any flood damage resulting from flushing of the system. Continue flushing until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration.

3.16.4.2 After Flushing

Drain system at low points. Remove, clean, and replace strainer screens. After flushing and cleaning, prepare systems for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system must be repaired. When the system flushing is complete, adjust the hot-water system for uniform circulation. Adjust flushing devices and automatic control systems for proper operation according to manufacturer's instructions. Flow rates on fixtures must not exceed those stated in Part 2 of this Section.

3.16.5 Operational Test

Upon completion of flushing and prior to disinfection procedures, subject the plumbing system to operating tests to demonstrate satisfactory installation, connections, adjustments, and functional and operational efficiency. Such operating tests must cover a period of not less than 8 hours for each system and include the following information in a report with conclusion as to the adequacy of the system:

a. Time, date, and duration of test.

b. Water pressures at the most remote and the highest fixtures.

c. Operation of each fixture and fixture trim.

d. Operation of each valve, hydrant, and faucet.

e. Pump suction and discharge pressures.

f. Temperature of each domestic hot-water supply.

g. Operation of each floor and roof drain by flooding with water.

h. Operation of each vacuum breaker and backflow preventer.

i. Complete operation of each water pressure booster system, including pump start pressure and stop pressure.

3.16.6 Disinfection

After operational tests are complete, disinfect the entire domestic hot- and cold-water distribution system. Flush the system as specified, before introducing chlorinating material. Provide hypochlorites or liquid chlorine chlorinating materials. Except as herein specified, water chlorination procedure must be in accordance with AWWA C651 and AWWA C652. Feed the chlorinating material into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). Use a properly adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution-feed chlorinator and booster pump. If after the 24 hour and 6 hour holding periods, the residual solution contains less than 25 ppm and 50 ppm chlorine respectively, flush the piping and tank with potable water, and repeat the above procedures until the required residual chlorine levels are satisfied. Flush the system, including the tanks, with clean water until the residual chlorine level is reduced to less than one part per million. During the flushing period, open and close each valve and faucet several times. Obtain samples of water in disinfected containers from several locations selected by the Contracting Officer. The samples of water must be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA 10084. The testing method used must be either the multiple-tube fermentation technique or the membrane-filter technique. Repeat disinfection procedure until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.16.7 Domestic Water Systems Flushing Program

Perform System Flushing, Operational Test, and Disinfection within three weeks of turnover of the facility to the Government. Develop and institute a Domestic Water Systems Flushing Program for domestic water systems. Institute the Program during the period between the conclusion of domestic water systems disinfection and turnover of the facility to the Government. Measure each domestic water system residual oxidant (disinfectant) level with a digital colorimeter at distal plumbing fixtures on each building daily. Distal plumbing fixtures must be as selected by the Contracting Officer. Measurement of residual oxidant levels by pool test kits or color-wheel test kits is not acceptable. Flush each domestic water system with fresh water when residual oxidant levels fall below or exceed the limits prescribed in PL 93-523. Retest residual levels and continue flushing until oxidant levels are within the limits prescribed by PL 93-523. Provide test results to the Government upon turnover to the Government.

-- End of Section --

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SECTION 22 05 48.00 20

MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL
04/06, CHG 1: 05/15

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 575	(2017) Method of Measuring Machinery Sound Within an Equipment Space
ANSI/AHRI 370	(2015; Addendum 1 2016) Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM D471	(2016a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D2240	(2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition
SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

1.2 RELATED REQUIREMENTS

The provisions of Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS apply to this section.

1.3 DEFINITIONS

1.3.1 Decibels dB

Measure of sound level. Decibels are referenced to either 20 uPa for sound pressure levels or one pW for sound power levels. dBA is the overall "A" weighted sound level.

1.3.2 Machinery

The vibration or noise producing equipment that must be isolated.

1.3.3 Manufacturer

The fabricator or supplier of vibration-isolation or seismic-protection materials and equipment. For mechanical equipment and machinery the term machinery manufacturer will be used.

1.3.4 Micropascal uPa

10 to the minus 6 power newtons per square meter.

1.3.5 Picowatt pW

10 to the minus 12 power watts.

1.4 SYSTEM DESCRIPTION

1.4.1 Spring Isolator Data

For each type and size of spring isolator, submit the spring outside diameter, deflection, operating spring height, unloaded spring height, solid spring height, the ratio of the outside diameter to the operating spring height, the load to deflection ratio of the springs, and weight and sizes of structural steel members.

1.4.2 Machinery Manufacturer's Sound Data

For each piece of indicated machinery to be vibration isolated, the calculated sound power test data or sound pressure test data as levels in dB in the eight octave bands between 63 and 8,000 Hz. Refer sound power levels to one pW and sound pressure levels to 20 uPa. Submit the overall "A" weighted scale sound pressure level in dB. Submit the standard test procedure used to obtain the sound power or pressure data for the applicable vibration isolation equipment size.

1.4.3 Machinery

For each item of machinery, compare spring static deflections with the specified minimum static deflection, to show that the calculated spring static deflections are not less than the minimum static deflections specified. Rated spring static deflections are not acceptable in lieu of calculated spring static deflections. When seismic protection is required, substantiating calculations are required.

1.4.4 Machinery Over 300 Pounds

For machinery items over 300 pounds, provide calculations for shear, pull-up, primary overturning, and secondary overturning.

1.4.5 Machinery Vibration Criteria

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Absorption Refrigeration Machines	SV-R	1.0	SV-R	1.75	SV-R	2.75
Centrifugal Chillers or Heat Pumps						
Hermetic Type	SV-B	1.75	SV-B	2.5	SV-B	3.5
Open Type	SV-1	1.75	SV-I	2.5	SV-I	3.5
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
Reciprocating Chillers or Heat Pumps						

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
500 to 750 rpm	SV-R	1.75	SV-R	2.5	SV-R	3.5
751 rpm and up	SV-R	1.5	SV-R	2.5	SV-R	3.5
Packaged Boilers	SV	1.0	SV	2.5	SV-R	3.5
Closed Coupled Pumps						
Up to 7-1/2 hp	S-I	1.0	S-I	1.0	S-I	1.0
Over 7-1/2 hp	S-I	1.5	S-I	2.5	S-I	2.5
Base Mounted Pumps						
Up to 20 hp	S-I	1.5	S-I	2.5	S-I	2.5
20 to 75 hp	S-I	1.5	S-I	2.5	S-I	3.5
Over 75 hp	S-I	2.5	S-I	3.5	S-I	3.5
Cooling Towers and Evaporative Condensers	SV with deflections specified for centrifugal blowers when springs are supported on beams. Use selection listed for column supported floors with up to 30 foot column spacing when springs are located on columns or bearing walls.					
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))						
Suspended Units						
Up to 5 hp	H	1.0	H	1.0	H	1.0
Over 5 hp						

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Up to 400 rpm	H	1.75	H	1.75	H	1.75
Over 401 rpm	H	1.0	H	1.5	H	2.5
Floor Mounted Units						
Up to 5 hp	S	1.0	S	1.0	S	1.0
Over 5 hp						
Up to 400 rpm	S-R	1.75	S-R	1.75	S-R	2.5
Over 401 rpm	S-R	1.0	S-R	1.5	S-R	2.5
Centrifugal Blowers						
175 - 224 rpm	S-B	4.75	S-B	4.75	S-B	4.75
225 - 299 rpm	S-B	3.75	S-B	4.75	S-B	4.75
300 - 374 rpm	S-B	2.75	S-B	4.5	S-B	4.75
375 - 499 rpm	S-B	2.5	S-B	3.5	S-B	4.5
Over 500 rpm	S-B	1.75	S-B	2.5	S-B	3.5
Tubular Centrifugal and Axial Fans (Note (2))						
Suspended		H with deflection specified for centrifugal blowers				
Floor Mounted Arrangements 1 & 9		S-B with deflections specified for centrifugal blowers				
Utility Fans (Note (2))						

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Suspended		H with deflections specified for centrifugal blowers but not to exceed 2.75 inches				
Floor-Mounted		S-R with deflections not specified for centrifugal blowers but not to exceed 2.75 inches				
High Pressure Fans (6 Inch Water-Column Static Pressure) and Other Machineries Producing Thrust (Note (2))		HR recommended for minimizing undesirable thrust effects				
Internal Combustion Engines and Engine Driven Equip						
750 rpm and over	S	1.5	S	2.5	S	3.5
Dimmer Banks and Transformers						
Up to 1000 lbs.	NM	0.35	NM	0.35	NM	3.5
Over 1000 lbs.	SV	1.0	SV	1.0	SV	1.0
NOTES:						
(1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)						
B - Welded structural steel bases.						
H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.						
HR - Thrust restraints						
I - Concrete inertia bases with steel forms.						
NM - Neoprene mounts.						

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
NP - Neoprene pads.						
R - Structural steel rail for equipment mounts.						
S - Freestanding spring isolators (floor-mounted equipment).						
SV - Freestanding spring isolators (floor-mounted equipment).						
SX - Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment. Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.						
(2) Fans						
a. When fan motors are 75 hp or larger, use the deflection requirements for the next wider column spacing. Except for building slab on grade a minimum of 2.5 inches should be used unless larger deflections are specified in the centrifugal blower table.						
b. Provide sway brace isolators for tubular centrifugal and axial fans when the fan pressure exceeds 4 inches water column.						
c. Provide inertia bases for all fans in lieu of structural steel bases or rails specified above when the fan pressure exceeds 4 inches water column.						
d. With attaching brackets, suspension spring isolators bridge between the structure and the thrust-producing machinery such as high-pressure fan. Both types H and HR normally provide reaction in tension, while types S, SV, and SX normally provide reaction in compression. Thrust restraints are low-cost and effective components available from manufacturers. Use thrust restraints to eliminate the need for or reduce the magnitude of inertia mass when the mass is only used to reduce the displacement effects of the thrust.						

TABLE 1B		
Class II Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
Absorption Refrigeration Machines	NP	0.25
	NM	0.35
Centrifugal Chillers or Heat Pumps		
Hermetic Type	NP	0.25
	NM	0.35
Open Type	NM-I	0.35
Reciprocating Air or Refrigeration Compressors		
500 to 750 rpm	S	1.0
751 rpm and up	S	1.0
Reciprocating Chillers or Heat Pumps		
500 to 750 rpm	SV	1.0
751 rpm and up	SV	1.0
Packaged Boilers	NP	0.25
	NM	0.35
Pumps		
Closed Coupled	NP	0.25
Up to 7 1/2 hp	NM	0.35
Over 7 1/2 hp	S-I	1.0
Base Mounted		
Up to 20 hp	S-I	1.0
20 to 75 hp	S-I	1.0
Over 75 hp	S-I	1.0
Cooling Towers and Evaporative Condensers	NP	0.25
	NM	0.35
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))		
Suspended Units		
Up to 5 hp	H	1.0
Over 5 hp		
Up to 400 rpm	H	1.75
Over 401 rpm	H	1.0
Floor Mounted Units		

TABLE 1B		
Class II Vibration Isolator Types and Minimum Static Deflection		
(MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
Up to 5 hp	NP	0.25
	NM	0.35
Over 5 hp		
Up to 400 rpm	NM	0.35
Over 401 rpm	NM	0.35
Centrifugal Blowers		
175 - 224 rpm	NM-B	0.35
225 - 299 rpm	NM-B	0.35
300 - 374 rpm	NM-B	0.35
375 - 499 rpm	NM-B	0.35
Over 500 rpm	NM-B	0.35
Tubular Centrifugal and Axial Fans (Note (2))		
Suspended	H with deflections specified for centrifugal blowers	
Floor Mounted Arrangements 1 & 9	NM	0.35
Utility Fans (Note (2))		
Suspended and centrifugal	H with deflections specified for	
Floor-Mounted	NM	0.35
High Pressure Fans (Over 6 Inch Water-ColumnStatic Pressure) and Other Machineries Producing Thrust Note (2))		HR recommended for minimizing undesirable thrust effects
Internal Combustion Engines and Engine Driven Equip		
750 rpm and over	S	1.0
Dimmer Banks and Transformers		
Up to 1000 lbs.	NP	0.25
	NM	0.35
Over 1000 lbs.	SV	1.0
NOTES: Note (1) and Note (2) are same as for TABLE 1A.		

Provide vibration isolators and seismic snubbers for mechanical and electrical machinery and associated piping and ductwork , to minimize transmission of vibrations and structure borne noise to the building structure or spaces or from the building structure to the machinery. Comply with the following vibration schedule.

1.4.6 Machinery Airborne Sound Level Criteria

TABLE 2A

Sound Data Schedule

Equipment	Maximum Sound Power Level (dB) Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Air Handling Unit	94	90	89	89	89	84	82	79
Make-Up Air Fan	91	91	80	84	82	76	71	65
Air Conditioning Unit	100	96	90	89	86	80	75	72
Boiler	75	72	72	75	76	63	55	50
Chiller	98	98	96	95	93	94	88	81
Cooling Tower	110	110	105	102	98	95	92	87
Air Compressor	90	89	92	93	92	92	90	81
Pump	85	80	82	82	80	77	74	72
Fan	55	50	48	47	48	46	42	37

1.4.6.1 Basic Criteria

For each piece of machinery in the human work environment, do not exceed the maximum airborne sound levels 84 dB A-weighted scale, continuous or intermittent, or 140 dB peak sound pressure-level, impact or impulse, noise.

1.4.6.2 Sound Data Schedule

TABLE 2A								
Sound Data Schedule								
Equipment	Maximum Sound Power Level (dB)							
	Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Air Handling Unit	94	90	89	89	89	84	82	79
Make-Up Air Fan	91	91	80	84	82	76	71	65
Air Conditioning Unit	100	96	90	89	86	80	75	72
Boiler	75	72	72	75	76	63	55	50
Chiller	98	98	96	95	93	94	88	81
Cooling Tower	110	110	105	102	98	95	92	87
Air Compressor	90	89	92	93	92	92	90	81
Pump	85	80	82	82	80	77	74	72
Fan	55	50	48	47	48	46	42	37

1.4.7 Seismic Protection Criteria

Use a Horizontal Force Factor minimum 60 percent of the machinery weight considered passing through the machinery center of gravity in any horizontal direction. Unless vibration isolation is required to protect machinery against unacceptable structure transmitted noise or vibration, protect the structure or machinery from earthquakes by rigid structurally sound attachment to the load-supporting structure. Protect each piece of vibration-isolated machinery with protected spring isolators or separate seismic restraint devices. Determine by calculations the number and size of seismic restraints needed for each machinery. Verify seismic restraint vendor's calculations by a registered professional engineer. Provide seismic snubbers and protected spring isolators rated in three principle axes. Verify ratings by independent laboratory testing, by analysis of an independent licensed structural engineer.

1.4.8 Welding

AWS D1.1/D1.1M.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Inertia Bases

Machinery Bases

Platforms

Rails

Saddles

SD-03 Product Data

Isolators

Flexible Connectors

Flexible Duct Connectors

Pipe Guides

Seismic Snubbers

Vertical Stops

Thrust Restraints

Inertia Bases

Machinery Bases

Machinery Foundations and Subbases

Platforms

Rails

Saddles

Machinery Manufacturer's Sound Data

SD-05 Design Data

Inertia Bases

Machinery Bases

Platforms

Rails

Saddles

Each Item of Machinery

Each Item of Machinery Over 300 Pounds

Submit design calculations for inertia bases, machinery bases, platforms, rails, and saddles, either by the machinery manufacturer for the recommended machinery mounting or by the vibration-isolation equipment manufacturer.

SD-06 Test Reports

Seismic Snubbers

Equipment Vibration Tests

Equipment Sound Level Tests

Protected Spring Isolators

Submit seismic protection rating in three principal axes certified by an independent laboratory or analyzed by an independent licensed structural engineer.

SD-08 Manufacturer's Instructions

Vibration and Noise Isolation Components

Seismic Protection Components

1.6 QUALITY ASSURANCE

1.6.1 Vibration Isolator Procurement

For each piece of machinery to be isolated from vibration, supply the inertia base, machinery base, platform, rails, , vibration isolators, seismic snubbers, and other associated materials and equipment as a coordinated package by a single manufacturer or by the machinery manufacturer. Select isolators that provide uniform deflection even when machinery weight is not evenly distributed. This requirement does not include the flexible connectors or the hangers for the associated piping and ductwork.

1.6.2 Unitized Machinery Assemblies

Mounting of unitized assemblies directly on vibration isolation springs is acceptable if machinery manufacturer certifies that the end supports of the assemblies have been designed for such installation.

PART 2 PRODUCTS

2.1 CORROSION PROTECTION FOR STEEL PARTS

ASTM A123/A123M ASTM A653/A653M hot-dipped galvanized, or equivalent manufacturer standard coatings. Where steel parts are exposed to the weather, provide galvanized coating of at least 2 ounces of zinc per square foot of surface. Coat springs with neoprene.

2.2 NEOPRENE

ASTM D471 and ASTM D2240, Grade Durometer 40, 50, or 60, and oil resistant.

2.3 FLOOR-MOUNTED ISOLATORS

2.3.1 Neoprene Isolation Pads

Provide pads at least 1/4 inch thick with cross-ribbed or waffle design. For concentrated loads, provide steel bearing plates bonded or cold cemented to the pads.

2.3.2 Neoprene Isolators

Provide molded neoprene isolators having steel base plates with mounting holes and, at the top, steel mounting plates with mounting holes or threaded inserts. Provide elements of type and size coded with molded letters or color-coded for capacity identification. Embed metal parts completely in neoprene.

2.4 SPRING ISOLATORS AND PROTECTED SPRING ISOLATORS

Provide spring isolators or protected spring isolators that are adjustable and laterally stable with free-standing springs of horizontal stiffness at minimum 80 percent of the vertical (axial) stiffness. For machine-attached and floor-attached restraining elements, separate from metal-to-metal contact by neoprene cushions 1/8 inch thick minimum. Provide neoprene acoustic friction pads at least 1/4 inch thick.

2.4.1 Springs

Provide springs with base and compression plates, to keep spring ends parallel during and after deflection to operating height. Provide outside coil diameters at least 0.8 of the operating height. At operating height, springs shall have additional travel to complete (solid) compression equal to at least 50 percent of the operating deflection.

2.4.2 Mounting and Adjustment

Provide base and compression plates with mounting holes or threaded fittings. Bolt leveling adjustment bolts to machinery or base.

2.5 SUSPENSION ISOLATORS

Provide hangers with suspension isolators encased in open steel brackets. Isolate hanger rods from isolator steel brackets with neoprene-lined opening.

2.5.1 Suspension Neoprene Isolators

Provide double-deflection elements with minimum 3/8 inch deflection.

2.5.2 Suspension Spring Isolators

Provide hangers with springs and molded neoprene elements in series. Provide isolators with adjustable spring-preloading devices where required to maintain constant pipe elevations during installation and when pipe operational loads are transferred to the springs.

2.6 MACHINERY BASES , PLATFORMS , RAILS SADDLES

ASTM A36/A36M and AISC 360.

2.7 INERTIA BASES

ASTM A36/A36M steel, ASTM C94/C94M (2,500 psi) concrete.

2.8 FLEXIBLE CONNECTORS FOR PIPING

Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.

2.8.1 Elastomeric Flexible Connectors

Fabricated of multiple plies of tire cord fabric and elastomeric materials with integral reinforced elastomeric flanges with galvanized malleable iron back up rings.

2.8.2 Metal Flexible Connectors

Fabricated of Grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover.

2.9 FLEXIBLE DUCT CONNECTORS

Provide flexible duct connectors fabricated in accordance with SMACNA HVAC Duct Contruction Standards.

2.10 SEISMIC SNUBBERS FOR EQUIPMENT

Factory-fabricated, omni-directional with factory set air gaps between 1/8 inch minimum and 1/4 inch maximum. Load capacity of each snubber at 50 percent neoprene element deflection shall be 0.5g minimum. Provide replaceable neoprene elements 1/4 inch minimum thickness.

2.11 PIPE GUIDES

Factory-fabricated. Weld steel bar guides to the pipe at a maximum radial spacing of 60 degrees. The outside diameter around the guide bars shall be smaller than the inside diameter of the guide sleeve in accordance with standard field construction practice. For pipe temperatures below 60 degrees F, provide metal sleeve, minimum one pound per cubic foot density insulation.

2.12 THRUST RESTRAINTS

Adjustable spring thrust restraints, able to resist the thrust force with at least 25 percent unused capacity. The operating spring deflection shall be not less than 50 percent of the static deflection of the isolation supporting the machinery.

2.13 SEISMIC PROTECTION COMPONENTS FOR PIPING AND DUCTWORK

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS. SMACNA 1981.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Vibration and Noise Isolation Components

Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

3.1.2 Suspension Vibration Isolators

Provide suspension isolation hangers for piping, suspended equipment, and suspended equipment platforms in mechanical equipment rooms. For operating load static deflections of 1/4 inch or less, provide neoprene pads or single deflection neoprene isolators. For operating load static deflections over 5/16 to 3/8 inch, provide double-deflection neoprene element isolators. For operating load static deflections over 3/8 inch, provide isolators with spring and neoprene elements in series.

3.1.3 Vertical Stops

For machinery affected by wind pressure or having an operational weight different from installed weight, provide resilient vertical limit stops which prevent spring extension when weight is removed. Provide vertical stops for machinery containing liquid, such as water chillers, evaporative coolers, boilers, and cooling towers. Spring isolated or protected spring isolated machinery must rock and move freely within limits of stops or seismic restraint devices.

3.1.4 Thrust Restraints

Where required, provide pairs of thrust restraints, symmetrically installed on both sides of the steady state line of thrust.

3.1.5 Flexible Pipe and Duct Connectors

Install flexible connectors in accordance with the manufacturer's instructions. When liquid pulsation dampening is required, flexible connectors with spherical configuration may be used. Provide restraints for pipe connectors at pumps to prevent connector failure upon pump startup.

3.1.6 Seismic Snubbers

Provide snubbers as close as possible to each vibration isolator as indicated. After installing and leveling of the machinery, adjust snubbers in accordance with the snubber manufacturer's instructions.

3.1.7 Machinery

Provide vibration isolators, flexible connectors and seismic snubbers in accordance with manufacturer's recommendations. Machinery with spring isolators or protected spring isolators shall rock or move freely within limits of stops or seismic snubber restraints.

3.1.7.1 Stability

Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.

3.1.7.2 Lateral Motion

The installed vibration isolation system for each piece of floor or ceiling mounted machinery shall have a maximum lateral motion under machinery start up and shut down conditions of not more than 1/4 inch. Restrain motions in excess by approved spring mountings.

3.1.7.3 Unbalanced Machinery

Provide foundation suspension systems specifically designed to resist horizontal forces for machinery with large unbalanced horizontal forces. Vibration isolator systems shall conform to the machinery manufacturer's recommendations.

3.1.7.4 Nonrotating Machinery

Mount nonrotating machinery in systems which includes rotating or vibrating machinery on isolators having the same deflection as the hangers and supports for the pipe connected to.

3.1.7.5 Unitized Machinery Assemblies

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Absorption Refrigeration Machines	SV-R	1.0	SV-R	1.75	SV-R	2.75
Centrifugal Chillers or Heat Pumps						
Hermetic Type	SV-B	1.75	SV-B	2.5	SV-B	3.5
Open Type	SV-1	1.75	SV-I	2.5	SV-I	3.5
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
Reciprocating Chillers or Heat Pumps						

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
500 to 750 rpm	SV-R	1.75	SV-R	2.5	SV-R	3.5
751 rpm and up	SV-R	1.5	SV-R	2.5	SV-R	3.5
Packaged Boilers	SV	1.0	SV	2.5	SV-R	3.5
Closed Coupled Pumps						
Up to 7-1/2 hp	S-I	1.0	S-I	1.0	S-I	1.0
Over 7-1/2 hp	S-I	1.5	S-I	2.5	S-I	2.5
Base Mounted Pumps						
Up to 20 hp	S-I	1.5	S-I	2.5	S-I	2.5
20 to 75 hp	S-I	1.5	S-I	2.5	S-I	3.5
Over 75 hp	S-I	2.5	S-I	3.5	S-I	3.5
Cooling Towers and Evaporative Condensers	SV with deflections specified for centrifugal blowers when springs are supported on beams. Use selection listed for column supported floors with up to 30 foot column spacing when springs are located on columns or bearing walls.					
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))						
Suspended Units						
Up to 5 hp	H	1.0	H	1.0	H	1.0
Over 5 hp						

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Up to 400 rpm	H	1.75	H	1.75	H	1.75
Over 401 rpm	H	1.0	H	1.5	H	2.5
Floor Mounted Units						
Up to 5 hp	S	1.0	S	1.0	S	1.0
Over 5 hp						
Up to 400 rpm	S-R	1.75	S-R	1.75	S-R	2.5
Over 401 rpm	S-R	1.0	S-R	1.5	S-R	2.5
Centrifugal Blowers						
175 - 224 rpm	S-B	4.75	S-B	4.75	S-B	4.75
225 - 299 rpm	S-B	3.75	S-B	4.75	S-B	4.75
300 - 374 rpm	S-B	2.75	S-B	4.5	S-B	4.75
375 - 499 rpm	S-B	2.5	S-B	3.5	S-B	4.5
Over 500 rpm	S-B	1.75	S-B	2.5	S-B	3.5
Tubular Centrifugal and Axial Fans (Note (2))						
Suspended		H with deflection specified for centrifugal blowers				
Floor Mounted Arrangements 1 & 9		S-B with deflections specified for centrifugal blowers				
Utility Fans (Note (2))						

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Suspended		H with deflections specified for centrifugal blowers but not to exceed 2.75 inches				
Floor-Mounted		S-R with deflections not specified for centrifugal blowers but not to exceed 2.75 inches				
High Pressure Fans (6 Inch Water-Column Static Pressure) and Other Machineries Producing Thrust (Note (2))		HR recommended for minimizing undesirable thrust effects				
Internal Combustion Engines and Engine Driven Equip						
750 rpm and over	S	1.5	S	2.5	S	3.5
Dimmer Banks and Transformers						
Up to 1000 lbs.	NM	0.35	NM	0.35	NM	3.5
Over 1000 lbs.	SV	1.0	SV	1.0	SV	1.0
NOTES:						
(1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)						
B - Welded structural steel bases.						
H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.						
HR - Thrust restraints						
I - Concrete inertia bases with steel forms.						
NM - Neoprene mounts.						

<table>
<tr><td colspan="7">TABLE 3A</td></tr>
<tr><td colspan="7">Vibration Isolator Types and Minimum Static Deflection</td></tr>
<tr><td colspan="7">(MSD, inches) for 4-8 inch slab on grade and column supported.</td></tr>
<tr><td>Column Spacing</td><td colspan="2">Slab on earth and 0-30 feet</td><td colspan="2">31-40 feet</td><td colspan="2">41-50 feet</td></tr>
<tr><td>Equipment</td><td>Type (Note (1))</td><td>MSD (Note (1))</td><td>Type (Note (1))</td><td>MSD (Note (1))</td><td>Type (Note (1))</td><td>MSD (Note (1))</td></tr>
<tr><td colspan="7">NP - Neoprene pads.</td></tr>
<tr><td colspan="7">R - Structural steel rail for equipment mounts.</td></tr>
<tr><td colspan="7">S - Freestanding spring isolators (floor-mounted equipment).</td></tr>
<tr><td colspan="7">SV - Freestanding spring isolators (floor-mounted equipment).</td></tr>
<tr><td colspan="7">SX - Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment. Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.</td></tr>
<tr><td colspan="7">(2) Fans</td></tr>
<tr><td colspan="7">a. When fan motors are 75 hp or larger, use the deflection requirements for the next wider column spacing. Except for building slab on grade a minimum of 2.5 inches should be used unless larger deflections are specified in the centrifugal blower table.</td></tr>
<tr><td colspan="7">b. Provide sway brace isolators for tubular centrifugal and axial fans when the fan pressure exceeds 4 inches water column.</td></tr>
<tr><td colspan="7">c. Provide inertia bases for all fans in lieu of structural steel bases or rails specified above when the fan pressure exceeds 4 inches water column.</td></tr>
<tr><td colspan="7">d. With attaching brackets, suspension spring isolators bridge between the structure and the thrust-producing machinery such as high-pressure fan. Both types H and HR normally provide reaction in tension, while types S, SV, and SX normally provide reaction in compression. Thrust restraints are low-cost and effective components available from manufacturers. Use thrust restraints to eliminate the need for or reduce the magnitude of inertia mass when the mass is only used to reduce the displacement effects of the thrust.</td></tr>
</table>

Unitized assemblies such as chillers with evaporator and condenser, and top mounted centrifugal compressor or unitized absorption refrigeration machines, structurally designed with end supports, may be mounted on steel rails and springs in lieu of steel bases and springs. Where the slab or deck is less than 4 inches thick, provide spring isolation units with the deflection double that of the vibration isolation schedule, up to a maximum static deflection of 5 inches.

3.1.7.6 Roof and Upper Floor Mounted Machinery

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Absorption Refrigerat Machines	SV-R	1.0	SV-R	1.75	SV-R	2.75
Centrifugal Chillers or Heat Pumps						
Hermetic Type	SV-B	1.75	SV-B	2.5	SV-B	3.5
Open Type	SV-1	1.75	SV-I	2.5	SV-I	3.5
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
Reciprocating Chillers or Heat Pumps						
500 to 750 rpm	SV-R	1.75	SV-R	2.5	SV-R	3.5
751 rpm and up	SV-R	1.5	SV-R	2.5	SV-R	3.5
Packaged Boilers	SV	1.0	SV	2.5	SV-R	3.5
Closed Coupled Pumps						
Up to 7-1/2 hp	S-I	1.0	S-I	1.0	S-I	1.0

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Over 7-1/2 hp	S-I	1.5	S-I	2.5	S-I	2.5
Base Mounted Pumps						
Up to 20 hp	S-I	1.5	S-I	2.5	S-I	2.5
20 to 75 hp	S-I	1.5	S-I	2.5	S-I	3.5
Over 75 hp	S-I	2.5	S-I	3.5	S-I	3.5
Cooling Towers and Evaporative Condensers		SV with deflections specified for centrifugal blowers when springs are supported on beams. Use selection listed for column supported floors with up to 30 foot column spacing when springs are located on columns or bearing walls.				
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))						
Suspended Units						
Up to 5 hp	H	1.0	H	1.0	H	1.0
Over 5 hp						
Up to 400 rpm	H	1.75	H	1.75	H	1.75
Over 401 rpm	H	1.0	H	1.5	H	2.5
Floor Mounted Units						
Up to 5 hp	S	1.0	S	1.0	S	1.0
Over 5 hp						

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection

(MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Up to 400 rpm	S-R	1.75	S-R	1.75	S-R	2.5
Over 401 rpm	S-R	1.0	S-R	1.5	S-R	2.5
Centrifugal Blowers						
175 - 224 rpm	S-B	4.75	S-B	4.75	S-B	4.75
225 - 299 rpm	S-B	3.75	S-B	4.75	S-B	4.75
300 - 374 rpm	S-B	2.75	S-B	4.5	S-B	4.75
375 - 499 rpm	S-B	2.5	S-B	3.5	S-B	4.5
Over 500 rpm	S-B	1.75	S-B	2.5	S-B	3.5
Tubular Centrifugal and Axial Fans (Note (2))						
Suspended	H with deflection specified for centrifugal blowers					
Floor Mounted Arrangements 1 & 9	S-B with deflections specified for centrifugal blowers					
Utility Fans (Note (2))						
Suspended	H with deflections specified for centrifugal blowers but not to exceed 2.75 inches					
Floor-Mounted	S-R with deflections not specified for centrifugal blowers but not to exceed 2.75 inches					
High Pressure Fans (6 Inch Water-Column Static Pressure) and Other Machineries Producing Thrust (Note (2))	HR recommended for minimizing undesirable thrust effects					

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Internal Combustion Engines and Engine Driven Equip						
750 rpm and over	S	1.5	S	2.5	S	3.5
Dimmer Banks and Transformers						
Up to 1000 lbs.	NM	0.35	NM	0.35	NM	3.5
Over 1000 lbs.	SV	1.0	SV	1.0	SV	1.0
NOTES:						
(1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)						
B - Welded structural steel bases.						
H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.						
HR - Thrust restraints						
I - Concrete inertia bases with steel forms.						
NM - Neoprene mounts.						
NP - Neoprene pads.						
R - Structural steel rail for equipment mounts.						
S - Freestanding spring isolators (floor-mounted equipment).						
SV - Freestanding spring isolators (floor-mounted equipment).						
SX - Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment. Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.						
(2) Fans						

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
a. When fan motors are 75 hp or larger, use the deflection requirements for the next wider column spacing. Except for building slab on grade a minimum of 2.5 inches should be used unless larger deflections are specified in the centrifugal blower table.						
b. Provide sway brace isolators for tubular centrifugal and axial fans when the fan pressure exceeds 4 inches water column.						
c. Provide inertia bases for all fans in lieu of structural steel bases or rails specified above when the fan pressure exceeds 4 inches water column.						
d. With attaching brackets, suspension spring isolators bridge between the structure and the thrust-producing machinery such as high-pressure fan. Both types H and HR normally provide reaction in tension, while types S, SV, and SX normally provide reaction in compression. Thrust restraints are low-cost and effective components available from manufacturers. Use thrust restraints to eliminate the need for or reduce the magnitude of inertia mass when the mass is only used to reduce the displacement effects of the thrust.						

TABLE 3B		
Class II Vibration Isolator Types and Minimum Static Deflection		
(MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
Absorption Refrigeration Machines	NP	0.25
	NM	0.35
Centrifugal Chillers or Heat Pumps		
Hermetic Type	NP	0.25
	NM	0.35
Open Type	NM-I	0.35
Reciprocating Air or Refrigeration Compressors		

TABLE 3B		
Class II Vibration Isolator Types and Minimum Static Deflection		
(MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
500 to 750 rpm	S	1.0
751 rpm and up	S	1.0
Reciprocating Chillers or Heat Pumps		
500 to 750 rpm	SV	1.0
751 rpm and up	SV	1.0
Packaged Boilers	NP	0.25
	NM	0.35
Pumps		
Closed Coupled	NP	0.25
Up to 7 1/2 hp	NM	0.35
Over 7 1/2 hp	S-I	1.0
Base Mounted		
Up to 20 hp	S-I	1.0
20 to 75 hp	S-I	1.0
Over 75 hp	S-I	1.0
Cooling Towers and Evaporative Condensers	NP	0.25
	NM	0.35
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))		
Suspended Units		
Up to 5 hp	H	1.0
Over 5 hp		
Up to 400 rpm	H	1.75
Over 401 rpm	H	1.0
Floor Mounted Units		
Up to 5 hp	NP	0.25
	NM	0.35
Over 5 hp		
Up to 400 rpm	NM	0.35
Over 401 rpm	NM	0.35
Centrifugal Blowers		
175 - 224 rpm	NM-B	0.35
225 - 299 rpm	NM-B	0.35
300 - 374 rpm	NM-B	0.35

TABLE 3B		
Class II Vibration Isolator Types and Minimum Static Deflection		
(MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
375 - 499 rpm	NM-B	0.35
Over 500 rpm	NM-B	0.35
Tubular Centrifugal and Axial Fans (Note (2))		
Suspended	H with deflections specified for centrifugal blowers	
Floor Mounted Arrangements 1 & 9	NM	0.35
Utility Fans (Note (2))		
Suspended and centrifugal	H with deflections specified for	
Floor-Mounted	NM	0.35
High Pressure Fans (Over 6 Inch Water-Column Static Pressure) and Other Machineries Producing Thrust (Note (2))		HR recommended for minimizing undesirable thrust effects
Internal Combustion Engines and Engine Driven Equip		
750 rpm and over	S	1.0
Dimmer Banks and Transformers		
Up to 1000 lbs.	NP	0.25
	NM	0.35
Over 1000 lbs.	SV	1.0
NOTES: Note (1) and Note (2) are same as for TABLE 3A.		

On the roof or upper floors, mount machinery on isolators with vertical stops. Rest isolators on beams or structures designed and installed in accordance with the SMACNA 1793, Plate 61.

3.1.8 Piping and High Pressure Ductwork

Provide vibration isolation for piping and high pressure ductwork with over 6 inches water column. The isolator deflections shall be equal to or greater than the static deflection of the vibration isolators provided for the connected machinery as follows:

3.1.8.1 High Pressure Ductwork

For a distance of 50 feet from fans, exhausters and blowers.

3.1.8.2 Piping Connected to Vibration Isolated Machinery

For a distance of 50 feet or 50 pipe diameters, whichever is greater.

3.1.8.3 Steam Pressure Reducing Valves

Connected piping for a distance of 50 feet or 50 pipe diameters, whichever is greater.

3.1.8.4 Condenser Water

For the full length of the piping.

3.1.8.5 Chilled, Hot, and Dual Temperature Piping

For risers from pumps and for the first 20 feet of the branch connection of the main supply and return piping at each floor.

3.1.9 Water and Steam Distribution Piping Application

Resiliently support piping with combination spring and neoprene isolation hangers. Provide spring elements with 5/8 inch static deflection; install the hanger with spacing so that the first harmonic natural frequency is not less than 360 Hz. Provide double-deflection neoprene elements. For the first two isolation hangers from the rotating equipment of 3 1/2 inch and smaller piping systems, ensure a deflection equal to the equipment-isolation static deflection. For the first four piping isolation hanger supports from rotating equipment of 4 inch and larger piping systems, use resilient hanger-rod isolators at a fixed elevation regardless of load changes. Incorporate an adjustable preloading device to transfer the load to the spring element within the hanger mounting after the piping system has been filled with water.

3.1.10 Pipe Hanger and Support Installation

3.1.10.1 Pipe Hangers

Provide eye-bolts or swivel joints for pipe hangers to permit pipe thermal or mechanical movement without angular misalignment of hanger vibration isolator.

3.1.10.2 High Temperatures

Where neoprene elements of vibration isolator may be subjected to high pipe temperatures, above 160 degrees F, provide metal heat shields or thermal isolators.

3.1.10.3 Valves

Provide vibration isolation hangers and supports at modulating, pressure reducing, or control valves which will induce fluid pulsations. When required or indicated, isolate valves with flexible connectors.

3.1.10.4 Machinery Without Flexible Connections

When piping is not connected to vibrating machinery with flexible connectors, provide the first four hangers with isolation elements designed for deflections equal to equipment vibration isolator deflections (including static, operating, and start-up).

3.1.10.5 Twelve Inch and Larger Pipe

Suspend 12 inch and larger pipe vibration hangers from resilient hanger rod isolators. Resilient hanger rod isolators shall be capable of supporting pipe during installation at a fixed elevation regardless of load changes. Provide an adjustable preloading device to transfer the load to isolation element after operational load is applied. Provide 12 inch and larger pipe supports with unrestrained stable springs for one inch deflection and with built-in leveling device and resilient vertical limit stops to prevent spring elongation when partial load is removed. Provide isolators capable of providing rigid anchoring during erection of piping so that it can be erected at a fixed elevation.

3.1.10.6 Pipe Risers

Provide pipe riser supports with bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with 1/4 inch steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.

3.1.10.7 Supports at Base of Pipe Risers

Piping isolation supports at the base of risers shall be two layers of 1/2 inch thick heavy-duty neoprene pad separated by 1/4 inch thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.

3.1.10.8 Pipe Anchors

Attach each end of the pipe anchor to an omni-directional pipe isolator which in turn shall be rigidly fastened to the steel framing or structural concrete. Provide a telescoping pipe isolator of two sizes of steel tubing separated by a minimum 1/2 inch thick pad of heavy-duty neoprene or heavy-duty neoprene and canvas. Provide vertical restraints by similar material to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.1.11 High Pressure Ductwork Hanger and Support Installation

Provide ductwork with vibration isolation hangers and supports where required or indicated. Connect ductwork to equipment with flexible duct connectors. Segment ductwork with flexible duct connectors.

3.1.11.1 Duct Risers

Provide duct riser supports within shafts with suitable bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with 1/4 inch steel plate.

3.1.11.2 Supports at Base of Duct Risers

For duct isolation supports at the base of risers, provide two layers of 1/2 inch thick heavy-duty neoprene pad separated by 1/4 inch thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the duct and isolation support to the pipe, and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support ducts, provide a maximum deflection of 1/4 inch at the midspan of this steel under the supported load. Rigidly support duct from the supplementary steel and the supplementary steel isolators.

3.1.11.3 Duct Anchors

Attach each end of the duct anchor to an omni-directional isolator which in turn shall be rigidly fastened to the steel framing or structural concrete as indicated. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.1.12 Equipment Room Sound Isolation

Do not allow direct contact between pipe or ducts and walls, floor slabs, roofs, ceilings or partitions of equipment rooms.

3.1.12.1 Pipe Penetrations

Provide galvanized Schedule 40 pipe sleeves and tightly pack annular space between sleeves and pipe with insulation having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E84, maximum effective temperature 1000 degrees F, bulk density 6 pounds/cu. ft. minimum. Provide uninsulated pipe with a one inch thick mineral fiber sleeve the full length of the penetration and seal each end with an interior or exterior and weather resistant non-hardening compound. Provide sealant and mineral-fiber sleeve of a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E84.

3.1.12.2 Duct Penetrations

Pack openings around ducts with mineral fiber insulation the full length of the penetration having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E84. At each end of duct opening provide sealing collars and seal with an interior or exterior and weather resistant non-hardening compound.

3.1.12.3 Ducts Passing Through Equipment Rooms

Provide with sound insulation equal to the sound attenuation value of the wall, floor, or ceiling penetrated.

3.1.13 Machinery Foundations and Subbases

Provide cast in place anchor bolts as recommended by the machinery manufacturer.

3.1.13.1 Machinery Subbases

Provide concrete subbases at least 4 inches high for floor mounted equipment except elevators. Rest subbases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both ends. Provide at least 2 inch clearance between subbases and inertia bases, steel bases, and steel saddles with machinery in operation.

3.1.13.2 Common Machinery Foundations

Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.

3.1.13.3 Foundation and Subbase Concrete

Cast concrete foundations and subbases of ASTM C94/C94M 2500 psi concrete reinforced with steel bars as indicated or recommended by machinery manufacturer.

3.1.13.4 Anchor Bolts and Grout

Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.

3.1.14 Inertia Bases

Install inertia bases in accordance with the recommendations of the machinery manufacturer or inertia base manufacturer, as applicable.

3.1.15 Seismic Restraints for Piping and Ductwork

Provide seismic restraints in accordance with SMACNA 1981.

3.1.16 Suspended Machinery Platforms

Provide with vibration-isolation hangers.

3.1.17 Electrical Connections

Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit 2 inch minimum displacement in any direction without damage.

3.1.18 Systems Not To Be Vibration Isolated

Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

3.2 FIELD QUALITY CONTROL

Provide equipment and apparatus required for performing inspections and tests. Notify Contracting Officer 14 days prior to machinery sound vibration seismic testing. Rebalance, adjust, or replace machinery with noise or vibration levels in excess of those given in the machinery specifications, or machinery manufacturer's data.

3.2.1 Field Inspections

Prior to initial operation, inspect the vibration isolators and seismic snubbers for conformance to drawings, specifications, and manufacturer's data and instructions. Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Check connector alignment before and after filling of system and during operation. Correct misalignment without damage to connector and in accordance with manufacturer's recommendations.

3.2.2 Spring Isolator Inspection

After installation of spring isolators or protected spring isolators, and seismic restraint devices, the machinery shall rock freely on its spring isolators within limits of stops or seismic restraint devices. Eliminate or correct interferences.

3.2.3 Tests

Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2.3.1 Equipment Vibration Tests

Perform vibration tests to determine conformance with vibration isolation schedule specified .

3.2.3.2 Equipment Sound Level Tests

Measure continuous or intermittent steady state noise with a sound level meter set for low response. Measure impact or impulse noise as dB peak sound pressure level (20 uPa) with an impact noise analyzer. Measure work distance from person to machinery noise center. Perform sound level tests to determine conformance with sound level schedule specified.

a. Interior Machinery Sound

In accordance with AHRI 575, measure the sound data for air conditioning and refrigeration machinery, such as fans, boilers, valves, engines, turbines, or transformers. Measure the sound pressure levels around mechanical and electrical machinery located in equipment spaces, 3 feet horizontally from the edge closest to the acoustical center of the machinery at points 3 feet and 5.5 feet above floor. Take measurements at the center of each side of the machinery. Locate the microphone at least 3 feet from the observer and measuring instruments. Observer shall not be between the machinery and the measuring instrument.

b. Exterior Machinery Sound

Measure sound data in accordance with ANSI/AHRI 370 for machinery radiating noise outside the building in such applications as grade installations, area-ways, wall and roof installations for cooling towers, refrigerant condensers, engine driven generator sets, fans, air conditioning machinery, heat pumps, evaporative coolers, exhaust silencers, and air intakes.

-- End of Section --

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SECTION 22 05 83.63

CURED-IN-PLACE PIPE (CIPP) LINING FOR PLUMBING APPLICATIONS
08/22

PART 1 GENERAL

It is the intent of this specification to provide for the reconstruction of pipelines and conduits by the installation of a resin-impregnated flexible tube that is either inverted or pulled into the original pipeline/conduit and expanded to fit tightly against said pipeline by the use of water, steam, or air pressure. Once in position the resin system shall be cured by elevating the temperature of the fluid (water/air) used for the tube's inflation to a level required for the initiators in the resin to commence a hardening of the resin system by polymerization. If the proposed CIPP process involves a UV initiated resin system in accordance with ASTM F2019, the polymerization process will be affected by an appropriate exposure to UV light. The CIPP shall extend the full length of the original pipe and provide a structurally sound, jointless and water-tight new pipe-within-a-pipe. The pipe can also be repaired in sections in accordance with ASTM F2599.

The Contractor must submit 3 recent relevant successfully completed projects along with project address, Owner's contact person, supervising design professional.

The Contractor is responsible for proper, accurate and complete installation of the CIPP using the system selected by the Contractor meeting the Owners requirements. Neither the CIPP product, system, nor its installation, shall cause adverse effects to any of the Owner's processes or facilities. The installation pressure for the product shall not damage the system in any way, and the use of the product shall not result in the formation or production of any detrimental compounds or by-products at the wastewater treatment plant. The Contractor shall notify the Owner and identify any by-products produced as a result of the installation operations, test and monitor the levels, and comply with any and all local waste discharge requirements. The Contractor is responsible for proper, accurate and complete installation of the CIPP using the system selected by the Contractor. Neither the CIPP system, nor its installation, shall cause adverse effects to any of the Owner's wastewater facilities and to facilities of the adjacent private properties connected to the Owner's wastewater facilities. The use of the product shall not result in the formation or production of any detrimental compounds or by-products at the wastewater treatment plant. The Contractor shall notify the Engineer and identify any by-products resulting from the installation operations, test and monitor the levels, and comply with any and all local State and Federal waste discharge requirements. The Contractor shall cleanup and restore existing surface conditions and structures, and repair any of the CIPP system determined to be defective. The Contractor shall conduct installation operations and schedule cleanup in a manner to cause the least possible obstruction and inconvenience to traffic, pedestrians, businesses, property owners, and tenants.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 13A	(2010; Errata 1 2014; Errata 2-3 2015) Specification for Drilling-Fluid Materials

ASTM INTERNATIONAL (ASTM)

ASTM D543	(2020) Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D790	(2017) Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM F1216	(2021) Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
ASTM F1743	(2016) Standard Practice for Rehabilitation of Existing Pipeline and Conduits by Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP)
ASTM F2019	(2011) Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)
ASTM F2599	(2020) Standard Practice for Sectional Repair of Damaged Pipe By Means of an Inverted Cured-In-Place Liner

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Installation Equipment; G

CIPP Lining Tube; G

Pipe Thermoset Epoxy Resin; G

Liner Materials; G

SD-08 Manufacturer's Instructions

CIPP Manufacturer's Written Installation Instructions

SD-11 Closeout Submittals

Report Summarizing The Extent Of the Pipe Lining Performed; G

Pipe Pre-Lining Inspection

Pipe Post-Lining Inspection

Manufacturer's Warranty

Record Drawings

1.3 PROJECT/SITE CONDITIONS

Inspect the line with closed-circuit television (CCTV) and determine the overall condition of the pipe before the pre-conditioning of the pipe.

1.4 WARRANTY

Submit 4 copies of the signed Manufacturer's Warranty for products within 30 days of final completion of the work.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a new cured-in-place pipe (CIPP) lining systems for the roof drain leader piping from the roof to floor level, cold and hot potable water piping, drain piping, electrical conduit, gas, process piping, steam, ventilation, wastewater or stormawater piping that is complete and ready for operation.

Perform the reconstruction using a tube of one or more layers of flexible needle-perforated felt or an equivalent non-woven perforated material, of a specified length not to exceed[____], and a thermo-set resin with physical and chemical properties appropriate for the application, in accordance with ASTM F1216. Submit product data for the epoxy resin, liner materials, and installation equipment. Ensure that all drilling fluids conform to API Spec 13A.

2.2 MATERIALS

2.2.1 CIPP Lining Tube

Provide a liner tube consisting of one or more layers of flexible needle-perforated felt or an equivalent non-woven perforated material, continuous in length with uniform wall thickness. Allow overlapping sections in the length of the liner. Ensure that the liner tube can conform to 45- and 90-degree bends, offset joints, bells, and disfigured pipe sections.

Provide an integrated bladder within the felt tube. Ensure that the bladder is made from materials compatible with the felt and resin systems used and can withstand the required installation pressure.

2.2.2 CIPP Properties

Provide a CIPP that meets minimum chemical-resistance requirements in accordance with ASTM D543. Conduct a test whereby the CIPP is exposed to the chemical solutions listed in Table 1 at temperatures up to 75 degrees F. Conduct this test for a minimum of one month. Do not accept the CIPP if the values for the CIPP's structural properties show a loss of 20 percent or more from the initial values.

TABLE 1 - CHEMICAL-RESISTANCE REQUIREMENTS

Chemical Solution Concentration	Percent
Tap Water (pH 6-9)	100.0
Nitric Acid	5.0
Phosphoric Acid	10.0
Sulfuric Acid	10.0
Gasoline	100.0
Vegetable Oil	100.0
Detergent or Soap	0.1

Ensure that the CIPP meets the minimum structural properties listed in Table 2:

TABLE 2 - CIPP INITIAL STRUCTURAL PROPERTIES - ASTM F1743

Property	ASTM Test Method	Minimum Value
Tensile Strength	ASTM D638	3,000 psi
Flexural Strength	ASTM D790	4,500 psi
Short-Term Flexural Modulus of Elasticity	ASTM D790	250,000 psi

Provide a cured liner with a light blue reflective internal wall color so that a CCTV inspection can show details clearly.

2.2.3 Resin

Provide an epoxy free resin-impregnated, cured tube that is resistant to shrinkage, corrosion, and oxidation resistant to abrasion from solids, grit, and sand in rainwater; and is solvent-free. Use a resin with proven resistance to storm water and ultra-violet light (sunlight) before to installation. Do not use polyester or vinyl ester resins.

Ensure that the proposed resin system does not contain silicones, stearates, or natural waxes that would adversely affect the adhesive properties or other chemical or physical properties of the CIPP liner.

PART 3 EXECUTION

3.1 INSTALLATION

Install the CIPP system, including materials, workmanship, fabrication, assembly, erection, examination, and inspection.

3.1.1 General

Inform the Contracting Officer of a temporary roof drain flow stoppage, for a period typically lasting 2 to 3 days. Provide a by-pass of the collector pipe.

For access at the bottom of the pipe sections, remove pipe sections near the floor at the point on the vertical rain leader specified in the design drawings.

3.1.2 Deviations

If the pre-installation inspection reveals conditions in the rain leader that are substantially different from those used in the design of wall thickness, liner tube construction, liner tube length, or resin system, notify the Contracting Officer and provide a videotape recording of the existing conditions and design data. Do not proceed without direction from the Contracting Officer.

3.1.3 Pipe Preparation

Precondition the pipe section by cleaning the section and removing corrosion, grease buildup, or other obstructions that may interfere with lining operations.

Leave obstructions in place that are less than 15 percent of the pipe diameter and cannot be removed from the pipe, and line over them.

To ensure that the pipe is ready for lining, use a CCTV to inspect the line immediately before lining and after cleaning is complete.

3.1.4 CIPP Installation Procedure

3.1.4.1 Wet Out

Calculate the amount of resin and catalyst required. Measure and mix the resin and catalyst. Saturate and impregnate the flexible felt tube with the amount of epoxy resin that was estimated before installation. Handle the resin-impregnated flexible tube in a way that retards or prevents resin from setting until the resin is ready for insertion.

3.1.4.2 Insertion

Use the pull in place or inversion method to install the liner or bladder system. Pull the liner or bladder system to the specified location in the pipe. Use compressed air to inflate the bladder to a pressure adequate to form the liner so that the liner fits tightly against the internal circumference of the pipe and causes the resin to migrate into pipe joints, voids and defects. Install the liner at low pressure (not to exceed 10 psi) in order to prevent damage to the host pipe (or further damage, if damage has already occurred).

3.1.4.3 Curing

Use compressed air or water to inflate the bladder and leave the liner in place until the resin-curing cycle is complete (within one hour at ambient temperature).

When the curing process is complete, release the pressure and pull out the inflation bladder. Ensure that the cured composite liner remains in place within the host pipe and that the liner provides a smooth bore interior that conforms to the existing pipe, eliminating rain water leakage. Ensure that the tube is continuous in length and wall thickness, and that the tube is uniform. If defects that were in the original pipe remain, reline the pipe again.

3.1.4.4 Finish

Ensure that the host pipe has not been left with any barriers, coatings, or material other than the cured liner tube or resin composite, which is specifically designed for desirable physical and chemical-resistance properties. Remove materials used in the installation, except for the cured liner tube or resin composite. Remove the cured liner tube or resin composite pipes left protruding from the service connection. Ensure that the finished CIPP is continuous and free from visual defects such as inclusions of foreign materials, dry spots, pinholes, and delimitation.

3.1.5 Liner Inspection

Perform a final CCTV inspection to verify that the composite liner has cured and that the integrity of the liner is maintained.

3.2 FIELD QUALITY CONTROL

Test system in accordance with ASTM F1743, as supplemented and modified by the CIPP manufacturer's written installation instructions.

Upon completion, submit DVD records of the pre-lining inspection and post-lining inspection, along with a written report summarizing the extent of the pipe lining performed. Update pipe the lining contract record drawings to reflect the as-built condition after the lining is complete and submit the drawings to the Contracting Officer. The Contracting Officer may review the video and documentation, and may inspect the work site to determine that the scope of work is complete, that the work is satisfactory, and that the site has been returned to its original condition.

3.3 ADJUSTING AND CLEANING

After liner installation has been completed and accepted, clean the entire project area and restore the site to its original condition before work began. Dispose of excess material and debris not incorporated into the permanent installation.

-- End of Section --

SECTION 22 07 19.00 40

PLUMBING PIPING INSULATION
08/16

PART 1 GENERAL

Section 22 00 00 PLUMBING, GENERAL PURPOSE applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C195	(2007; R 2013) Standard Specification for Mineral Fiber Thermal Insulating Cement
ASTM C449	(2007; R 2013) Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C534/C534M	(2020a) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2019) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2022) Standard Specification for Cellular Glass Thermal Insulation
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C592	(2022a) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered)

	(Industrial Type)
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C795	(2008; R 2018) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010; R 2015) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM C1136	(2021) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM D226/D226M	(2017) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D579/D579M	(2015) Standard Specification for Greige Woven Glass Fabrics
ASTM D5590	(2000; R 2010; E 2012) Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2022) Standard Test Methods for Gravimetric Determination ofWater Vapor Transmission Rate of Materials

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220	(2021) Standard on Types of Building Construction
NFPA 255	(2006; Errata 2006) Standard Method of Test of Surface Burning Characteristics of Building Materials

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 3779	(2016; Rev B) Tape Adhesive, Pressure Sensitive Thermal Radiation Resistant, Aluminum Foil/Glass Cloth

SAE AMS-STD-595A	(2017) Colors used in Government Procurement

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-PRF-19565	(1988; Rev C) Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G[, [____]]

SD-03 Product Data

Adhesives; G[, [____]]

Coatings; G[, [____]]

Insulating Cement; G[, [____]]

Insulation Materials; G[, [____]]

Jacketing; G[, [____]]

Tape; G[, [____]]

SD-08 Manufacturer's Instructions

Installation Manual; G[, [____]]

SD-11 Closeout Submittals

Record Drawings

Adhesives; S

Coatings; S

Insulation Materials; S

Recycled Materials; S

1.3 QUALITY CONTROL

1.3.1 Recycled Materials

Provide thermal insulation containing recycled materials to the extent practicable, provided that the material meets all other requirements of this section. The minimum recycled material content of the following insulation types are:

a. Rock Wool - 75 percent slag by weight

b. Fiberglass - 20-25 percent glass cullet by weight

c. Plastic Rigid Foam - 9 percent recovered material

d. Polyisocyanurate/Polyurethane - 9 percent recovered material

e. Rigid Foam - 9 percent recovered material

Submit recycled materials documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in project.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Performance Requirements

Provide noncombustible thermal-insulation system materials, as defined by NFPA 220. Provide adhesives, coatings, sealants, facings, jackets, and thermal-insulation materials, except cellular elastomers, with a flame-spread classification (FSC) of [25 or less] [_____], and a smoke-developed classification (SDC) of [50 or less] [_____]. Determine these maximum values in accordance with [ASTM E84] [NFPA 255]. Provide coatings and sealants that are nonflammable in their wet state.

Provide adhesives, coatings, and sealants with published or certified temperature ratings suitable for the entire range of working temperatures normal for the surfaces to which they are to be applied.

2.2 COMPONENTS

2.2.1 Insulation

[2.2.1.1 Mineral Fiber Insulation

Provide mineral fiber insulation conforming to [ASTM C592] [ASTM C553] [ASTM C547] and suitable for surface temperatures up to 370 degrees F. Provide insulation with a density not less than [_____][4]-pound per cubic foot and with thermal conductivity not greater than [_____][0.26] Btu-inch per hour per square foot per degree F at 150 degrees F mean.

[For pipe sizes 10-inches and larger, in lieu of fibrous glass pipe insulation, fiber pipe wrap insulation having an insulating efficiency not less than that of the specified thickness of fibrous glass pipe insulation may be provided.

]][2.2.1.2 Cellular Elastomer Insulation

Provide cellular elastomer insulation conforming to ASTM C534/C534M.

Ensure the water vapor permeability does not exceed [_____][0.30] grain per foot per inch per hour per square foot mercury pressure difference for 1-inch thickness of cellular elastomer.

][2.2.1.3 Cellular Glass Insulation

Conform to ASTM C552, Type II, Grade 2, pipe covering for Cellular Glass. Substitutions for this material are not permitted. Ensure minimum thickness is not less than 1-1/2 inches.

][2.2.1.4 Calcium Silicate Insulation

Conform to ASTM C533. Ensure the apparent thermal conductivity does not exceed [_____][0.54] Btu-inch per hour per square foot per degree F at 200 degrees F mean.

][2.2.1.5 Fiberglass Insulation

Conform to ASTM C547. Ensure the apparent thermal conductivity does not exceed [_____][0.54] Btu-inch per hour per square foot per degree F at 200 degrees F mean.

Fiber glass pipe insulation having an insulating efficiency not less than that of the specified thickness of mineral fiber pipe insulation may be provided in lieu of mineral fiber pipe insulation for aboveground piping.

][2.2.1.6 Polyisocyanurate Pipe Insulation

Conform to ASTM C591 for polyisocyanurate, minimum density of 1.7 pounds per cubic foot.

][2.2.1.7 Pipe Barrel

For temperatures up to and including 1200 degrees F, use pipe barrel insulation Type II, Molded, Grade A or Type III, Precision V-Groove, Grade A.

][2.2.1.8 Pipe Fittings

Provide molded pipe fitting insulation covering for use at temperatures up to and including 1200 degrees F.

]2.2.1.9 Flexible Blankets

Provide flexible blankets and felts for use at temperatures up to and including 350 degrees F with a density of 1 pound per cubic foot. Ensure thermal conductivity is no greater than [_____][0.26] Btu per hour per square foot per degree F at 75 degrees F mean.

2.2.2 Adhesives

2.2.2.1 Lagging Adhesive

Lagging is the material used for thermal insulation, especially around a cylindrical object. This may include the insulation as well as the cloth/material covering the insulation. [To resist mold/mildew, ensure lagging adhesive conforms to ASTM D5590 with 0 growth rating.]Provide nonflammable and fire-resistant lagging adhesives with a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Adhesive are MIL-A-3316, Class 1, pigmented [white] [red] and suitable for bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bonding glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or Class 2 for attaching fibrous glass insulation to metal surfaces. Apply lagging adhesives in strict accordance with the manufacturer's recommendations for pipe and duct insulation.

2.2.2.2 Vapor-Barrier Material Adhesives

Ensure adhesives conform to the requirements of ASTM C916, Type I, when attaching fibrous-glass insulation to metal surfaces or attaching insulation to itself, to metal, and to various other substrates.

2.2.2.3 Cellular Elastomer Insulation Adhesive

For cellular elastomer insulation adhesive, provide a solvent cutback chloroprene elastomer conforming to ASTM C916, Type I, and is approved by the manufacturer of the cellular elastomer for the intended use.

2.2.3 Insulating Cement

2.2.3.1 General Purpose Insulating Cement

Provide general purpose insulating cement, [diatomaceous silica] [mineral fiber], conforming to ASTM C195. Ensure composite is rated for1800 degrees F service, with a thermal-conductivity maximum of [_____][0.85] Btu per inch per hour per square foot for each degree F temperature differential at 200 degrees F mean temperature for a 1 inch thickness.

2.2.3.2 Finishing Insulating Cement

Provide finishing insulating cement of a mineral-fiber, hydraulic-setting type conforming to ASTM C449.

2.2.4 Caulk

Provide elastomeric joint sealant in accordance with ASTM C920, Type S, Grade NS, Class 25, Use A.

2.2.5 Corner Angles

Provide a nominal 0.016 inch thick aluminum 1 by 1 inch corner angle piping insulation with factory applied kraft backing. Ensure aluminum conforms to ASTM B209, Alloy [3003] [3105] [5005].

2.2.6 Jacketing

[2.2.6.1 Aluminum Jacket

Provide aluminum jackets conforming ASTM B209, Temper H14, minimum thickness of 0.016 inch, with factory-applied polyethylene and kraft paper moisture barrier on the inside surface. Provide smooth surface jackets for jacket outside diameters less than 8 inches. Provide corrugated surface jackets for jacket outside diameters 8 inches and larger. Provide stainless steel bands, minimum width of 0.5 inch. Provide factory prefabricated aluminum covers for insulation on fittings, valves, and flanges.[Provide aboveground jackets and bands with factory-applied baked-on semi-gloss brown color conforming to Federal Standard SAE AMS-STD-595A, "Colors," color chip number 20062.]

][2.2.6.2 Asphalt-Saturated Felt

Provide asphalt-saturated felt conforming to ASTM D226/D226M, without perforations, minimum weight of 10 pounds per 100 square feet.

][2.2.6.3 Stainless Steel Jacket

Provide stainless steel jackets conforming to ASTM A240/A240M; Type 304, minimum thickness of 0.010 inch, smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 0.5 inch. Provide factory prefabricated stainless steel covers for insulation on fittings, valves, and flanges.

][2.2.6.4 Glass Cloth Jacket

Provide plain-weave glass cloth conforming to ASTM D579/D579M, Style 141, weighing not less than [_____][7.23] ounces per square yard before sizing. Factory apply cloth wherever possible.

Provide leno weave glass reinforcing cloth, 26-end and 12-pick thread conservation, with a warp and fill tensile strength of 45 and 30 pounds per inch of width, respectively, and a weight of not less than [_____] [1.5] ounces per square yard. [At the Contractor's option, Style 191 leno-weave glass cloth conforming to ASTM D579/D579M may be provided.]

][2.2.6.5 PVC Jacket

Provide 0.010 inch thick, factory-premolded polyvinylchloride, [one-piece fitting] [pipe-barrel sheeting vapor-barrier jacketing] that is self-extinguishing, with high-impact strength and moderate chemical resistance. Ensure jacket has a permeability rating of 0.01 grain per hour per square foot per inch of mercury pressure difference, determined in accordance with ASTM E96/E96M. Provide manufacturer's standard solvent-weld type vapor-barrier joint adhesive.

Ensure conformance to ASTM C1136 for, Type I, low-vapor transmission, high-puncture resistance vapor barriers.

]2.2.7 Coatings

[2.2.7.1 Outdoor Vapor-Barrier Finishing

Provide a nonasphaltic, hydrocarbon polymer, mastic coating. Ensure the coating conforms to the requirements of ASTM C1136 and ASTM C921.

][2.2.7.2 Indoor Vapor-Barrier Finishing

Provide a pigmented resin and solvent compound coatings conforming to ASTM C1136, Type II.

][2.2.7.3 Outdoor and Indoor Nonvapor-Barrier Finishing (NBF)

Provide a pigmented polymer-emulsion as recommended by the insulation material manufacturer for the surface to be coated.

]2.2.7.4 Vapor Retarder

The vapor retarder coating shall be fire and water resistant and appropriately selected for either outdoor or indoor service. Color shall be white. The water vapor permeance of the compound shall be 0.013 perms or less at 43 mils dry film thickness as determined according to procedure B of ASTM E96/E96M utilizing apparatus described in ASTM E96/E96M. The coating shall be nonflammable, fire resistant type. [To resist mold/mildew, coating shall meet ASTM D5590 with 0 growth rating.]Coating shall meet MIL-PRF-19565 Type II (if selected for indoor service) and be Qualified Products Database listed. All other application and service properties shall be in accordance with ASTM C647.

2.2.7.5 Cellular-Elastomer Finishing

Provide a polyvinylchloride lacquer coating recommended by the manufacturer of the cellular elastomer finish.

2.2.7.6 Coating Color

[Provide white][Conform to the color code specified][Blend with background of surrounding area][Provide as specified by the Contracting Officer] for the coating color.

2.2.8 Tape

Provide a knitted elastic cloth glass lagging specifically suitable for continuous spiral wrapping of insulated pipe bends and fittings that produces a smooth, tight, wrinkle-free surface. Conform to requirements of SAE AMS 3779, ASTM D579/D579M, and ASTM C921 for tape, weighing not less than [_____][10] ounces per square yard.

2.3 MATERIALS

Submit manufacturer's catalog data for the following items:

a. Adhesives

b. Coatings

c. Insulating Cement

d. Insulation Materials

e. Jacketing

f. Tape

Provide compatible materials that do not contribute to corrosion, soften, or otherwise attack surfaces to which applied, in either the wet or dry state. Meet ASTM C795 requirements for materials to be used on stainless steel surfaces. Provide materials that are asbestos free.

PART 3 EXECUTION

Apply insulation only to the system or component surfaces that have previously been tested and approved by the Contracting Officer.

3.1 PREPARATION

Submit installation drawings for pipe insulation, conforming with the adhesive manufacturer's written instructions for installation. Submit installation manual clearly stating the manufacturer's instructions for insulation materials.

Clean surfaces to remove oil and grease before insulation adhesives or mastics are applied. Provide solvent cleaning required to bring metal surfaces to such condition.

3.2 INSTALLATION OF INSULATION SYSTEMS

Apply materials in conformance with the recommendations of the manufacturer.

Install smooth and continuous contours on exposed work. Smoothly and securely paste down cemented laps, flaps, bands, and tapes. Apply adhesives on a full-coverage basis.

Install insulation lengths tightly butted against each other at joints. Where lengths are cut, provide smooth and square and without breakage of end surfaces. Where insulation terminates, neatly taper and effectively seal ends, or finish as specified. Direct longitudinal seams of exposed insulation away from normal view.

Use insulation meeting maximum value conductance as tested at any point, do not use an average. Meet or exceed the specified maximum conductance by adding additional insulation thickness.

[3.2.1 Dual-Temperature (Hot- and Chilled-) Water Piping

Install a [mineral fiber with vapor barrier jacket, Type T-1] [cellular class with vapor barrier jacket, Type T-4] insulation, with a thickness of not less than [_____]. Insulate aboveground pipes, valve bodies, fittings, unions, and flanges.

][3.2.2 Hot-Water, Steam, and Condensate-Return Piping

Install a mineral fiber insulation with glass cloth jacket, Type T-2, with a thickness of not less than [_____]. Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

][3.2.3 Cold-Water and Condensate-Drain Piping

Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

[Provide 3/8 inch mineral fiber insulation with glass cloth jacket, Type T-2, with a thickness of not less than [_____].

][Install a cellular-elastomer insulation conforming to ASTM C534/C534M, with a water-vapor permeability not exceeding 0.1 grain per square foot per hour per inch mercury pressure-differential for 1 inch thickness.

][Provide flexible cellular-elastomeric thermal insulation for cold water piping, Type T-3, with a thickness of [3/8][1/2] inch. Use expanded, closed-cell pipe insulation only aboveground, not for underground piping.

]][3.2.4 Refrigerant Suction Piping

Install a cellular-elastomer insulation, Type T-3, with a nominal thickness of 3/4-inch. Insulate surfaces, including valve, fittings, unions, and flanges.

][3.2.5 Cooling-Tower Circulating Water Piping

Install a cellular-elastomer insulation, Type T-3, with a thickness of not less than [_____]. Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

Install a mineral fiber insulation with aluminum jacket, Type T-6, with a thickness of not less than [_____]. Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

][3.2.6 Steam and Condensate Piping, 350 Psig

Install a calcium silicate insulation with glass cloth jacket, Type T-5. Ensure a thickness of not less than [_____], based on an 80 degrees F ambient temperature in still air with an insulation "K" factor of 0.37 at 200 degrees F mean temperature:

][3.2.7 Hot Water Heating Converter

Install a calcium silicate insulation with glass cloth jacket, Type T-7, with a thickness of 1-1/2 inches.

][3.2.8 Chilled-Water and Dual-Temperature Pumps

Install a cellular elastomer insulation, Type T-9, with a thickness of 1-inch. Cover surfaces subject to condensation, and provide a vapor-barrier coating.

][3.2.9 Low-Pressure Steam and Condensate, Weather-Exposed

Install a calcium silicate insulation with weatherproof jacket, Type T-17, with a thickness of not less than [_____]. Insulate all surfaces.

][3.2.10 Steam and Condensate, Weather-Exposed, 125 Psig

Install a calcium silicate insulation with weatherproof jacket, Type T-17, with a thickness not less than [_____]. Insulate all system surfaces.

][3.2.11 Steam and Condensate, Weather-Exposed, 350 Psig

Install a calcium silicate insulation with weatherproof jacket, Type T-17, with a thickness not less than [_____]. Insulate all system surfaces.

]3.3 APPLICATION

[3.3.1 Type T-1, Mineral Fiber with Vapor-Barrier Jacket

Apply factory and field attached vapor barrier jacket to piping insulated with mineral fiber. Maintain vapor seal. Securely cement jackets, jacket laps, flaps, and bands in place with vapor-barrier adhesive. Provide jacket overlaps not less than [_____][1-1/2] inches and jacketing bands for butt joints 3-inches in width.

Insulate exposed-to-view fittings and valve bodies with preformed mineral-fiber of the same thickness as the pipe-barrel insulation.

Temporarily secure fitting insulation in place with light cord ties. Apply a 60-mil coating of white indoor vapor-barrier coating and, while still wet, wrap with glass lagging tape with 50 percent overlap, and smoothly blend into the adjacent jacketing. Apply additional coating as needed with rubber-gloved hands to smooth fillets or contour coating. Allow to fully cure before the finish coating is applied. Field fabricate and install insulation for concealed fittings and special configurations. Build up insulation from mineral fiber and a special mastic consisting of a mixture of insulating cement and lagging adhesive diluted with 3 parts water. Where standard vapor-barrier jacketing cannot be used, make the surfaces vapor tight by using coating and glass lagging cloth or tape as previously specified.

In lieu of materials and methods previously specified, fittings may be wrapped with a twine-secured, mineral-wool blanket to the required thickness and covered with premolded polyvinylchloride jackets. Make seams vapor tight with a double bead of manufacturer's standard vapor-barrier adhesive applied in accordance with the manufacturer's instructions. Hold all jacket ends in place with AISI 300 series corrosion-resistant steel straps, [_____][15]-mils thick by [_____][1/2]-inch wide.

Set pipe insulation into an outdoor vapor-barrier coating applied intermittently over a minimum length of [_____][6] inches at maximum [_____][12] feet spacing. Seal the ends of the insulation to the jacketing with the same coating material to provide an effective vapor-barrier stop.

Do not use staples as a means to apply insulation. Install continuous vapor-barrier materials over all surfaces, including areas inside pipe sleeves, hangers, and other concealment.

Provide piping insulation at hangers consisting of 13-pounds per cubic foot density; fibrous-glass inserts or expanded, rigid, closed-cell, polyvinylchloride. Where required, seal junctions with vapor-barrier jacket, glass-cloth mesh tape, and vapor-barrier coating.

Expose white-bleached kraft paper side of the jacketing to view.

Finish exposed-to-view insulation with not less than a [6]-mil dry-film thickness of nonvapor-barrier coating suitable for painting.

][3.3.2 Type T-2, Mineral Fiber with Glass Cloth Jacket

Apply factory attached presized, white, glass cloth jacket to piping insulated with mineral fiber. Securely cement jackets, jacket laps, flaps, and bands in place with vapor-barrier adhesive. Provide jacket overlaps not less than 1-1/2 inches and jacketing bands for butt joints 3 inches wide.

Insulate exposed-to-view fittings with preformed mineral-fiber of the same thickness as the pipe insulation. Temporarily secure in place with light cord ties. Install impregnated glass lagging tape with indoor vapor-barrier on 50 percent overlap basis. Blend tape smoothly into the adjacent jacketing. Apply additional coating as needed, using rubber gloved hands to a smooth fillets or contour coatings. Tape ends of insulation to the pipe at valves 2 inches and smaller. Field fabricate and install insulation for concealed fittings and special configurations. Build up insulation from mineral fiber and a mixture of insulating cement and lagging adhesive, diluted with 3 parts water. Finish surfaces with glass cloth or tape lagging.

[Cover all valves 2-1/2 inches and larger and all flanges with preformed insulation of the same thickness as the adjacent insulation.

][Finish exposed-to-view insulation with a minimum [_____][6]-mil dry-film thickness of nonvapor-barrier coating suitable for painting.

][In lieu of materials and methods specified above, fittings may be wrapped with a twine-secured, mineral-wool blanket to the required thickness and covered with premolded polyvinylchloride jackets. Hold all jacket ends in place with AISI 300 series corrosion-resistant steel straps, [_____][15] mils thick by [_____][1/2]-inch [_____] wide. Provide fitting insulation, thermally equivalent to pipe-barrel insulation to preclude surface temperatures detrimental to polyvinylchloride.

]][3.3.3 Type T-3, Cellular Elastomer

Cover piping-system surfaces with flexible cellular-elastomer sheet or preformed insulation. Maintain vapor seal. Cement insulation into continuous material using a solvent cutback chloroprene adhesive recommended by the manufacturer for the specific purpose. Apply adhesive to both of the contact surfaces on a 100-percent coverage basis to a minimum thickness of 10-mils wet or approximately 150 square feet per gallon of undiluted adhesive.

Set cold water piping insulation into an outdoor vapor-barrier coating applied intermittently over a minimum length of [6] inches at maximum intervals of 12 feet. At piping supports, ensure insulation is continuous by using outside-carrying type clevis hangers with insulation shield. Install [Cork] [Wood dowel] load-bearing inserts between the pipe and insulation shields to prevent insulation compression.

Insulate hot-water, cold-water, and condensate drain pipes to the extent shown with nominal [3/8][1/2]-inch thick, fire retardant (FR), cellular elastomer, preformed pipe insulation. Seal joints with adhesive.

At pipe hangers or supports where the insulation rests on the pipe hanger strap, cut the insulation with a brass cork borer and insert a [No. 3] superior grade cork. Seal seams with approved adhesive. Insulate sweat fitting with miter-cut pieces of cellular elastomer insulation of the same nominal pipe size and thickness as the insulation on the adjacent piping or tubing. Join miter-cut pieces with approved adhesive. Slit and snap covers over the fitting, and seal joints with approved adhesive.

Insulate screwed fittings with sleeve-type covers formed from miter-cut pieces of cellular elastomer thermal insulation having an inside diameter large enough to overlap adjacent pipe insulation. Lap pipe insulation against fittings, and overlap not less than [_____][1] inch. Use adhesive to join cover pieces and cement the cover to the pipe insulation.

Finish surfaces exposed to view or ultraviolet light with not less than a [_____][2] mil minimum dry-film thickness application of a polyvinylchloride lacquer recommended by the manufacturer. Apply in not less than [two] [_____] coats.

][3.3.4 Type T-4, Cellular Glass with Vapor-Barrier Jacket

Apply factory and field attached vapor barrier jacket to piping insulated with cellular glass. Maintain vapor seal. Securely cement jackets, jacket laps, flaps, and bands in place with vapor-barrier adhesive. Provide jacket overlaps not less than [1-1/2][_____] inches. Provide jacket bands for butt joints of not less than[3][_____] inches width. Provide insulation continuous through hangers. Bed insulation in an outdoor vapor-barrier coating applied to all piping surfaces.

Insulate flanges, unions, valves, anchors, and fittings with factory premolded or prefabricated or field fabricated segments of insulation of the same material and thickness as the adjoining pipe insulation. When segments of insulation are used, provide elbows with not less than three segments. For other fittings and valves, cut segments to the required curvature or nesting size.

Secure segments of the insulation in place with twine or copper wire. After the insulation segments are firmly in place, apply a vapor-barrier coating over the insulation in two coats with glass tape imbedded between coats. Vary the tint of the first coat from the expected white color of the second coat to ensure the complete application of the two coats. Apply coatings to a total dry-film thickness of 1/16 inch minimum. Overlap glass tape seams not less than[1][_____]inch and tape ends not less than [4][_____]inches.

In lieu of materials and methods specified above, fittings may be wrapped with 3/8-inch thick, vapor-barrier, adhesive-coated strips of cellular elastomer insulation. Install insulation under tension, compressed to 25 percent of original thickness, and wrapped until overall thickness is equal to adjacent insulation. Secure cellular elastomer in place with twine and sealed with vapor-barrier coating applied to produce not less than [_____][1/16]-inch dry-film thickness. Cover fittings with premolded polyvinylchloride jackets. Make seams vapor-tight with a double bead of manufacturer's standard vapor-barrier adhesive applied in accordance with the manufacturer's instructions. Hold jacket ends in place with AISI 300 series corrosion-resistant steel straps, [_____][15]-mils thick by [_____][1/2]-inch wide.

To prevent condensation, insulate anchors secured directly to piping for not less than [_____][6] inches from the surface of the pipe insulation.

Install white-bleached kraft paper side of jacket exposed to view.

Finish exposed-to-view insulation with not less than a [_____][6]-mil dry-film thickness of nonvapor-barrier coating suitable for painting.

][3.3.5 Type T-5, Calcium Silicate with Glass Cloth Jacket (Piping)

Apply factory attached presized, white glass cloth jacket to piping insulated with calcium silicate. Field apply jackets when required. Securely cement jackets, jacket laps, flaps, and bands in place with vapor-barrier adhesive. Ensure jacket overlap is not less than [_____][1-1/2] inches and jacketing bands for butt joints are 4 inches wide. Fabricate fittings from segmented pipe barrel sections bedded in general purpose insulating cement and wired in place. Fill voids with a general purpose insulating cement with not less than [_____][1/4] inch thick, final coating. Apply glass lagging tape with a minimum overlap of 50 percent glass lagging tape with lagging adhesive, blended smoothly into adjacent jacketing. Apply additional adhesive as needed using rubber-gloved hands to smooth filets and contour coatings.

][3.3.6 Type T-6, Mineral Fiber with Aluminum Jacket

Apply factory or field attached aluminum jacket to piping insulated with mineral fiber.

Insulate fittings and valve bodies with preformed mineral-fiber of the same thickness as the pipe-barrel insulation. Temporarily secure fitting insulation in place with light cord ties. Apply a 60-mil coating of vapor-barrier mastic, and while still tacky, wrap with glass lagging tape.

Apply additional mastic as needed using rubber-gloved hands to smooth fillets or contour coatings. Field fabricate and install insulation for special configurations. Build up insulation from mineral fiber and a mixture of insulating cement and lagging adhesive diluted with 3 parts water. Only where standard aluminum jacketing cannot be used, make the surfaces vapor-tight by using mastic and glass lagging cloth or tape as specified above with an added finish coat of mastic.

Set pipe insulation into outdoor vapor-barrier coating applied intermittently over a minimum length of [_____][6]-inches with a maximum coating application of [_____][12]-foot. Seal ends of the insulation to the jacketing with the same coating material to provide effective vapor barrier stops.

Install continuous vapor barrier over all surfaces, including areas inside pipe sleeves, hangers, and other concealment.

Apply piping insulation to both sides of pipe hangers. Insulate junctions with a special mastic mixture, glass cloth mesh tape, and mastic as previously specified.

Securely cement jacket laps, flaps, and bands in place with aluminum jacket sealant. Provide 6 inch wide minimum jacketing bands for butt joints.

Wherever possible, lap joints against the weather so that the water runs off the lower edge and in accordance with the pipe drainage pitch. Locate longitudinal laps on horizontal lines 45 degrees below the horizontal centerline and alternately staggered 1 inch. Lap jacketing material a minimum of [_____][2] inches, circumferentially sealed with mastic, and strapped to provide a waterproof covering throughout. Locate straps 8 inches on center and pull up tight to hold jacketing securely in place. Use screws in addition to straps when necessary to obtain a waterproof covering. Place extra straps on each side of supporting devices and at openings. Where flanging access occurs, strap a chamfer sheet to the pipe at jacketing.

Stiffen exposed longitudinal edges of aluminum jacketing by bending a 1 inch hem on one edge.

Provide expansion joints for maximum and minimum dimensional fluctuations.

To prevent corrosion, do not allow the aluminum jacketing to come in direct contact with other types of metal.

At openings in jacket, apply an outdoor vapor-barrier coating for [_____][2] inches in all directions. Apply jacketing while waterproofing is tacky.

Use screws at each corner of each sheet, at fitting jackets, and as necessary for the service. Place Number 7, 3/8 inch long, binding-head aluminum sheet metal screws through the mastic seal.

][3.3.7 Type T-7, Calcium Silicate with Glass Cloth Jacket (Surfaces)

Cover surfaces with insulation block bedded in an insulating cement and covered with glass cloth jacketing.

Clean surfaces with a chlorinated solvent. Mix general purpose insulating cement with 3 parts water to 1 part nonvapor-barrier adhesive to bring to application consistency. Set block into bedding and joints and fill spaces with a bedding mix and wrap with galvanized chicken wire mesh well laced into an envelope. Trowel a 3/8 inch thick coating of bedding mix jacket on the nonvapor-barrier adhesive and glass cloth. Finish surfaces with not less than a [_____][6]-mil dry-film thickness of nonvapor-barrier coating.

[Aluminum sheet jacketing may be used in lieu of glass cloth.

]][3.3.8 Type T-9, Cellular Elastomer

Clean pump surfaces with solvent. Apply not less than [_____][1] inch of general purpose insulating cement, mixed with nonvapor-barrier adhesive diluted with 3 parts water, to achieve smooth surface and configuration contours. After all water has been removed, cover surfaces with 1/2 inch thick cellular elastomer insulation, attached and joined into a continuous sheet with an outdoor vapor-barrier coating recommended by the insulation manufacturer for the specific purpose. Apply coating to both of the contact surfaces on a 100-percent coverage basis with a minimum thickness of [_____][10] mils wet. Blend coating into the adjacent flange insulation. Cover joint with a band of cellular elastomer equal to the flange assembly width. Use same coating to seal insulation to the casing at penetrations and terminations. Insulate pumps in a manner that permits insulation to be removed to repair or replace pumps.

Finish insulation with a [_____][2] mil minimum dry-film application of a polyvinylchloride lacquer coating recommended by the manufacturer and applied in not less than [two] [_____] coats.

][3.3.9 Type T-10, Mineral-Fiber Fill

Pack voids surrounding pipe with mineral-fiber fill.

][3.3.10 Type T-17, Calcium Silicate Weatherproof Jacket

Cover piping system surfaces with calcium silicate insulation. Cover fittings and valve bodies with preformed insulation of the same material and thickness as the adjoining pipe insulation.

]3.4 CLOSEOUT ACTIVITIES

Final acceptance of the performed work is dependent upon providing Record Drawings details to the Contracting Officer. Include construction details, by building area, the insulation material type, amount, and installation method. An illustration or map of the pipe routing locations may serve this purpose.

Provide a cover letter/sheet clearly marked with the system name, date, and the words "Record Drawings Insulation/Material" for the data. Forward to the [Systems Engineer][Condition Monitoring Office][Predictive Testing Group][_____] for inclusion in the Maintenance Database."

-- End of Section --

SECTION 22 13 29

SANITARY SEWERAGE PUMPS
02/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Equipment Installation; G[, [_____]]

SD-03 Product Data

Materials and Equipment
Framed Instructions
Spare Parts

SD-06 Test Reports

Field Testing and Adjusting Equipment

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals; G[, [_____]]

1.3 DELIVERY, STORAGE, AND HANDLING

Protect from the weather, excessive humidity and excessive temperature variation; and dirt, dust, or other contaminants all equipment delivered and placed in storage.

1.4 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the related submittals, and not later than [_____] months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Pump casings shall be constructed of cast iron of uniform quality and free from blow holes, porosity, hard spots, shrinkage defects, cracks, and other injurious defects. Impellers shall be [cast iron] [ductile iron] [unless otherwise specified for rotors].

2.1.1 Nameplates

Provide each major item of equipment with the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.2 Equipment Guards

Enclose or guard belts, pulleys, chains, gears, projecting setscrews, keys, and other rotating parts so located that any person may come in close proximity thereto.

2.1.3 Special Tools

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment.

2.1.4 Electric Motors

Motors shall conform to NEMA MG 1.

2.1.5 Motor Controls

Controls shall conform to NEMA ICS 1.

2.1.6 Bolts, Nuts, Anchors, and Washers

Bolts, nuts, anchors, and washers shall be steel; galvanized in accordance with ASTM A153/A153M.

2.1.7 Pressure Gauges

Compound gauges shall be provided on the suction side of pumps and standard pressure gauges on the discharge side of pumps. Gauges shall comply with ASME B40.100. Gauge ranges shall be as appropriate for the particular installation.

2.1.8 Seal Water Systems

Pumping systems requiring seal water shall utilize [potable] [_____] water. A package seal water system, consisting of a [50 gallon] [_____] galvanized tank, float valve mounted directly on the tank, and 2 centrifugal pumps of equal capacity, with close coupled motors, shall be factory assembled and supplied as a single self-contained unit.

2.1.8.1 Float Valve

The float valve shall be mounted on the tank to maintain a water level below an overflow provided near the top of the tank and to maintain a 6 inch air gap between the water system and the top of the tank.

2.1.8.2 Auxiliary Equipment

Auxiliary equipment required to complete the system shall be as indicated and shall include the necessary piping, valving, pressure gauges, pressure regulators, pressure switches, solenoid valves, strainers, and accessories.

2.1.8.3 Controls

The solenoid valve shall open whenever the process pump motor is energized. The pressure switch shall signal an alarm and stop the process pump whenever the seal pressure is below a set point. The pressure regulating valve shall be located on a bypass line back to the seal water reservoir tank. The pressure switch and pressure regulating valve set points shall be determined by the process pump manufacturer. A valved bypass around each solenoid valve shall also be provided.

2.1.8.4 System Characteristics

The seal water systems for pump number[s] [_____] shall be sized for [_____]

gpm at [_____] psi and [_____] horsepower.

2.2 CENTRIFUGAL SOLIDS HANDLING PUMPS

Centrifugal solids handling pumps shall be of the nonclogging centrifugal type designed to pump solids up to 3 inches in diameter and which provide no internal interstices that catch solids and stringy materials to cause clogging.

2.2.1 Pump Characteristics

Pump number[s] [_____] located in [_____] shall have the following operating characteristics:

Pump Service	[_____]
Design Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Maximum Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Minimum Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Impeller Type	[_____]
Operating Speed	[_____] rpm
Maximum NPSH Required at Maximum Operating Point	[_____]
Motor Type	[_____]
Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm
Pump Control	[_____]

2.2.2 Pump Casing

Pump casing shall be constructed with tapped and plugged holes for venting and draining the pump. The casing shall be capable of withstanding pressures 50 percent greater than the maximum operating pressure. The volute shall have smooth passages. The casing shall be such that the impeller can be removed without disturbing the suction and discharge connections. The casing shall have a handhole to permit inspection and cleaning of the pump interior. Lifting eyes shall be provided to facilitate handling of the pump.

2.2.3 Impeller

The impeller shall be designed with smooth passages to prevent clogging and pass stringy or fibrous materials. The impeller shall be statically, dynamically, and hydraulically balanced within the operating range and to the first critical speed at 150 percent of the maximum operating speed. The impeller shall be securely keyed to the shaft with a locking arrangement whereby the impeller cannot be loosened by torque from either forward or reverse direction.

2.2.4 Wearing Rings

Renewable wearing rings shall be provided on the impeller and casing and shall have wearing surfaces normal to the axis of rotation. Wearing rings shall be constructed of [steel] [cast iron]. Wearing rings shall be designed for ease of maintenance and shall be secured to prevent rotation. Replaceable steel wear plates fastened to casing may be used in lieu of wearing rings on casing and impeller.

2.2.5 Pump Shaft

Pump shaft shall be of stainless or high grade alloy steel and shall be of adequate size and strength to transmit the full driver horsepower with a liberal safety factor.

2.2.6 Pump Shaft Sleeve

The pump shaft shall be protected from wear by a stainless steel, high grade alloy steel, or bronze shaft sleeve. The joint between the shaft and sleeve shall be sealed to prevent leakage.

2.2.7 Stuffing Box

The stuffing box shall be of the same material as the casing and shall be [grease] [or] [water] sealed. The stuffing box shall be designed for a minimum of five rings of packing and shall have easily removable split type glands.

2.2.8 Mechanical Seals

[Single] [Double] mechanical seals shall be provided to seal the pump shaft against leakage. Each seal interface shall be held in contact by its own spring system, supplemented by external liquid pressures. The seal system shall be constructed to be readily removable from the shaft.

2.2.9 Bearings

Pump bearings shall be ball or roller type designed to handle all thrust loads in either direction. Pumps depending only on hydraulic balance end thrust will not be acceptable. Bearings shall have an ABEMA L-10 life of 50,000 hours minimum, as specified in ABMA 9 or ABMA 11.

2.2.10 Lubrication

Bearings shall be [oil bath] [or] [grease] lubricated. [An oil reservoir shall be provided for oil bath lubricated bearings. The reservoir shall have an overflow opening to prevent overfilling and shall have a drain at the lowest point.] [A grease fitting shall be provided for grease-lubricated bearings. The grease fitting shall be of the type that prevents overlubrication and the building up of pressure injurious to the bearings. If the grease fitting is not easily accessible, grease tubing shall be provided to a convenient location.]

2.2.11 Pump Support

Horizontal centrifugal pumps shall be provided with a common base plate for the pump and motor. Vertical shaft centrifugal pumps shall be provided with separate bases for the pump and motor. Vertical dry pit centrifugal pumps shall be supported by a heavy cast iron base with adequate legs to provide maximum rigidity and balance.

2.2.12 Coupling

Couplings shall be of the heavy-duty flexible type, keyed or locked to the shaft. Disconnecting of the coupling shall be possible without removing the driver half or the pump half of the coupling from the shaft. Couplings for extended shaft vertical centrifugal pumps may be of the universal type.

2.3 SUBMERSIBLE CENTRIFUGAL PUMPS

Submersible centrifugal pumps shall be centrifugal type pumps designed to pump solids up to 3 inches in diameter and shall be capable of withstanding submergence as required for the particular installation.

2.3.1 Pump Characteristics

Pump number[s] [_____] located in [_____] shall have the following operating characteristics:

Pump Service	[_____]
Design Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Maximum Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Minimum Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Impeller Type	[_____]
Operating Speed	[_____] rpm
Depth of Submergence	[_____] feet
Motor Type	[_____]

Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm
Pump Control	[_____]

2.3.2 Pump Casing

The casing shall be capable of withstanding operating pressures 50 percent greater than the maximum operating pressures. The volute shall have smooth passages which provide unobstructed flow through the pump.

2.3.3 Mating Surfaces

Mating surfaces where watertight seal is required, including seal between discharge connection elbow and pump, shall be machined and fitted with nitrile rubber O-rings. Fitting shall be such that sealing is accomplished by metal-to-metal contact between mating surfaces, resulting in proper compression of the O-rings without the requirement of specific torque limits.

2.3.4 Coatings

Exterior surfaces of the casing in contact with sewage shall be protected by a sewage resistant coal tar epoxy coating. All exposed nuts and bolts shall be stainless steel.

2.3.5 Impeller

The impeller shall be of the [single] [double] shrouded non-clogging design to minimize clogging of solids, fibrous materials, heavy sludge, or other materials found in sewage. The impeller shall be statically, dynamically, and hydraulically balanced within the operating range and to the first critical speed at 150 percent of the maximum operating speed. The impeller shall be securely keyed to the shaft with a locking arrangement whereby the impeller cannot be loosened by torque from either forward or reverse direction.

2.3.6 Wearing Rings

Wearing rings, when required, shall be renewable type and shall be provided on the impeller and casing and shall have wearing surfaces normal to the axis of rotation. Material for wear rings shall be standard of pump manufacturer. Wearing rings shall be designed for ease of maintenance and shall be adequately secured to prevent rotation.

2.3.7 Pump Shaft

The pump shaft shall be of high grade alloy steel and shall be of adequate size and strength to transmit the full driver horsepower with a liberal safety factor.

2.3.8 Seals

A tandem mechanical shaft seal system running in an oil bath shall be provided. Seals shall be of [_____] with each interface held in contact by its own spring system. [Conventional mechanical seals which require a constant pressure differential to effect sealing will not be allowed.]

2.3.9 Bearings

Pump bearings shall be ball or roller type designed to handle all thrust loads in either direction. Pumps depending only on hydraulic balance end thrust will not be acceptable. Bearings shall have an ABEMA L-10 life of 50,000 hours minimum, as specified in ABMA 9 or ABMA 11.

2.3.10 Motor

The pump motor shall have Class F insulation, NEMA B design, in accordance with NEMA MG 1, and shall be watertight. The motor shall be either oil filled, air filled with a water jacket, or air filled with cooling fins which encircles the stator housing.

2.3.11 Power Cable

The power cable shall comply with NFPA 70, Type SO, and shall be of standard construction for submersible pump applications. The power cable shall enter the pump through a heavy duty entry assembly provided with an internal grommet assembly to prevent leakage. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board which shall isolate the motor interior from foreign material gaining access through the pump top. [Epoxies, silicones, or other secondary sealing systems are not acceptable.]

2.3.12 Installation Systems

2.3.12.1 Rail Mounted Systems

Rail mounted installation systems shall consist of guide rails, a sliding bracket, and a discharge connection elbow. Guide rails shall be of the size and type standard with the manufacturer and shall not support any portion of the weight of the pump. The sliding guide bracket shall be an integral part of the pump unit. The discharge connection elbow shall be permanently installed in the wet well along with the discharge piping. The pump shall be automatically connected to the discharge connection elbow when lowered into place and shall be easily removed for inspection and service without entering the pump well.

2.3.12.2 Bolt Down Systems

The pump mount system shall include a base designed to support the weight of the pump. The base shall be capable of withstanding all stresses imposed upon it by vibration, shock, and direct and eccentric loads.

2.3.12.3 Lifting Chain

Lifting chain to raise and lower the pump through the limits indicated shall be provided. The chain shall be galvanized and shall be capable of supporting the pump.

2.4 SELF-PRIMING CENTRIFUGAL PUMPS

Self-priming centrifugal pumps shall be designed to pump solids up to 3 inches in diameter and shall be of the centrifugal type capable of repeated reprime when handling trash-laden sewage.

2.4.1 Pump Characteristics

Pump number[s] [_____] located in [_____] shall have the following operating characteristics:

Pump Service	[_____]
Design Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Maximum Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Minimum Operating Point	[_____] gpm flow, [_____] feet head, [_____] percent efficiency
Maximum Priming Lift	[_____] feet
Maximum Reprime Lift	[_____] feet
Impeller Type	[_____]
Rotation Direction	[Clockwise] [Counterclockwise]
Operating Speed	[_____] rpm
Motor Type	[_____]
Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm
Pump Control	[_____]

2.4.2 Pump Casing

The casing shall be capable of withstanding pressures 50 percent greater than the maximum operating pressures. The pump casing shall contain no openings of smaller diameter than the specified sphere size. There shall be no internal devices that will inhibit maintenance or interfere with priming and performance. The pump shall be designed to retain sufficient liquid in the casing to ensure unattended operation. The casing shall be such that the impeller can be removed without disturbing the suction and discharge connections. Front access shall be provided to the pump interior to permit inspection and cleaning of the pump interior without removing suction or discharge piping.

2.4.3 Impeller

The impeller shall be of the two-vane, semi-open, non-clog type with pump-out vanes cast integrally on its backside. The impeller shall be statically, dynamically, and hydraulically balanced within the operating range and to the first critical speed at 150 percent of the maximum operating speed. The impeller shall be securely keyed to the shaft with a locking arrangement whereby the impeller cannot be loosened by torque from either forward or reverse direction.

2.4.4 Wear Plate

A replaceable wear plate constructed of [cast iron] [alloy steel] shall be provided.

2.4.5 Pump Shaft

Pump shaft shall be of high grade alloy steel or stainless steel and shall be of adequate size and strength to transmit the full driver horsepower with a liberal safety factor.

2.4.6 Pump Shaft Sleeve

The pump shaft shall be protected from wear by a high grade alloy steel or stainless steel shaft sleeve. A seal, if needed, shall be placed between the shaft and sleeve to prevent leakage.

2.4.7 Seals

The pump shaft shall be sealed against leakage by [oil lubricated] [water lubricated] mechanical seal. The stationary sealing member shall be [tungsten carbide] [silicon carbide] and the rotating member shall be [tungsten carbide] [silicon carbide]. The seal shall be such that the faces will not lose alignment during shock loads that cause deflection, vibration, and axial or radial movement of the pump shaft.

2.4.8 Bearings

Pump bearings shall be ball or roller type designed to handle all thrust loads in either direction.

2.4.9 Lubrication

Bearings shall be [oil bath] [or] [grease] lubricated. [An oil reservoir for oil bath lubricated bearings shall be provided. The reservoir shall have an overflow opening to prevent overfilling and shall have a drain at the lowest point.] [A grease fitting shall be provided to add grease for grease-lubricated bearings. The grease fitting shall be of the type that prevents overlubrication and the building up of pressure injurious to the bearings. If the grease fitting is not easily accessible, grease tubing to a convenient location shall be provided.]

2.4.10 Suction Check Valve

The pump shall contain a suction check valve to maintain prime. The suction check valve shall be removable without disturbing the suction piping. [The pump shall be capable of prime or reprime in the event of check valve failure.]

2.4.11 Pump Support

A common fabricated steel base plate shall be provided for the pump and motor.

2.4.12 Coupling

Power shall be transmitted from the motor to the pump by a [flexible coupling] [V-belt drive assembly]. [Flexible couplings shall be of the heavy duty type, keyed or locked to the shaft.] [The V-belt drive assembly shall have a minimum of two belts. The drive assembly shall be selected on the basis of the power to be transmitted from the motor to the pump. The drive shall be enclosed on all sides by a solid metal guard.]

2.5 SCREW PUMPS

Screw pumps shall have a spiral flight screw operating in a concrete trough with the screw rotation elevating the liquid up the inclined trough. The pump shall consist of a lower bearing assembly, a spiral screw with deflectors, an upper bearing assembly, a drive assembly, and an automatic grease lubricated system for the lower bearing.

2.5.1 Pump Characteristics

Pump number[s] [_____] located in [_____] shall have the following characteristics:

Pump Service	[_____]
Total Lift	[_____] feet
Angle of Inclination	[22] [30] [38] [_____] degrees from horizontal
Spiral Screw Diameter	[_____] feet [_____] inches
Flight Thickness	[_____] feet
Quantity of Flights	[1] [2] [3]
Design Capacity	[_____] gpm
Tube Diameter	[_____] feet [_____] inches
Screw Speed	[_____] rpm
Motor Type	[_____]
Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm
Pump Control	[_____]

2.5.2 Lower Bearing Assembly

The lower bearing assembly shall be sleeve or roller bearing type design. If sleeve bearing is utilized, either the bronze phosphor sleeve shall rotate around stationary shaft or shaft shall be attached to bronze bushing which rotates inside stationary cartridge. Sleeve bearing shall be hermetically sealed, automatic grease lubricated. Roller bearings shall be oil lubricated and designed to guard against oil leakage. Labyrinth arrangement shall protect fire seal from damage. Bearings shall have L-10 life of 100,000 hours. The bearing housing shall permit precise adjustment in the field. A spare lower bearing assembly shall be provided.

2.5.2.1 Seals

Contaminants shall be prevented from entering the bearing by two spring-loaded lipseals, one to exclude wastewater and contaminants and one to retain the grease in the bearing, or by a fixed journal with hollow axis to allow grease to the top end of the bearing where it flows the length of the bearing sealing out contaminants.

2.5.2.2 Bearing Shield

A heavy-duty bearing shield shall be provided to protect the bearing assembly from heavy debris.

2.5.3 Spiral Screw

The spiral screw shall consist of a steel torque tube with steel flights welded to the exterior of the tube, a drive shaft, and lower stub shaft.

2.5.3.1 Torque Tube

The torque tube shall be sealed at both ends with welded steel plates. Care shall be taken to insure that the end plates are parallel after welding. The flights shall be continuously welded to the tube on both sides. The drive shaft and lower stub shaft shall be bolted to the torque tube ends with a registered fit to ensure axial alignment of the tube and shafting.

2.5.3.2 Shafts

The upper and lower shafts and the outside diameter of the flights of the completed spiral screw shall have the same axis. The maximum deflection at midspan shall not exceed 5/32 inch when calculated as a uniformly loaded horizontal simple beam supported between the upper and lower bearings. The completed spiral screw shall be statically balanced.

2.5.4 Flow Defector Plates

Flow deflector plates shall be provided for installation in the pump trough along the uptake side of the spiral screw for the full length of the spiral. The deflector plates shall be concave to effect an extension of the circular arch of the trough to at least the height of the top surface of the torque tube. The deflector plates shall be fabricated from not less than 1/8 inch thick steel plate and shall be complete with stiffeners and anchors where required.

2.5.5 Upper Bearing Assembly

The upper bearing assembly shall consist of an upper bearing housing, bearing, seals, mounting, and cover.

2.5.5.1 Housing

The upper bearing housing shall be cast iron and shall have grease fittings on the exterior of the housing for periodic manual lubrication.

2.5.5.2 Bearing

The upper bearing shall have an ABEMA L-10 life of 50,000 hours minimum, as specified in ABMA 9 or ABMA 11, and shall be one of the following: a dual bearing consisting of a spherical roller thrust type bearing for pump thrust loads and a spherical roller bearing for radial loads; or a single combination radial and thrust, self-aligning, spherical roller bearing.

2.5.5.3 Seals

Two seals shall be provided for protection of the upper bearings. One seal shall be attached to the extended shaft of the spiral screw to prevent contamination from entering the bearing top side. The other seal shall be on the bottom side to retain the grease within the bearing.

2.5.5.4 Mounting Plate

A fabricated steel mounting plate and anchor bolts shall be provided for mounting the upper bearing assembly.

2.5.5.5 Cover

A fabricated steel cover shall be provided to close the opening in the wall for the spiral shaft.

2.5.6 Drive Assembly

The drive assembly shall consist of a motor, gear reducer, and backstop.

2.5.6.1 Gear Reducer

The gear reducer shall have the torque rating for the spiral speed based upon continuous operation with a uniform load. The gear reducer shall have an outer cast iron housing, totally enclosed and rigidly constructed to maintain precise alignment of the gears and bearings. The gear reducer shall be designed with a service factor of not less than [_____] based on the torque requirements of the screw or [_____] based on the motor horsepower, whichever is greater. Gears and bearings shall be splash lubricated or, if necessary, pressure lubricated to ensure oil is provided to all gears and bearings. Shaft-mounted gear reducers shall be positively secured to the screw shaft and shall have a torque arm anchored to the floor. Double lip oil seals shall be provided on the shaft. Non-shaft-mounted gear reducers shall be provided with an adjustable base and shall be connected to the screw shaft by a flexible coupling.

2.5.6.2 Backstop

A backstop shall be provided to prevent the reverse rotation of the spiral screw and drive assembly when the power to the motor is disconnected.

2.5.6.3 Drive

The gear reducer shall be connected to the drive motor by means of belts and sheaves designed with the same service factor as the gear reducer. A safety cover shall be provided for the belt drive.

2.5.7 Lubrication System

An automatic grease lubricator with grease pump and reservoir shall be provided to continuously grease the lower bearing when the pump is operating. The grease pump shall have a [_____] hp, [_____] volts ac, [_____] phase, [60] [_____] Hz motor. The grease pump shall be interlocked with the screw pump motor to prevent the screw pump from operating if the lubricator malfunctions. A visual or automatic indicator shall be provided to confirm that the lower bearing is receiving grease from the lubrication system.

2.5.8 Radius Screed

Provide a radius screed and any additional sheaves and belts as necessary to adjust screw speed to enable the installation of the grout in the trough with the screw installed.

2.6 PLUNGER PUMPS

Plunger pumps shall be of the positive displacement type designed to pump sewage sludges with a minimum amount of clogging.

2.6.1 Pump Characteristics

Pump number[s] [_____] located in [_____] shall have the following operating characteristics:

Pump Service	[_____]
Design Capacity	[_____] gpm
Design Head	[_____] feet
Suction Lift	[_____] feet
Stroke Speed	[_____] strokes per minute
Pump Type	[simplex] [duplex] [triplex] [quadraplex]
Motor Type	[_____]
Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm

Pump Control	[_____]

2.6.2 Pump Base

A common, welded steel, drip-rim base with a 1-inch threaded drain connection shall be provided for the pump and motor. The base shall be of heavy section, fully braced to withstand all shock loads and to resist buckling when properly anchored.

2.6.3 Pump Body

The pump body shall be cast iron. The pump shall be of heavy construction, designed to handle its maximum rated capacity and head on a continuous duty basis and shall be hydrostatically tested at 1.5 times the maximum rated head of the pump. The pump body shall be of sectional construction so that the stuffing box, valve bodies, and air chamber adapters are independently removable. The construction shall permit removal of the stuffing box, plunger, and connecting rod without disturbing the body, valve chambers, manifolds, piping, or shaft.

2.6.4 Valves

Valve chambers shall be provided on both the inlet and discharge connections of each cylinder. The valve chambers shall be constructed with contoured interiors to minimize clogging. Valves shall be ball type, at least 5-1/8 inches in diameter, and constructed of neoprene. Valve seats shall be independent, fully machined plates which may be replaced without disturbing valve bodies or piping.

2.6.5 Connecting Rod, Eccentric, Eccentric Bearings, and Shaft

The connecting rod and eccentric strap assembly shall be cast as one piece and shall have a quality hot-poured Babbitt lining. The eccentric, bearings, and shaft shall be designed to handle the stresses and deflections imposed upon it by the specified service. [The shaft shall be offset from the vertical centerline of the cylinder by an amount appropriate to the cylinder diameter to reduce lateral thrust on the cylinder during the discharge stroke.]

2.6.6 Plungers

Plungers shall be ductile iron and shall have a plugged drain hole in the bottom which shall be accessible through the top of the plunger.

2.6.7 Cylinders

Cylinders shall be machined to a smooth bore to provide a uniform surface throughout the full travel of the plunger.

2.6.8 Stuffing Box

The cylinder and plunger shall have an effective packing arrangement to provide lubrication for the plunger and maintain the most effective vacuum. The stuffing box shall be of heavy cast construction and shall be provided with a circular drain lip and 1 inch threaded drain connection. The stuffing box shall be provided with a minimum of four rings of [_____] packing.

2.6.9 Air Chambers

Air chambers shall be provided on [the discharge side] [both suction and discharge sides] of the pump. Air chambers shall have a minimum capacity of 1800 cubic inches and a minimum 3 inch diameter opening.

2.6.10 Sampling Valve

A 2 inch sampling valve shall be provided on the discharge side of the pump.

2.6.11 Pressure Relief Valve

A pressure relief valve shall be provided with a bypass line from the main suction and discharge manifolds. The valve shall be factory set to prevent motor overload or pump damage.

2.6.12 Lubrication

Each pump eccentric shall be provided with a sight-feed oil lubricator.

2.6.13 Chain Drive

Capacity variations shall be provided by stroke adjustment accomplished at each eccentric assembly, through the use of eccentric flanges coupled to the eccentric body. Overall drive reduction shall be obtained through the combination of a gearhead motor and silent roller chain. Motor gearhead shall be totally enclosed and running in oil. Chain capacity shall be at least 150 percent of the chain manufacturers published horsepower rating. The entire chain drive assembly shall be completely enclosed in a sealed lip, dust resistant steel guard.

2.6.14 V-Belt and Integral Gear Drive

Capacity variations shall be provided by stroke adjustment accomplished at each eccentric assembly, through the use of eccentric flanges coupled to the eccentric body. Overall drive reduction shall be obtained through a combination of gears and V-belts. Gears shall run in an oil bath contained in an oil-tight cast iron or aluminum enclosure. The gear reduction design, gear materials and face widths, shafting, and bearings shall be selected for the specified operating conditions. The entire V-Belt drive assembly shall be covered by a rigid safety guard.

2.6.15 Gear Reducer Drive

Capacity variations shall be provided by pump speed change only. The low speed shaft of the reducer shall be directly connected to the main shaft of the pump through a flexible coupling with shear pin protection. The shear pin overload protection shall be designed for release at 150 percent to 175 percent of normal torque. The high speed shaft of the reducer shall be connected to the motor by a heavy duty flexible coupling. The entire gear reduction unit shall be enclosed in a dustproof and oil-tight housing.

2.7 PROGRESSIVE CAVITY PUMPS

Progressive cavity pumps shall consist of a single helical rotor rotating in a double helical stator.

2.7.1 Pump Characteristics

Pump number[s] [_____] located in [_____] shall have the following operating characteristics:

Pump Service	[_____]
Design Capacity	[_____] gpm
Operating Head	[_____] feet
Operating Speed	[_____] rpm
[Single] [Double] stage	
Motor Type	[_____]
Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm
Pump Control	[_____]

2.7.2 Casing

[The pump body shall be cradle mounted such that the suction chamber can be rotated to allow the suction port to accommodate any piping configuration.] Two inspection ports shall be incorporated 180 degrees apart in the suction housing to provide access to internal parts. A drain plug shall be provided in the casing.

2.7.3 Rotor

The pump rotor shall be a helix constructed of machined and polished [high quality tool steel] [stainless steel] [and shall be covered with a layer of hard chrome plate].

2.7.4 Stator

The rotor shall revolve in a helix elastomeric stator consisting of Buna-N chemically bonded to a steel tube.

2.7.5 Drive Shaft and Connecting Rod

The rotor shall be driven by a connecting rod between the rotor and drive shaft, connected at each end with a crowned gear [or pin or cardan] type universal joint. The universal joints shall be of adequate design to transmit the required thrust and torque. The connecting rod and universal joint in combination shall impart no thrust on the seal. Universal joints shall be [grease] [_____] lubricated and totally sealed and shielded. The seal shall prevent liquid from contaminating the joints, and the shields shall prevent foreign objects from damaging the seal.

2.7.6 Flexible Drive Shaft

The rotor shall be driven by a one-piece, flexible, high strength spring steel drive shaft with a corrosion and abrasion-resistant thermoplastic coating.

2.7.7 Seals

Pump seals shall be a stuffing box with a split packing gland and lantern ring or shall be a mechanical seal. Fittings for [grease] [water] lubrication shall be provided.

2.7.8 Bearings

Bearings shall be designed for an ABEMA L-10 life of at least 50,000 hours minimum, as specified in ABMA 9 or ABMA 11, and shall be grease lubricated. Lubrication fittings in the bearing housing shall be provided.

2.8 DIAPHRAGM PUMPS

Diaphragm pumps shall be of the self-priming, positive displacement type designed to pump sludge of various concentrations and levels of abrasiveness. The pump shall be designed such that operating the pump without liquid in the pump casing will not damage any portion of the pump.

2.8.1 Pump Characteristics

Pump number[s] [_____] located in [_____] shall have the following operating characteristics:

Pump Service	[_____]
Operator	[mechanical] [air]
Design Head	[_____] feet
Peak Capacity	[_____] gpm flow
Total Dynamic Head	[_____] feet
Suction and Discharge Check Valve Size	[_____] inches
Pump Speed	[_____] strokes per minute
Motor Type	[_____]
Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm

Pump Control	[_____]

2.8.2 Casing

All interior wetted parts shall be lined with [1/4 inch thick chlorosulfonated polyethylene]. The pump body shall be designed to permit access to the casing interior without disassembling the suction and discharge piping.

2.8.3 Suction and Discharge Check Valves

The suction and discharge check valves shall be of the [quick opening ball check type,] [in-line ball check type,] [or] [in-line flap check type]. [Quick-opening ball check valves shall have replaceable [stainless steel,] [bronze,] [or] [cast iron] seats and an easily removable cover plate to permit inspection and cleaning of the valve interior without disassembling the adjacent piping.] [In-line ball check valves shall have a streamlined internal design, eliminating projections on which material can collect.] [In-line flap check valves shall have an elastomeric seal on the disc to insure sealing and shall have a removable cover to permit inspection and cleaning of the valve interior without disassembling the adjacent piping.]

2.8.4 Pulsation Dampers

An air chamber type pulsation damper shall be provided on the pump [inlet] [and] [discharge].

2.8.5 Air-Operated Actuators

A complete air operated actuator shall be provided, with all accessories required for proper operation, including the following:

2.8.5.1 Valve

A three-way solenoid valve on the air supply line. The valve shall operate on a signal from the flow control timer.

2.8.5.2 Timer

An adjustable solid state flow control timer to control pump stroke rate and length. Stroke rate shall be adjustable from 0 to [40] [_____] strokes per minute. Stroke length shall be adjustable from [0.75] [_____] to [1.25] [_____] seconds.

2.8.5.3 Muffler

An air exhaust muffler to ensure quiet operation.

2.8.5.4 Pressure Regulator

An air pressure regulator to maintain a constant air supply pressure to the pumping system. The air pressure regulator shall be field adjustable from [_____] to [_____] psi.

2.8.5.5 Strainer

An air supply strainer to remove particles larger than [_____] microns from the air supply. The strainer shall have a removable cover to permit cleaning without dismantling adjacent piping.

2.8.5.6 Assist

Spring assist or air cylinder assist as required for adequate suction lift.

2.8.6 Mechanical Actuators

The mechanical actuator shall consist of an electric motor and [gear reducer] [belt drive] connected to the diaphragm by a connecting rod and eccentric.

2.9 RECESSED IMPELLER PUMPS

Recessed impeller pumps shall be of the vortex type designed to handle fluids containing solids, air, and stringy material normally found in sewage. Pumps shall be designed to pump solids up to 3 inches in diameter.

2.9.1 Pump Characteristics

Pump number[s] [_____] located in [_____] shall have the following operating characteristics:

Pump Service	[_____]
Design Operating Point	[_____] gpm flow at [_____] feet head
Maximum Operating Point	[_____] gpm flow at [_____] feet head
Minimum Operating Point	[_____] gpm flow at [_____] feet head
Discharge Diameter	[_____] feet
Suction Diameter	[_____] feet
Operating Speed	[_____] rpm
Maximum NPSH Required at Maximum Operating Point	[_____]
Seal Type	[packing] [mechanical]
Motor Type	[_____]
Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm
Pump Control	[_____]

2.9.2 Pump Casing

Pump casing shall be constructed with tapped and plugged holes for priming, venting, and drainage of the pump. The casing shall be capable of withstanding pressures 50 percent greater than the maximum operating pressure. All internal casing clearances shall be equal to the discharge nozzle diameter so that all material that can pass through the discharge nozzle can pass through the casing. Casing connections shall be flanged.

2.9.3 Impeller

The impeller shall be of the recessed design. The impeller shall be securely keyed to the shaft with a locking arrangement whereby the impeller cannot be loosened from either forward or reverse direction.

2.9.4 Pump Shaft

Pump shaft shall be of [high grade alloy steel] [or] [stainless steel] and shall be sized to provide a minimum amount of deflection.

2.9.5 Sleeve

The pump shaft shall be protected throughout the packing area by a removable [stainless steel] [or] [bronze] sleeve.

2.9.6 Seals

A stuffing box, designed for the interchangeable use of packing or mechanical seals, and suitable for use of grease, oil, or water as the sealing liquid, shall be provided.

2.9.6.1 Packing

The stuffing box shall be designed to accommodate a minimum of [_____] rings of [graphite] [oil] impregnated [nonasbestos] [metallic] packing with lantern ring and packing gland. Packing shall be readily removable from the shaft.

2.9.6.2 Mechanical Seals

Mechanical seals shall be of the [single] [double] type of [carbon-ceramic] [tungsten carbide] construction. Each seal interface shall be held in place by its own [stainless steel] spring system. The seal system shall be constructed to be readily removable from the shaft.

2.9.7 Bearings

Pump bearings shall be antifriction ball or roller type bearings designed to carry all radial or thrust loads. Bearings shall be [grease] [oil] lubricated and shall be contained in dust- and moisture-proof housings. [An oil reservoir with overflow and drain openings shall be provided.] [A grease fitting of the type that prevents overlubrication shall be provided. If the grease fitting is not readily accessible, an extension tube shall be provided.]

2.10 ROTARY LOBE PUMPS

Rotary lobe pumps shall be of the positive displacement type and shall consist of two tri-lobe rotors which draw product into pockets formed between the rotors and rotor case and push pumped material 180 degrees around the interior of the contoured rotor case and out through the discharge port.

2.10.1 Pump Characteristics

Pump number[s] located in [_____] shall have the following characteristics:

Pump Service	[_____]
Design Capacity	[_____] to [_____] gpm
Operating Head	[_____] feet maximum to [_____] feet minimum
Operating Speed	[_____] rpm
Discharge Diameter	[_____] feet
Suction Diameter	[_____] feet
Motor Type	[_____]
Electrical Characteristics	[_____] volts ac, [_____] phase, [60] [_____] Hz
Size	Within rated load driving pump at specified rpm
Pump Control	[_____]

2.10.2 Casing

Rotor casing shall be constructed of [ductile iron] [cast iron]. The gear casing shall be constructed of cast iron. A removable end cover shall allow access to tri-rotor elements without need to disturb packing glands, bearings, suction, or discharge connections.

2.10.3 Rotors

Pump rotors shall be tri-lobe form [profile machined in cast iron] [high quality tool steel encapsulated in urethane] [stainless steel]. A removable and replaceable wear plate shall be provided between the rotors and rotor case to protect the rotor case from wear. Rotors shall be located on shafts by positive locking assembly.

2.10.4 Shafts and Sleeves

Shafts shall be of [high grade alloy steel] [_____] fitted with replaceable stainless shaft sleeves where passing through gland area. Shafts shall be timed in their rotation by zero backlash timing gears keyed to shafts and running in a separate oil chamber gear case. Seals shall prevent ingress of pumped material into gear case.

2.10.5 Packing Glands

Seals shall be of adjustable packing gland type. Stuffing box glands shall be provided with split lantern rings for through water flush.

2.10.6 Bearings

Pump shall have heavy duty antifriction roller or ball type bearings for shaft support, with a ABEMA L-10 life of [40,000] [100,000] hours at maximum operating conditions. Oil seals shall prevent ingress of pumpage into gear case. A slinger for each shaft shall be provided.

2.11 ELECTRICAL WORK

Provide electrical motor driven equipment specified complete with motors, motor starters, controls and wiring in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics shall be as specified or indicated. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control specified. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices but not shown, shall be provided.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 EQUIPMENT INSTALLATION

Submit Drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show on the Drawings proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

3.2.1 Pump Installation

Install pumping equipment and appurtenances in the position indicated and in accordance with the manufacturer's written instructions. Provide all appurtenances required for a complete and operating pumping system, including such items as piping, conduit, valves, wall sleeves, wall pipes, concrete foundations, anchors, grouting, pumps, drivers, power supply, seal water units, and controls.

3.2.2 Concrete

Concrete shall conform to Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.3 Grouting Screw Pump Flow Channel

After installation and adjustment of the screw pump, place grout in the flow channel to the configuration and dimensions indicated and as required to insure a proper fit between the screw pump and flow channel. A radius screed provided by the pump manufacturer shall be temporarily attached to provide proper clearance between the screw and the flow channel. The flow channel shall be grouted in strict accordance with the manufacturer's instructions.

3.3 PAINTING

Pumps and motors shall be thoroughly cleaned, primed, and given two finish coats of paint at the factory in accordance with the recommendations of the manufacturer. Field painting required for ferrous surfaces not finished at the factory is specified in Section 09 90 00 PAINTS AND COATINGS.

3.4 FRAMED INSTRUCTIONS

Post, where directed, framed instructions containing wiring and control diagrams under glass or in laminated plastic. Condensed operating instructions, prepared in typed form, shall be framed as specified above and posted beside the diagrams. Post the framed instructions before acceptance testing of the system. Submit pump characteristic curves showing capacity in gpm, net positive suction head (NPSH), head, efficiency, and pumping horsepower from 0 gpm to 110 percent (100 percent for positive displacement pumps) of design capacity. Submit a complete list of equipment and material, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Diagrams, instructions, and other sheets proposed for posting.

3.5 FIELD TESTING AND ADJUSTING EQUIPMENT

3.5.1 Operational Test

Prior to acceptance, an operational test of all pumps, drivers, and control systems shall be performed to determine if the installed equipment meets the purpose and intent of the specifications. Tests shall demonstrate that the equipment is not electrically, mechanically, structurally, or otherwise defective; is in safe and satisfactory operating condition; and conforms with the specified operating characteristics. Prior to applying electrical power to any motor driven equipment, the drive train shall be rotated by hand to demonstrate free operation of all mechanical parts. Tests shall include checks for excessive vibration, leaks in all piping and seals, correct operation of control systems and equipment, proper alignment, excessive noise levels, and power consumption.

3.5.2 Retesting

If any deficiencies are revealed during any test, such deficiencies shall be corrected and the tests shall be reconducted.

3.5.3 Performance Test Reports

Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. In each test report indicate the final position of controls.

3.6 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installation, adjustment, and testing of the equipment.

3.7 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members. Training shall be provided for a total period of [_____] hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. Field training shall cover all of the items contained in the operating and maintenance manuals. Submit [six] [_____] copies of operation and [six] [_____] copies of maintenance manuals for the equipment furnished. One complete set prior to performance testing and the remainder upon acceptance. Operation manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Include in the operation manuals the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include piping and equipment layout and simplified wiring and control diagrams of the system as installed. Manuals shall be approved prior to the field training course.

-- End of Section --

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SECTION 22 13 36

PNEUMATIC SEWAGE EJECTORS
02/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

CAGI B19.1	(2010) Safety Standard for Compressor Systems

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PS 11.01	(1982; E 2004) Black (or Dark Red) Coal Tar Epoxy Polyamide Painting System

1.2 SUMMARY

Provide sewage ejectors of the duplex pneumatic type complete with [receivers,] [receivers and compressors,] electric motors, control equipment, piping, and all necessary accessories. Capacities of all equipment and materials less than those specified or indicated are not acceptable. Ejector must be able to pass through maximum sphere size of [2-1/2] [3] [4] [_____] inch diameter.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Equipment Installation

SD-03 Product Data

Materials and Equipment

Sewage Receiver

Air Compressor

Air Reservoir

Electric Motor

Controls

Spare Parts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, excessive humidity and excessive temperature variation; and dirt, dust, or other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified and include a complete list of parts and supplies, with current unit prices and source of supply. Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment.

PART 2 PRODUCTS

2.1 GENERAL MATERIAL AND EQUIPMENT REQUIREMENTS

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and tat essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Provide equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Submit data consisting of manufacturer's descriptive and technical literature, catalog cuts, performance charts and curves, and installation instructions

2.1.2 Nameplates

For each major item of equipment, provide the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Protection from Moving Parts

Fully enclose or guard belts, pulleys, chains, couplings, projecting setscrews, keys, and other rotating parts located so that any person can come in close proximity thereto.

2.2 MATERIALS AND EQUIPMENT

Provide materials and equipment conforming to the following requirements:

2.2.1 Check Valves

Provide check valves conforming to MSS SP-80, Type 3 or 4, Class 125, except provide valves on the discharge side of the receivers with replaceable valve seats.

2.2.2 Cast Iron Gate Valves

Provide cast iron gate valves conforming to MSS SP-70, Type I, II, or III, Class 125, threaded or flanged ends.

2.2.3 Bronze Gate Valves

Provide bronze gate valves conforming to MSS SP-80, Type 1, Class 125.

2.2.4 Motor Controls

Provide motor controls conforming to NEMA ICS 2.

2.2.5 Cast Iron Pipe

Provide cast iron pipe conforming to AWWA C115/A21.15, Class 150, as applicable to pipe barrel only; ASME B16.1, Class 125, for pipe flange.

2.2.6 Steel Pipe

Provide steel pipe conforming to ASTM A53/A53M, standard weight, zinc coated.

2.2.7 Cast Iron Pipe Fittings

Provide cast iron pipe fittings conforming to ASME B16.1.

2.2.8 Malleable Iron Fittings

Provide malleable iron fittings conforming to ASME B16.3.

2.2.9 Malleable Iron Unions

Provide malleable iron unions conforming to ASME B16.39, Type B.

2.2.10 Pipe Hangers and Supports

Provide pipe hangers and supports conforming to MSS SP-58, Type [_____] hanger, Type [_____] supports.

2.2.11 Bolts, Nuts, Anchors, and Washers

Furnish steel galvanized bolts, nuts, anchors, washers, and all other types of support necessary for the installation of the equipment according to ASTM A153/A153M.

2.3 SEWAGE RECEIVER

Furnish sewage receiver consisting of cast iron or welded steel construction conforming to ASME BPVC SEC VIII D1. Provide flanged sewage inflow and outflow pipe connections; provide screwed air-supply and vent-piping connections. Provide pipe threads conforming to ASME B1.20.1, and pipe flanges conforming to ASME B16.1. Design receiver for a working pressure of [_____] psi and tested at a pressure 50 percent greater than the working pressure. Provide receiver with suitable support and a manhole or handhole conveniently located. Coat steel receiver [inside] [inside and outside] with coal tar primer and enamel conforming to the requirements of AWWA C203 in all respects of material and application, or coat with a coal-tar epoxy paint system conforming to the requirements of SSPC PS 11.01. The interior walls of the receiver and inflow and outflow openings, approaches and fittings must be free from any obstructions that might interfere with the free passage of raw unscreened sewage. Provide ejector unit with sufficient capacity for the discharge of sanitary sewage under the conditions of rate of flow, static head, and friction loss. As used herein, rate of flow is the continuous rate of flow into the ejector station; static head is the difference between the invert elevations of the inlet sewer to the ejector station and the force main at the point of final discharge; and friction loss is computed on the basis of the indicated continuous rate of flow.

2.4 AIR COMPRESSOR

Supply air to the sewage receivers by air compressors of capacities indicated to supply air to operate the ejectors. Equip each compressor with suction silencer, complete automatic lubrication system, an air filter, and means for cooling. Design compressors for operation without water seal or any water connection. The air compressor must conform to CAGI B19.1. Air compressor unit must be a factory packaged assembly. Provide each duplex compressor system with [automatic alternation system] [manual alternation system].

2.5 AIR RESERVOIR

If the equipment furnished requires a compressed-air reservoir for proper operation, construct the tank in conformance with ASME BPVC SEC VIII D1, with flanged or screwed inlet and outlet connections as required. Provide a display of the ASME seal on the receiver or a certified test report from an approved independent testing laboratory indicating compliance. Design storage tank for a working pressure of [_____] psi and tested at a pressure 50 percent greater than the working pressure. Fit the tank with a pressure gauge, [manhole,] [inspection openings,] blowoff cock, and a safety valve set at [_____] psi. Provide the connection to the compressor with a check valve and a shutoff valve.

2.6 ELECTRIC MOTOR

Provide electric motor conforming to NEMA MG 1 and suitable for operation of [_____]-volt [_____]-Hz [_____]-phase alternating current. Provide [open] [dripproof] [totally enclosed] [explosion proof] motor frames. Base temperature rise on minus 40 degrees F ambient temperature.

2.7 CONTROLS

Provide an automatic-control system for each ejector. Provide controls consisting of suitable devices for regulating the cycle of each sewage receiver and each compressor. Provide valves and accessories as required to control the flow of air to the sewage receiver, to exhaust the residual air, and to vent the receiver to the outside. Provide pressure switches to control the operation of each compressor on the air reservoir. Enclose automatic controls in a NEMA 250, [Type 12] [Type 3R] [Type 4] panel, wire completely, and test with internal connections being made on terminal blocks. Provide factory preconnected sensor, motor control, and motor. Provide local or remote alarm signaling as required. Provide an air operated automatic valve between air compressor and ejector to control admission and relief of air to and from ejector, and to prevent waste materials or gases from entering compressor. Control the ejection cycle by a fully transistorized solid-state electronic liquid level control device, which activates the compressor motor. Provide liquid level control device to sense liquid level by use of a stainless steel probe mounted in the receiver. The ejection cycle must be adjustable from [_____] to [_____] seconds by an integral adjustable timer. Include manual-off-automatic three-way switch.

2.8 ELECTRICAL WORK

Provide electric motor driven equipment specified complete with motor, motor starter, wiring, and controls in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics are as indicated. Provide motor starters complete with properly sized thermal overload protection and other appurtenances necessary for the motor control specified. Furnish starters in [general purpose] [watertight] [explosion-proof, Class I, Division 1] enclosures. Provide motors of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating on the motor. Provide manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices.

2.9 FACTORY PAINTING

Thoroughly clean and prime equipment, and give two finish coats of paint at the factory in accordance with the recommendations of the manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 PIPING INSTALLATION

Provide flanged cast iron sewage influent and effluent lines. Provide steel air piping with malleable iron unions and fittings.

3.2.1 Cast Iron Pipe Joints

Wipe flanges of the pipe clean, and push the sections together evenly after a cloth-reinforced rubber gasket, as furnished by the manufacturer, has been placed between the flanges. Loosely assemble bolts and nuts by hand and then tightened evenly with a wrench of the type and length recommended by the manufacturer. Turn opposite nuts alternately to avoid damage from excessive tightening.

3.2.2 Steel Pipe Joints

Install steel pipe with sufficient unions to facilitate maintenance and removal of pipe and fittings. After cutting and before threading, ream pipe. Full cut threads, and do not expose no more than three threads on the pipe after assembly. Make joints tight with a stiff mixture of graphite and oil, or an inert filler and oil, or an approved thread lubricant, applied with a brush to the male threads only. Caulking of threaded joints will not be permitted.

3.2.3 Pipe Hangers and Supports

Use pipe hangers and supports on all pipe runs longer than 10 feet. Space pipe hangers and supports no more than 10 feet. Support horizontal pipe near fittings at each change in direction of piping and no more than 5 feet apart at valves. Support vertical piping at base, at intervals no more than 15 feet and at terminations.

3.3 VALVE INSTALLATION

Install bronze valves with screwed ends in the steel pipeline, and install valves with bronze-mounted iron bodies with flanged ends in the cast-iron pipeline. Cast the year of manufacture cast in the body of each valve. Remove and replace, at no additional cost to the Government, any valve that does not seat tightly or does not operate satisfactorily.

3.3.1 Gate Valves

Open gate valves by turning counterclockwise. The operating nut must have an arrow cast in the metal, indicating the direction of opening. Before the valve is installed, tighten the stuffing boxes and operate the valve to see that all parts are in working condition.

3.3.2 Check Valves

Provide check valves with freely operating, positively seating flaps, and easily removable covers.

3.4 EQUIPMENT INSTALLATION

Submit drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function as a unit. Show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Unless otherwise indicated, install all equipment in accordance with manufacturer's recommendations. Installation of the air [compressor] [compressor and air reservoir] must conform to CAGI B19.1.

3.5 FIELD PAINTING

Field painting, required for ferrous surfaces not furnished at the factory, is specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 CONCRETE FOUNDATIONS

Provide concrete for foundation as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide concrete foundations that are integral with and of the same class as the building floor unless otherwise indicated. Use Class B concrete in foundations that are entirely separated from the surrounding floor. When new foundations are constructed on existing concrete, bond the new concrete to the old as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide foundation bolts as required for positioning during the placement of the concrete.

3.7 TESTS

Either furnish the manufacturer's report of ejector capacity determined by shop tests or make such tests as may be necessary to determine the capacity, and perform such other tests as will ensure that the ejectors have been installed in accordance with the specifications.

3.8 MANUFACTURER'S FIELD SERVICES

Provide services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. Supervise the installation, adjustment, and testing of the equipment in accordance with the approved Operation and Maintenance Manuals. Submit [6] [_____] copies of operation and [6] [_____] copies of maintenance manuals as required for the equipment furnished. Furnish one complete set prior to performance testing and furnish the remainder upon acceptance. Manuals must be approved prior to the field training course. Detail the step-by-step procedures required for system start-up, operation, and shut-down. Include the manufacturer's name, model number, parts list, and a brief description of all equipment and their basic operating features. List routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include include piping and equipment layout and simplified wiring and control diagrams of the system as installed.

-- End of Section --

SECTION 22 14 29.00 40

SUMP PUMPS
05/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

HYDRAULIC INSTITUTE (HI)

HI M100	(2009) HI Pump Standards Set

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003; R 2008) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Connection Diagrams; G

Control Diagrams; G

Installation Drawings; G

SD-03 Product Data

Manufacturer's Catalog Data; G

Pump Performance Curve; G

Spare Parts List; G

Special Tools; G

Wet-Pit Sump Pumps; G

Submersible Pumps; G

Accessories; G

Floatless Electrode Level Controls; G

SD-06 Test Reports

Hydrostatic Leak; G

Static Heads; G

Pump Flow Capacity; G

SD-07 Certificates

Manufacturer's Certification of Bearing Life

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions

Vibration Specifications

1.3 QUALITY CONTROL

1.3.1 Predictive Testing and Inspection Technology Requirements

This section addresses systems or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure that the building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect the pump for damage or other distress when received at the project site. Store the pump and associated equipment indoors as recommended by the pump manufacturer, protected from construction or weather hazards at the project site. Before installation, provide adequate short-term storage for the pump and equipment in a covered, dry, and ventilated location. Follow the manufacturer's instructions for extended storage.

PART 2 PRODUCTS

Provide a pump and motor with vibration levels conforming to ISO 1940-1 unless otherwise noted. Ensure that motor vibration levels conform to NEMA MG 1, Motors and Generators, Part 7, unless otherwise noted.

2.1 SYSTEM DESCRIPTION

Show details of connection of cables and pump motors on connection diagrams for sump pumps.

Submit control diagrams for sump pumps showing motor starters, relays, or any other component necessary for safe operation.

Ensure that installation drawings for sump pumps are in accordance with the manufacturer's recommended instructions.

Submit manufacturer's catalog data for sump pumps showing the sump pump size, type, and efficiency rating along with performance data, including pump performance curve, indicating brake horsepower, head, flow rate, and NPSH (net positive suction head). Also include equipment foundation data and equipment data.

Provide manufacturer's installation instructions and vibration specifications.

2.2 EQUIPMENT

2.2.1 Wet-Pit Sump Pumps

Provide a pump with duty conditions as]follows: .

Construct and furnish pumps in accordance with the applicable requirements of HI M100 standards and those specified herein.

Include with the simplex pump unit a vertical, submerged, volute, centrifugal pump mounted below a coverplate; a vertical, flexible-connected, solid-shaft motor; a motor and bearing support housing attached to the coverplate; pump support and shaft housing pipe; discharge pipe; and automatic controls.

Include with the duplex pump unit two individual, vertical, submerged, volute, centrifugal pumps mounted below a coverplate; vertical, flexible-connected, solid-shaft motors; motor and bearing support housing attached to the coverplate; pump support and shaft housing pipes; discharge pipes; and automatic controls. Design the installation of the unit to permit removal of one pump assembly without disturbing the operation of the other.

Ensure that requirements for each material designation are in accordance with the applicable definition listed in the centrifugal pump section of HI M100 standards. Ensure that materials for components and accessories not covered by these definitions are as specified herein.

Avoid contact between dissimilar metals. Where such contact cannot be avoided, protect joints between dissimilar metals against galvanic corrosion by plating, organic-insulation coatings, gaskets, or other suitable means.

2.2.1.1 Pump Selection

Where parallel pump operation is indicated, select pumps with characteristics specifically suited for the service, without unstable operation.

Provide a pump unit that delivers, at rated speed, not less than the specified gallons per minute against the specified or indicated discharge head while the liquid level is not more than 1 foot above the datum elevation of the pump. Use the level of the entrance eye of the impeller as the datum elevation. Include in the calculations of the discharge head both the friction head of the system piping external to the pump unit and the static head measured from a point of reference on the sump to the highest point in the system. Base ratings on pumping clear, fresh water at a temperature of 68 degrees F.

2.2.1.2 Pump Casing

Provide cast-iron pump casing. Provide a volute and discharge nozzle of the pump casing cast as one piece. Construct the casing with a bolted plate to permit inspection and removal of the impeller. Ensure that the casing can withstand a hydrostatic pressure of not less than 1-1/2 times the design shutoff head of the pump.

2.2.1.3 Impeller

Provide a cast-iron or bronze impeller, enclosed or semi-open, with vanes on the back shroud. Refer to paragraph BEARINGS AND LUBRICATION for additional requirements. Ensure that the impeller is dynamically balanced.

2.2.1.4 Strainer

Protect the intake with a large cast-iron, slotted intake strainer with an effective free area sufficient to prevent cavitation and degradation of efficiency. Ensure that the strainer has a free area of at least four times the cross-sectional area of the suction casing.

2.2.1.5 Pump Shaft

Construct the pump shaft of ground and polished AISI Type 304 or 316 corrosion-resistant steel with hardened wearing surfaces at intermediate shaft-bearing locations. Hardened surfaces may be overlays of 500 Brinell, Deloro Stellite, Wall Colmonoy, or similar proprietary metals, or plasma-spray-applied ceramic materials of not less than 900 Brinell hardness.

Provide a means for external adjustment of the clearance between the impeller and the inner surfaces of the volute section.

2.2.1.6 Bearings and Lubrication

Furnish one or more antifriction ball- or roller-bearings in the motor and bearing support housing above the coverplate surface, with full provision for the mechanical and hydraulic radial and thrust loads imposed. Provide sealed and grease-lubricated bearings that have an L-10 rating of at least 80,000 hours in accordance with ABMA 9 or ABMA 11. Ensure that the shop drawings bear the manufacturer's certification of bearing life. Provide bearings manufactured from vacuum-processed or degassed-alloy steels.

Provide sleeve-type intermediate shaft bearings. Ensure that the center distance between any two bearings on the shaft does not exceed 4-1/2 feet for pumps operating between 1,700 and 1,800 revolutions per minute (rpm) or 5 feet for pumps operating at 1,200 rpm or less. Provide a sleeve bearing at least two times the shaft diameter and locate the bearing near the lower extremity of the shaft.

Provide heavy-duty bronze or bronze-backed, babbitt-lined sleeve bearings. Provide appropriate nonferrous piping and fittings to permit individual lubrication of the intermediate and lower bearings from above the sump coverplate. Provide a means to prevent the pumped fluid from entering the lower bearing. Include a suitable seal or a system wherein a partial vacuum developed below the bearing by the impeller rotation induces a positive flow of lubricant into the bearing. Fit bearings with a centralized grease lubricator that is manually or electrically operated from a single point.

Provide heavy-duty bronze- or corrosion-resistant steel-backed cutless-rubber sleeve bearings.

Provide heavy-duty bronze- or corrosion-resistant steel-backed cutless-rubber sleeve bearings with nonferrous piping and fittings provided for individual flushing of intermediate and lower bearings.

2.2.1.7 Potable Water

Supply potable water through a piping system containing a pressure regulator, a solenoid, and a backflow preventer. Provide plastic, nonmetallic composition, elastomer, or nonferrous metal for all wetted components.

2.2.1.8 Flexible Couplings

Connect the pump shaft to the motor shaft through a flexible coupling. Provide a tire shape or a solid-mass, serrated-edge, flexible disk-shaped member made of chloroprene material and retained by fixed flanges. Provide a flexible coupling that acts as a dielectric connector, that does not transmit vibration or end thrust, and that permits up to 4-degree misalignment under normal duty.

2.2.1.9 Support Pipe

Provide a wrought-iron or steel support pipe concentric with the pump shaft that connects the pump to the sump coverplate. Provide support pipe flanges that are machined and doweled to ensure proper alignment of the pump and shaft whenever the pipe is disassembled and reassembled in the field.

2.2.1.10 Discharge Pipe

Furnish a discharge pipe running from the pump discharge outlet to the sump coverplate as an integral part of the pump unit. Arrange the discharge pipe to preclude discharge piping beyond the pump assembly from imposing loads that could cause shaft misalignment. Provide black steel or wrought-iron pipe, with wall thickness not less than that specified in ASTM A53/A53M for Schedule 40 pipe. Ensure that the discharge pipe is gastight through the sump coverplate. Ensure that the discharge end of the pipe terminates in a screwed or flanged connection in accordance with the manufacturer's standard practice.

2.2.1.11 Liquid-Level Control

Provide a simplex unit with a float mechanism to provide automatic operation of the pump unit when the liquid in the sump rises to a predetermined level. Provide a means of adjustment, such as a float-rod stop, to allow for variation in the start and stop level-control points. Provide an AISI Type 304 or 316 corrosion-resistant steel float and stem. For all other parts of the fluid-level-sensing mechanism below the coverplate, provide bronze, brass, or material of equivalent resistance to the corrosive effects of sewage.

Provide a duplex pump unit with the electrical and mechanical devices necessary to provide automatic operation of the pump unit when the liquid in the sump rises to a predetermined level. Ensure that controls automatically transfer the operating cycle from one pump to the other and operate both pumps simultaneously whenever the inflow to the sump exceeds the capacity of the operating pump. Provide a means of adjustment such as float-rod stops to allow for variations in the start and stop level-control points. Provide AISI Type 304 or 316 corrosion-resistant steel float and rod. For all other parts of the fluid-level-sensing mechanism below the coverplate, provide bronze, brass, or material of equivalent resistance to the corrosive effects of sewage.

Provide stilling tubes where indicated.

Floatless electrode level controls may be submitted for approval, provided that the electrodes are isolated from the fluid being sensed.

2.2.1.12 Sump Tank and Coverplate

Provide a cast-iron sump tank, strong enough to support the pumps without distortion and to safely support maintenance personnel.

a. Tank

Provide a cast-iron, sump tank sized to provide a clearance of 6 inches or one discharge pipe iron pipe size (ips) diameter, whichever is larger, between the bottom of the pump and the bottom of the tank.

Furnish a standard opening for connection to the sewage inflow pipe in the indicated size and location with respect to the top of the tank.

Protect the concrete interior surface of the sump tank by not less than a two-coat, two-component system of amine-cured coal-tar epoxy totaling 15 mils in thickness.

b. Coverplate

Provide gasketed openings through the sump tank coverplate, unless otherwise specified. Provide a 2-inch ips or larger threaded outlet to permit installation of a vent pipe. Ensure that the sump coverplate has a manholeorhandhole access to the tank.

2.2.2 Submersible Pumps

Construct and furnish pumps and accessories in accordance with the requirements of HI M100 standards and those specified herein.

Provide a simplex pump unit that includes a submersible pump with an automatic level-control mechanism mounted above water level.

Install an operating switch such that in case of failure, the operating switch does not require breaking of pump-motor seals for repairs.

Provide a duplex unit that includes float level controls for each submersible pump.

Ensure that requirements for each material designation are in accordance with the applicable definition listed in the centrifugal pump section of HI M100 standards.

Avoid contact between dissimilar metals. Where such contact cannot be avoided, protect joints between dissimilar metals against galvanic corrosion by plating, organic-insulation coatings, gaskets, or other suitable means.

2.2.2.1 Pump Selection

Provide a pump with duty conditions as indicated.

Ensure that pump seals, lubricant, and electrical insulation are suitable for service in liquids up to 140 degrees F.

2.2.2.2 Pump Housing

Provide a pump housing that encloses the pump motor and volute with its integrally cast feet. Provide a cast-iron pump housing that is watertight under all heads normal to the service, and constructed to permit inspection and repair. Furnish a volute designed to withstand a hydrostatic pressure of not less than 1-1/2 times the design shutoff head of the pump.

2.2.2.3 Impeller

Provide a dynamically balanced and totally enclosed bronze impeller.

Provide a cast-iron nonclogging impeller designed to provide maximum freedom from clogging when liquid-containing rags and stringy material is handled. Provide an impeller that is dynamically balanced and that has a minimum solid-sphere handling capability of 1-1/2 inches.

2.2.2.4 Pump Shaft

Provide a pump shaft that is an extension of the motor shaft and constructed of ground and polished AISI Type 300 or 400 series corrosion-resistant steel with hard-wearing surfaces (over 300 Brinell).

2.2.2.5 Mechanical Seal

Provide the manufacturer's standard mechanical pump shaft seal specifically constructed for the service duty temperature and resistance to pumped fluid.

2.2.2.6 Bearings and Lubrication

Furnish antifriction ball- or roller-bearings with full provision for the mechanical and hydraulic, radial, and thrust loads imposed. Seal and permanently grease- or oil-lubricate the bearings.

2.2.2.7 Motor and Power Cord

Provide a permanently sealed, oil-filled, and watertight motor of the manufacturer's standard construction for the service. Fit the motor space with watertight expansion provisions to accommodate the temperature normal to the specified duty. Ensure that the motor seals remain watertight under any pressure developed in the volute and under a sump-level static head of not less than 30 feet of water.

Ensure that circuits for three-phase motors provide overload protection.

Provide single-phase motors with automatic-reset thermal-overload protection.

Provide a waterproof, internally grounded, oil-resistant, Type SO chloroprene power cord, with a three-prong plug of the indicated length.

2.2.2.8 Liquid-Level Control

Furnish simplex units with a float-operated switch mechanism to ensure automatic operation of the pump unit when the liquid in the sump rises to a predetermined level. Provide a cover-mounted switch and Type 1, general-purpose enclosure in accordance with NEMA 250. Provide a means of adjustment such as float-rod stops to allow for variation in the start and stop level-control points. Provide an AISI Type 304 or 316 corrosion-resistant steel float and stem. Provide bronze, brass, or materials of equivalent resistance to the corrosive effects of the pumped fluid for all other wetted parts of the fluid-level sensing mechanism.

Furnish a duplex pump unit with the electrical and mechanical devices necessary to provide automatic operation of the pump unit when the liquid in the sump rises to a predetermined level. Provide controls that automatically transfer the operating cycle from one pump to the other and that operate both pumps simultaneously whenever the inflow to the sump exceeds the capacity of the operating pump. Provide a means of adjustment such as float-rod stops to allow for variations in the start and stop level-control points. Provide an AISI Type 304 or 316 corrosion-resistant steel float and rod. For all other wetted parts of the fluid-level sensing mechanism, use bronze, brass, or other material of equivalent resistance to the corrosive effects of the pumped fluid.

Mount the controls on the discharge pipe below the basin cover. Provide Type 6 enclosures in accordance with NEMA 250.

Pedestal-mount the controls above the coverplate. Provide Type 1, general-purpose enclosures conforming to NEMA 250.

Provide stilling tubes where indicated.

Floatless electrode level controls may be submitted for approval provided that the electrodes are isolated from the fluid being sensed.

2.2.2.9 Sump Tank and Coverplate

a. Tank

Provide a cast-iron, sump tank sized as indicated.

Furnish a standard opening for connection to the drainage inflow pipe in the indicated size and location with respect to the top of the tank.

Protect the interior surfaces of the concrete-sump by not less than a two-coat, two-component system of amine-cured coal-tar epoxy totaling 15 mils in thickness.

b. Coverplate

Provide a cast-iron or steel sump coverplate, of adequate strength to support not less than 200 pounds per square foot without distortion. Seal all openings through the sump cover to be gastight and watertight. Provide a standard outlet for a vent pipe. Ensure that the sump cover provides a manhole or handhole access to the interior.

2.3 High-Water Alarm

Provide a high-water alarm switch complete with actuating mechanism for operation on an electrical circuit other than the motor circuit. Design the switch to operate the indicated alarm devices whenever a predetermined high-water level is reached in the sump. Provide a switch enclosure that is the same as the level-control switch.

2.4 Painting

Treat and paint equipment in accordance with the manufacturer's standard practice for the specified duty.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment in accordance with manufacturer's recommendations.

3.1.1 Alignment

Before attempting alignment, demonstrate that the pump does not have any load/force imposed by the piping system. Minimum alignment values (below) are for pump and driver at normal running temperatures. Compensate values for thermal growth. Correct limited movement of the pump or driver (commonly known as bolt-bound) to ensure alignment capability. Ensure that holddown bolts are not undercut in order to perform adjustment.

Ensure that shims are commercially die-cut, without seams or folds, and are made of corrosion-resistant stainless steel. Do not use more than four shims at any single point.

For units with drive motors over 25 hp, install alignment jack bolts.

Pump and driver may have an intermediate shaft, spacer, or spool piece (sometimes called a jackshaft) Based on the motor's nominal operating speed, align the pump and driver to the following minimum specifications:

Speed(RPM)	close-coupled offset(mils)	close-coupled angle(mils/in)	spool piece angle (mils/in @ coupling pt.)
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5
7200	1.0	0.3	0.4

Provide final alignment settings as part of the final test data.

3.2 FIELD QUALITY CONTROL

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

3.2.1 Vibration Analyzer

Use a Fast Fourier Transform (FFT) analyzer to measure vibration levels. Provide an FFT analyzer with the following characteristics: a dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz to 10 kHz (300 to 600,000 cpm); the capacity to perform ensemble averaging; the capability to use a Hanning window; autoranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

Use an accelerometer (either stud-mounted or mounted using a rare-earth, low-mass magnet) and sound disk(or finished surface) with the FFT analyzer to collect data. Ensure that the mass of the accelerometer and its mounting has minimal influence on the frequency response of the system over the selected measurement range.

3.2.2 Pump Acceptance

Ensure that vibration analysis verifies pump conformance to specifications. Ensure that vibration levels are not more than 0.075 in/sec at 1 times run speed and at pump frequency, and 0.04 in/sec at other multiples of run speed.

Perform tests, including hydrostatic leak checking of piping and operation of equipment, in accordance with the manufacturer's instructions.

Operate pumps against static heads indicated, and verify pump flow capacity.

Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

3.3 CLOSEOUT ACTIVITIES

Submit six copies of the manufacturer' complete spare parts list, showing all parts, spare parts, and bulletins for pumps. Clearly show all details and parts, and adequately describe parts or furnish proper identification marks. Drawings incorporated in the parts lists may be reduced to one-page size provided that they are clear and legible, or the full-size drawings may be folded to the size of the list pages. Photographs or catalog cuts of components may be included for identification.

Furnish one set of all special tools necessary to completely assemble, disassemble, or maintain the pumps. "Special tools" refers to oversized or specially dimensioned tools, special attachments or fixtures, or any similar items.

-- End of Section --

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SECTION 22 15 09.00 40

GENERAL SERVICE COMPRESSED-AIR SYSTEMS CLEANING PROCEDURES
05/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B479	(2006) Standard Specification for Annealed Aluminum and Aluminum-Alloy Foil for Flexible Barrier, Food Contact, and Other Applications
ASTM D4635	(2016) Standard Specification for Plastic Films Made from Low-Density Polyethylene for General Use and Packaging Applications
ASTM D6368	(2006; R 2012) Standard Specification for Vapor-Degreasing Grade, and General Grade Normal - Propyl Bromide
ASTM E1146	(2016) Standard Specification for Muriatic Acid (Technical Grade Hydrochloric Acid)
ASTM F312	(2008; R 2016) Standard Test Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters
ASTM F331	(2013; R 2020) Standard Test Method for Nonvolatile Residue of Solvent Extract from Aerospace Components (Using Flash Evaporator)

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-10.1	(2008) Commodity Specification for Nitrogen; 7th Edition

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

SEMICONDUCTOR EQUIPMENT AND MATERIALS INTERNATIONAL (SEMI)

SEMI C28	(2011) Specifications for Hydrofluoric Acid
SEMI C35	(2008) Specifications and Guidelines for Nitric Acid

1.2 DEFINITIONS

1.2.1 Cleanliness-Level Terms

"Particle" includes all foreign matter except fibers, whether metallic or nonmetallic.

"Particle size" is the largest particle dimension, in microns.

"Fiber" includes all foreign matter having a length greater than 100 microns and a length-to-diameter ratio of at least 10-to-1.

"Significant surfaces" are component surfaces that may come in contact with the service medium.

1.2.2 Cleanliness-Level Classifications

1.2.2.1 Class I - Oxidizers and Oxidizer Pressurants

Significant surfaces of [liquid and gaseous oxygen] [nitrogen] [helium] [chlorine trifluoride (CTF)] [_____] Systems are subject to Class I cleanliness requirements.

1.2.2.2 Class II - Fuels, Fuel Pressurants and Hydraulics

Significant surfaces of [liquid and gaseous hydrogen] [hydraulic] [high purity air] [_____] systems are subject to Class II cleanliness requirements.

1.2.2.3 Class III - Air Control and Instrument Pneumatics

Significant surfaces of [air-pneumatic control and instrument systems, downstream of regulatory panels to the control units] [_____] are subject to Class III cleanliness requirements.

1.2.2.4 Class IV - Standard Industrial Cleaning

Significant surfaces of [potable water] [industrial water] [vacuum] [_____] systems are subject to Class IV cleanliness requirements.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Prequalification Statement; G[, [____]]

SD-03 Product Data

Demineralized Water; G[, [____]]

Drying or Preservation Gas; G[, [____]]

Filter Discs; G[, [____]]

Nitric Acid; G[, [____]]

Citric Acid; G[, [____]]

Muriatic Acid; G[, [____]]

Hydrofluoric Acid; G[, [____]]

Normal - Propyl Bromide; G[, [____]]

Tape;G[, [____]]

Polyethylene Film; G[, [____]]

Low Water-Vapor Transmission Film; G[, [____]]

Aluminum Foil; G[, [____]]

SD-04 Samples

Polyethylene Film; G[, [____]]

Certification Tags; G[, [____]]

Low Water-Vapor Transmission Film; G[, [____]]

SD-06 Test Reports

Inspection Records; G[, [____]]

SD-07 Certificates

Cleaning Procedures; G[, [____]]

1.4 QUALITY CONTROL

1.4.1 Preconstruction Qualifications

Before contract work begins, submit a Prequalification Statement verifying previous work experience and containing references, and a statement of selected laboratory and testing entities.

1.4.2 Process Approval

Submit [6] [_____] copies of the Cleaning Procedures describing precleaning, cleaning, handling, preservation, and quality assurance processes for approval before use.

Include the following in the Cleaning Procedures:

a. Trade names and manufacturer's names, specifications, and chemical and physical properties.

b. Estimates of the amounts of waste generated from cleaning for each processing material used.

c. Processing equipment required, including manufacturer, type or model, and size.

d. In-process control procedures to prevent contamination or latent corrosion, and installation procedures for components in cleaned systems.

e. Methods and materials used to preserve cleaned components before installation, and of cleaned systems after acceptance.

1.4.3 Cleaning Certification Tags

Apply Certification Tags, as specified, to all cleaned systems, assemblies, and components to certify the cleanliness level of the tagged item.

1.4.4 Predictive Testing and Inspection Technology Requirements

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with the RCBEA GUIDE to ensure building equipment and systems have been installed and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Demineralized Water

Use demineralized water with a pH between 6.0 to 8.0 and a specific resistance greater than 50 ohms per cubic millimeter for rinsing or operations. Filter water to remove all particles larger than 175 microns in any dimension and yielding not more than 5 particles sized between 100 microns and -175 microns per 500-millimeter sample.

2.1.2 Drying or Preservation Gas

Filter air and nitrogen gas conforming to CGA G-10.1, Grade E, to a 100-micron level (absolute). Ensure that the oil content is no greater than 3 parts per million (ppm) by weight and that the moisture content not greater than 24 ppm by volume.

2.1.3 Filter Discs

Provide polytetrafluoroethylene (PTFE)-fiber filter discs with 5-microns pores.

2.1.4 Nitric Acid

Conform technical-grade nitric acid to SEMI C35.

2.1.5 Citric Acid

Provide industrial-grade citric acid.

2.1.6 Muriatic Acid (Hydrochloric)

Conform Muriatic acid to ASTM E1146.

2.1.7 Hydrofluoric Acid

Conform hydrofluoric acid to SEMI C28.

2.1.8 Normal - Propyl Bromide

Do not use normal - propyl bromide with oxygen service.

Ensure that the solvent used for testing or for immersion cleaning conforms to ASTM D6368, with no particle over 175 microns in any dimension and no more than 5 particles from 100 to 175 microns in size.

Ensure that the solvent used for vapor degreasing cleaning processes of stainless steel components conforms to ASTM D6368.

2.1.9 Tape

Provide waterproof, pressure-sensitive tape, with plastic-film backing material, suitable for a temperature range of minus 65 degrees F to plus 160 degrees F.

2.1.10 Polyethylene Film

Ensure that polyethylene film conforms to ASTM D4635, Type [1] [_____].

2.1.11 Low-Water-Vapor Transmission Film

Provide a transparent, flexible, thermoplastic film material, made from fluorinated-chlorinated resins, highly resistant to chemicals and liquid oxygen. The water-vapor transmission rate cannot be greater than 0.03 grams per 100 square inches per 24 hours.

2.1.12 Aluminum Foil

Ensure that aluminum foil conforms to ASTM B479.

2.1.13 Certification Tags

Provide certification tags made of stainless steel, and 12 inch-long stainless steel chain or wire.

2.1.13.1 Certification Tag Schedule

CERTIFICATION TAGS				
Tag Type	Thickness (inches)	Note "A" (pounds)	Note "B" (grams)	[Tie Wire] [inches]
20	0.020 to 0.022	200 to 240	1,130	[0.025]
15	0.015 to 0.017	150 to 190	850	[0.025]
13	0.013 to 0.015	130 to 170	610	[0.018]

CERTIFICATION TAGS
Note "A": Basis weight, 500 sheets, 22-1/2 inches by 28-1/2 inches.
Note "B": Tearing Resistance. Total of both directions, (minimum).

Note "A": Basis weight, 500 sheets, 22- 1/2 by 28- 1/2 inches.

Note "B": Tearing resistance. Total of both directions, (minimum).

Provide preprinted spaces for the following information, as applicable. Size tags such that the information is legible when entered with an indelible marking pen:

a. Part or identification number

b. Manufacturer's serial number

c. Contractor identification

d. Cleaning classification and specification identification

e. Date of cleaning

f. Service medium or intended use

g. Pressurizing medium and initial pressure

h. Title, date, and number of this specification

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

3.1.1 Test Procedures

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

3.1.1.1 Particle Size Determination

Determine the size distribution, and quantity of solid particles retained on significant surfaces by removing and measuring particles on a minimum 5 percent representative sample of the total surface.

Ensure that solid-particle contamination per 1 square foot of significant surface, when determined by the following procedure, does not exceed the specified amount:

a. Estimate or measure the size of the area to be sampled. Flush the selected sample surface with approximately 33 ounces of demineralized water per 1 square foot.

b. For individual small components having less than 1 square foot of surface area, use a minimum of 500 milliliter of flushing fluid.

c. For piping and large components having greater than 3 square feet of surface area, collect and analyze 3 separate samples.

d. Sample piping and piping systems at 3 separate locations as directed by the Contracting Officer.

e. During sampling, ensure the flow velocity through the pipe exceeds 8 feet per second, or is as approved by the Contracting Officer.

f. Catch the entire quantity of the flushing fluid in a precleaned container.

g. Transfer an equal quantity of the unused flushing fluid into a second precleaned container.

h. Filter both samples of flushing fluid through a filter disc and examine the residue under a 10 power to 45-power stereomicroscope. The difference in particle count in each size range represents the solid particle contamination of the entire surface examined. If the allowable limit is exceeded in any range, reclean the entire surface and repeat the test.

After satisfactory completion of the particle-size determination, dry all surfaces and protect the surfaces against corrosion or recontamination in accordance with the procedures identified in this Section, and mark as specified.

3.1.1.2 Moisture Determination

Visually examine small components and assemblies with all significant surfaces exposed for the presence of surface moisture. Determine moisture content of surfaces in tanks, piping sections and systems as follows:

a. Set up a flow of purge gas through the tank or system that contacts all significant surfaces. Several checks may be run covering different portions of the system in order to ensure the flow of purge gas over all significant surfaces.

b. Use a dry, oil-free nitrogen purge gas. While the gas is flowing, do not allow the velocity of purge gas at any point in the system being checked to exceed 60 feet per minute.

c. Maintain the system under a static lockup for at least 8 hours before sampling.

d. Measure the moisture content of the effluent gas using a dew point meter.

e. Rejection and correct moisture-vapor levels above the specification in tanks, systems, or sub-systems. Continue the drying process until a satisfactory moisture-vapor level is measured.

3.1.1.3 Acidity or Alkalinity

Test the external and internal surfaces of cleaned and rinsed components with pH-indicating paper while the component is still wet from the last rinse or after wetting the test surface with a few drops of distilled water. Ensure that the cleaned area registers a pH between [5.0 and 8.0][_____] acidity or alkalinity along the surface.

3.1.2 Quality Assurance Tests

Maintain current inspection records of examinations and tests and provide the inspection records to the Contracting Officer on request.

3.1.2.1 Tests Requirements for Class I Cleanliness

a. Solid-Particle Contamination

Conduct a microscopical particle population analysis in accordance with ASTM F312. Comply with the following criteria to determine cleanliness acceptability:

(1) No particles greater than 500 microns in any dimension.

(2) Not more than 5 particles between 150 and 500 microns.

(3) Not more than 100 particles between 5 and 150 microns.

(4) Fewer than 10 fibers per one square foot of significant surface.

(5) Maximum fiber-length cannot exceed [500] [_____] microns.

Particle population analysis (Automatic Particle Counters) may be used for the final verification of cleanliness, provided the individual counters have demonstrated accuracy and repeatability, which correlates with the accepted analytical methods, and are approved by the Contracting Officer.

b. Moisture Content

If the influent air at the point of delivery has a dew point of minus 80 degrees F or colder, ensure the effluent dew point is minus 60 degrees F or colder, as measured in effluent purge gas.

If the dew point of the furnished gas is warmer than minus 80 degrees F, ensure the dew point of the effluent is within 20 degrees F of the influent.

c. Acidity or Alkalinity

[As specified.] [_____]

d. Nonvolatile Residue Contamination

Perform Nonvolatile Residue Contamination (NVRC) solvent flush testing as a final flush and cleanliness verification test. Ensure that test procedures conform to the following accepted method:

(1) Gravimetric NVR Analysis Method - Evaporate the filtered solvent sample to determine the NVR content in accordance with ASTM F331.

(2) Solvent Purity Meter - Use solvent purity meter Model SP-1000, which is manufactured by the Virtis Co., Gardiner, New York; and which correlates with accepted analytical methods for demonstrated accuracy and repeatability, and is approved by the Contracting Officer.

(3) Infrared Spectrophotometric NVR Analysis Method - Infrared (IR) spectrophotometric NVR analysis of solvent samples may be used if the following apply:

(a) The method quantifies hydrocarbons and other contaminants that are reactive with liquid oxygen.

(b) The analysis method has demonstrated accuracy and repeatability and is approved by the Contracting Officer.

NVRC cannot exceed 0.001 grams per square foot of surface area.

3.1.2.2 Tests Requirements for Class II Cleanliness

a. Solid Particle Contamination

Comply with the following criteria to determine cleanliness acceptability:

(1) No particles greater than 500 microns in any dimension.

(2) Not more than 5 particles between 150 microns and 500 microns.

(3) Not more than 100 particles between 5 microns and 150 microns.

(4) Fewer than 10 fibers per 1 square foot of significant surface.

(5) Maximum fiber length cannot exceed [500] [_____] microns.

b. Moisture Content

If the influent air has a dew point of minus 65 degrees F or colder at the point of delivery, ensure the effluent dew point are minus 45 degrees F or colder, as measured in the effluent purge gas.

If the dew point of the furnished gas is warmer than minus 65 degrees F, ensure the dew point of the effluent gas is within 20 degrees F of the influent.

3.1.2.2.1 Acidity or Alkalinity

As specified.

3.1.2.3 Tests Requirements for Class III Cleanliness

3.1.2.3.1 Solid Particle Contamination

Comply with the following criteria to determine cleanliness acceptability:

a. No particles greater than 1500 microns in any dimension.

b. Not more than 50 particles between 150 microns and 1500 microns.

c. Not more than 500 particles between 5 microns and 150 microns.

d. Fewer than 50 fibers per 1 square foot of significant surface.

e. Maximum fiber length cannot exceed [_____] microns.

3.1.2.3.2 Moisture Content

Ensure that total quantity of moisture solvents, and products, including both absorbed surface film and vapor present in the entire system subject to Class III cleanliness requirements, does not exceed 150 ppm by volume as measured in the effluent purge gas.

3.1.3 Inspection Procedures

The Government reserves the right to perform any inspections set forth in the specification where such inspections are deemed necessary to ensure that the work conforms to the prescribed requirements.

3.1.3.1 Visual Examination

Visually inspect significant surfaces of cleaned components for moisture and foreign material such as corrosion, scale, dirt, hydrocarbons, crayon, and similar materials. Use a flashlight or borescope to examine internal surfaces. The presence of visible contamination will result in rejection by the Contracting Officer and necessitate recleaning of the item. Scale-free discoloration caused by welding and passivation is permitted.

3.1.3.2 Ultraviolet Light Examination

Examine significant surfaces of cleaned components using an ultra-violet light of at least 100 watts and producing a wavelength of approximately 3660 angstrom units. Presence of fluorescent particles on areas of any surface, metallic or nonmetallic, will result in rejection by the Contracting Officer and necessitate recleaning of the item. Any component or material, either metallic or nonmetallic, from which fluorescence cannot be eliminated will be rejected and replaced at no further cost to the Government.

3.1.4 Quality Assurance Inspections

Except as specified herein, perform the following inspections on all components, assemblies, and systems.

3.1.4.1 Inspections for Class I Cleanliness Requirements

a. Visual Examination: As specified, under a strong white light.

b. Ultraviolet Light Examination: As specified.

3.1.4.2 Inspections for Class II Cleanliness Requirements

a. Visual Examination: As specified, under a strong white light.

b. Ultraviolet Light Examination: As specified.

3.1.4.3 Inspections for Class III Cleanliness Requirements

a. Visual Examination: As specified, under a strong white light.

b. Ultraviolet Light Examination: As specified.

3.1.4.4 Inspections for Class IV Cleanliness Requirements

Visual Examination: As specified, under normal shop lighting conditions.

3.2 ADJUSTING AND CLEANING

Notify the Contracting Officer at least 48 hours before the time

Government-furnished air, gaseous nitrogen, and demineralized water are required for cleaning purposes.

Remove all gross contamination by mechanical processes, flushing, or high-velocity blowdown before final cleaning. Accomplish mechanical and electrical testing after precleaning and before final cleaning. Preclean all lengths of pipe, fittings, and piping system components before welding and assembly.

Treat corrosion-resistant steel assemblies using pickling and passivating processes to prevent latent corrosion or contamination.

Disassemble and clean assemblies (or clean before original assembly) not suitable for cleaning as assembled. This applies to assemblies composed of materials requiring different cleaning procedures, or assemblies from which cleaning solutions cannot be adequately drained.

Loosen flanged joints as required during the cleaning procedure to ensure complete drainage of cleaning and rinsing solutions.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Waste Disposal

Determination as to whether waste fluids or materials generated during cleaning operations are hazardous, controlled, non-hazardous, or non-controlled is made by the [_____].

Coordinate waste-generation activities with the [Hazardous Waste Section] [_____]. As a minimum, furnish suitable containers and tankage to collect, transport, and offload the collected waste in designated [tankage] [_____]. Store the waste for a minimum of [7] [30] [_____] calendar days after the storage container is filled to capacity.

[The Government will dispose of hazardous waste and controlled waste.

] Dispose nonhazardous wastes and noncontrolled wastes at no additional cost to the Government. Dispose of nonhazardous or noncontrolled waste [offsite as approved by the Government] [_____]. [Disposal of these fluids or materials is not permitted at [_____].]

3.4 PROTECTION

For [Class I,] [and] [Class II,] [and] [Class III] cleaning levels, place protected components that are not installed in a clean polyethylene bag. Purge the bag with dry, oil-free gas and heat-seal the ends of the bag to ensure an inert package during storage. Place the bagged component in a second heat-sealed and purged polyethylene bag with a cleaning certification tag placed in the second bag. Give equivalent protection to components that cannot be placed in a polyethylene bag and place a tag near each sealed opening used in the cleaning procedure.

3.4.1 Protection for Class I Cleanliness Requirements

Immediately after precleaning, cleaning, and drying, protect significant surfaces subject to Class I cleanliness requirements from recontamination by covering the surfaces or openings with a minimum of two layers of Low Water-vapor transmission film. Secure the film and reinforce it with pressure-sensitive tape.

3.4.2 Protection for Class II Cleanliness Requirements

Immediately after cleaning and drying, protect significant surfaces subject to Class II cleanliness requirements from recontamination by covering the surfaces or openings with [aluminum foil] [or] [a minimum of two layers of polyethylene film] [or] [precleaned dry covers], secured and reinforced with pressure-sensitive tape.

3.4.3 Protection for Class III Cleanliness Requirements

Immediately after cleaning and drying, protect significant surfaces subject to Class III cleanliness requirements from recontamination by covering the surfaces or openings with [aluminum foil] [or] [a minimum of two layers of polyethylene film] [or] [precleaned dry covers], secured and reinforced with pressure-sensitive tape.

3.4.4 Protection for Class IV Cleanliness Requirements

Drain liquids from all parts of the system and seal openings with [aluminum foil] [or] [polyethylene bags] [or] [approved devices].

-- End of Section --

SECTION 22 15 13.16 40

HIGH-PRESSURE COMPRESSED-AIR PIPING, PIPING COMPONENTS, AND VALVES, STAINLESS
11/17

PART 1 GENERAL

Section 23 30 00 HVAC AIR DISTRIBUTIONapplies to work specified in this section.

Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT applies to work specified in this section.

Section 40 17 30.00 40 WELDING GENERAL PIPING applies to work specified in this section.

Where the deviations from specified instructions are proposed, submit the proposed deviations to the Contracting Officer for approval.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.10	(2022) Face-to-Face and End-to-End Dimensions of Valves
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.25	(2017) Buttwelding Ends
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.3	(2020) Process Piping
ASME B36.10M	(2022) Welded and Seamless Wrought Steel Pipe
ASME B36.19M	(2022) Welded and Seamless Wrought

	Stainless Steel Pipe
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC II-C	(2017) BPVC Section II-Materials Part C-Specifications for Welding Rods Electrodes and Filler Metals
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS A5.13/A5.13M	(2021) Specification for Surfacing Electrodes for Shielded Metal Arc Welding
AWS WHB-2.9	(2004) Welding Handbook; Volume 2, Welding Processes, Part 1

ASTM INTERNATIONAL (ASTM)

ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A182/A182M	(2021) Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A216/A216M	(2021) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature

	Service
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A312/A312M	(2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A403/A403M	(2022) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM B148	(2014) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B370	(2022) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B749	(2020) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

CAGI B19.1	(2010) Safety Standard for Compressor Systems

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-7.1	(2011) Commodity Specification for Air; 5th Edition

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-53	(2021) Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and Other Piping Components - Magnetic Particle Examination Method

MSS SP-54	(2013) Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components, - Radiographic Examination Method
MSS SP-55	(2011) Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components - Visual Method for Evaluation of Surface Irregularities
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-61	(2019) Pressure Testing of Valves
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

PIPE FABRICATION INSTITUTE (PFI)

PFI ES 3	(2009) Fabricating Tolerances
PFI ES 11	(2014) Permanent Marking of Piping Materials
PFI ES 21	(2010) Internal Machining and Fit-up of GTAW Root Pass Circumferential Butt Welds

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS WW-P-541	(Rev E; Am 1; Notice 1) Plumbing Fixtures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Proposed Deviations; G

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Underground Piping; G

Aboveground Piping; G

Air Compressors; G

Manual Valves; G

Piping Specialties; G

Miscellaneous Materials; G

Supporting Elements; G

SD-06 Test Reports

System Pressure Test; G

SD-07 Certificates

Underground Piping

Aboveground Piping

Air Compressors

Manual Valves

Piping Specialties

Miscellaneous Materials

Supporting Elements

1.3 QUALITY CONTROL

Submit detail drawings for high-pressure compressed-air systems consisting of fabrication and assembly drawings for all parts of work in sufficient detail to enable the Government to check conformity with the requirements of the contract documents.

PART 2 PRODUCTS

2.1 COMPONENTS

2.1.1 Air Compressors

Provide an air compressor complete with air tank, air dryer,air cooler, and other appurtenances. Ensure that the compressor and installation conform to CAGI B19.1. Select a compressor of sufficient capacity to provide continuous control air when operating on a 1/3-on 2/3-off cycle. Provide the compressor with an oil-level sight indicator on the compressor and a coalescing oil filter on the compressor discharge line. Ensure that the air dryers are of the continuous-duty typesilica-gel type with reactivation or mass refrigerated dryer type and it maintains the air in the system with a dew point low enough to prevent condensation in accordance with CGA G-7.1. Locate air dryer at the outlet of the tank. Ensure that the control air delivered to the system conforms to ISA 7.0.01.

2.1.2 Manual Valves

Ensure that the valve markings conform to MSS SP-25 and are supplemented by securely attached identification plates that identify manufacturer, catalog number, pressure and temperature rating, size, flow direction, and serial numbers. Also indicate body, stem, disc, seat, and hard-surfacing materials.

Ensure that the valve face-to-face and end-to-end dimensions conform to ASME B16.10.

Ensure that the valve body butt-welding end configuration conforms to the following requirements:

a. For piping systems rated at 2,000 psi and higher, PFI ES 21 applies.

b. For piping systems rated at 350 psi water, oil, and gas (wog) and lower, ASME B16.25 applies.

Ensure that the valve body socket welding end configurations conform to ASME B16.11

Ensure that the valve body flanged end configurations and pressure temperature ratings conform to ASME B16.5.

Ensure the pressure and temperature ratings for steel butt-welding end valves conform to ASME B16.5 or ASME B16.34.

Ensure that the valves conform to applicable provisions of ASME BPVC SEC VIII D1.

Ensure that the hydrostatic testing of steel valves conforms to MSS SP-61.

Provide bolts and studs conforming to ASTM A193/A193M, Grade B7, and nuts conforming to ASTM A194/A194M, Grade 2H.

For packing, use wire-reinforced, nonasbestos fiber materials, jacketed and impregnated with 30 percent tetrafluoroethylene or a corrosion-inhibiting lubricant specifically suitable for service with the stem material provided.

Ensure that the hard-surfacing alloy (HSA) conforms to AWS A5.13/A5.13M, Class RNiCr-B or Class RCoCr-B, where specified.

Visually inspect cast-steel valves in accordance with MSS SP-55.

Ensure that the cast-steel valves are certified as inspected by using the dry-powder magnetic-particle method in accordance with MSS SP-53.

Ensure that cast-steel valves are certified as inspected by using radiographic methods in accordance with MSS SP-54.

2.1.2.1 Type BCS-6000A

Type BCS-6000A valves are Y-body globe type, rated at 2,500 pounds, and 6,000 psi with a seal-welded or pressure-sealed bonnet, outside screw and yoke (OS&Y), hard-surfaced body-guided loose disk, hard-surfaced integral or inserted and welded seat, hard-surfaced backseating, loose backseat, swing-eye gland bolts, and malleable iron impact valve wheels and handles.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A105/A105M.

Ensure that the trim conforms to ASTM A182/A182M, Grade F6.

Provide a bronze stem bushing conforming to ASTM B148, No. C95300, heat-treated, or an approved equal.

Select valves that have a full port.

Select valves that have full or reduced ports.

Provide a valve body with butt weld ends, except that valves 1-1/2-inch iron pipe size (ips) and smaller may be the socket weld end type.

2.1.2.2 Type BCS-6000B

Type BCS-6000B valves are Y-body-type piston check, rated at 2,500 pounds and 6,000 psi with a seal-welded or pressure-sealed bonnet, hard-surfaced spring-loaded body-guided disk, and a hard-surfaced integral or inserted and welded seat.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A105/A105M.

Ensure that the trim conforms to ASTM A182/A182M, Grade F 11.

Ensure that the spring is corrosion-resistant steel.

Provide a valve body with butt weld ends, except that valves 1-1/2 inch ips (iron pipe size) and smaller may be the socket weld end type.

2.1.2.3 Type BCS-2000A

Type BCS-2000A valves are globe-type, rated at 600 pounds and 2,000 psi with a union, seal-welded or pressure-sealed bonnet, OS&Y, hard-surfaced loose disk, hard-surfaced seat, minimum 375 Brinell backseating, loose backseat where required for access, and malleable iron hand wheel or handle.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A105/A105M.

Ensure that the trim conforms to ASTM A182/A182M, Grade F6, or the manufacturer's standard equivalent materials for the specified service.

Provide a valve body with butt weld ends, except that valves 1-1/2-inch ips and smaller may be the socket weld end type.

2.1.2.4 Type BCS-2000B

Type BCS-2000B valves are Y-body-type, piston check, rated at 600 pounds and 2,000 psi with a bolted, seal-welded or pressure-sealed bonnet, hard-surfaced spring-loaded body-guided disk, and a hard-surfaced integral or inserted and welded seat.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A105/A105M, Class 70, or cast carbon steel conforming to ASTM A216/A216M, Grade WCB.

Ensure that the trim is the manufacturer's standard for the service.

Provide a corrosion-resistant steel spring.

Install valve body with butt weld ends, except that the forged steel valves may be the socket weld end type up to 2-inch ips in size.

2.1.2.5 Type BCS-2000C

Type BCS-2000C valves are gate type, rated at 600 pounds and 2,000 psi with a union, bolted, seal-welded or pressure-sealed bonnet, OS&Y, hard-surfaced solid wedge disk, hard-surfaced seats, minimum 375 Brinell backseating, and a malleable iron handwheel.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A105/A105M.

Ensure that the trim conforms to ASTM A182/A182M, Grade F6, or the manufacturer's standard equivalent materials for the specified service.

Install valve body with butt weld ends except that valves 1-1/2-inch ips and smaller may be the socket weld end type.

2.1.2.6 Type BCS-350A

Type BCS-350A valves are globe and angle type, rated at 300 pounds and 740 psi with a bolted bonnet, OS&Y, hard-surfaced plug-type loose disk, hard-surfaced seat, minimum 350 Brinell backseating, swing-eye gland bolts, and a malleable iron wheel.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A216/A216M, Grade WCB.

Ensure that the stem material conforms to ASTM A182/A182M, Grade F6.

For a valve body in sizes 2 inches and larger, select butt weld ends.

2.1.2.7 Type BCS-350B

Type BCS-350B valves are horizontal swing check, rated at 300 pounds and 740 psi with bolted bonnet.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A216/A216M, Grade WCB.

Ensure that the seating materials conform to ASTM A182/A182M, Grade F6.

For valve body in sizes 2 inches and larger, select butt weld ends.

2.1.2.8 Type BCS-350C

Type BCS-350C valves are gate type, rated at 300 pounds and 740 psi with a bolted bonnet, OS&Y, hard-surfaced solid or one-piece flexible wedge disk, hard-surfaced seats, minimum 350 Brinell backseating, swing-eye gland bolts, and a malleable iron wheel.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A216/A216M, Grade WCB.

Ensure that the stem material conforms to ASTM A182/A182M, Grade F6.

For valve body in sizes 2 inches and larger select butt weld ends.

2.1.2.9 Type SS-6000A

Type SS-6000A valves are Y-body globe type, rated at 2,500 pounds and 6,000 psi with a seal-welded or pressure-sealed bonnet, OS&Y, hard-surfaced body-guided disk, hard-surfaced integral or inserted and welded seat, hard-surfaced backseating, loose backseat, swing-eye gland bolts, and malleable iron impact-type valve wheels and handles.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A182/A182M, Grade F 316.

Ensure that the trim conforms to ASTM A182/A182M, Grade F 316.

Ensure that bronze stem bushings conform to ASTM B148, No. C95300, heat-treated.

Select valves that have a full port.

Select valves that have full or reduced ports.

Use valve bodies with butt weld ends, except that valves 1-1/2-inch ips and smaller may be the socket weld end type.

2.1.2.10 Type SS-6000B

Type SS-6000B valves are Y-body type, piston check, rated at 2,500 pounds and 6,000 psi with a seal-welded or pressure-sealed bonnet, and a hard-surfaced spring-loaded body-guided disk, hard-surfaced integral or inserted and welded seat.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A182/A182M, Grade F 316.

Ensure that the trim conforms to ASTM A182/A182M, Grade F 316.

Provide a corrosion-resistant steel spring.

Use valve bodies with butt weld ends, except that valves 1-1/2-inch ips and smaller may be the socket weld end type.

2.1.2.11 Type SS-2000A

Type SS-2000A valves are globe type, rated at 6,000 pounds and 2,000 psi with a union, seal-welded or pressure-sealed bonnet, OS&Y, hard-surfaced loose disk, hard-surfaced seat, minimum 375 Brinell backseating, loose backseat where required for access, and a malleable iron hand wheel or handle.

Provide a forged carbon steel body and bonnet assembly conforming to ASTM A182/A182M, Grade F 316.

Ensure that the trim conforms to ASTM A182/A182M, Grade F 316, or the manufacturer's standard equivalent materials for the specified service.

Use valve bodies with butt weld ends, except that valves 1-1/2-inch ips and smaller may be the socket weld end type.

2.1.3 Supporting Elements

2.1.3.1 General

Provide all necessary piping system components and miscellaneous supporting elements required, including building structure attachments; supplementary steel; hanger rods, stanchions, and fixtures; vertical pipe attachments; horizontal pipe attachments; anchors; guides; shock absorbers; and variable and constant supports. Ensure that all supporting elements are suitable for stresses imposed by system pressures and temperatures, along with natural and other external forces.

Ensure that the supporting elements are UL-approved or listed and conform to the requirements of ASME B31.3, MSS SP-58, and MSS SP-69, or the BOCA National Plumbing Code, except as supplemented and modified by these specifications.

Code-mark and submit individual supporting element details as part of the shop drawings for all piping systems.

Details include an exact bill of materials for components making up each assembly. Include a dimensioned location plan for each assembly with respect to building structure or equipment.

Individually bundle and tag each coded assembly with a code mark before delivery to the site.

Provide constant supports, with travel stops where necessary, at vertically drifting piping to preclude excessive stresses at terminal points.

Provide shock absorbers and sway suppressors to absorb the system reactive forces where indicated.

Ensure that the attachments welded to the pipe are of identical material to that of the pipe or of materials accepted as permissible raw materials by referenced codes or standard specification. Ensure that heat treatment for attachment stress relief is performed in a furnace allowing for controlled conditions and uniformity of temperature. The type of devices specified herein are defined in the cited MSS Standard, unless otherwise noted.

2.1.3.2 Building Structure Attachments

Provide adjustable positions for cast-in-floor mounted-equipment anchor devices.

Provide built-in masonry anchor devices, unless otherwise approved by the Contracting Officer.

Do not use powder-actuated anchoring devices to support any mechanical system components.

Use center-loading beam clamps, MSS SP-58 Type 21, 28, 29, or 30, UL-listed, catalogued and load-rated, commercially manufactured products.

Do not use C-clamps.

Construct concrete inserts in accordance with the requirements of MSS SP-58 for Type 18 and MSS SP-69. When applied to piping in sizes 2-inch ips and larger and where otherwise required by imposed loads, insert and wire a 1-foot length of 1/2-inch reinforcing rod through wing slots. Proprietary-type continuous inserts may be similarly used when approved by the Contracting Officer.

2.1.3.3 Horizontal Pipe Attachments

For single pipes, wherever possible, support the piping by MSS SP-58 Type 2, Type 3, or Type 4 attachments. Pipe rolls are Type 41 or 49. Where clamps and rolls are not used, pipe supports are Type 1.

Provide spring supports in accordance with cited standards.

2.1.3.4 Vertical Pipe Attachments

Vertical pipe attachments are Type 8.

Provide spring supports in accordance with cited codes and standards.

2.1.3.5 Hanger Rods and Fixtures

Use only circular-cross-section rod hangers to connect building structure attachments to pipe support devices. Use pipe straps or bars of equivalent strength for hangers only where approved by the Contracting Officer.

Provide turnbuckles, swing eyes, and clevises as required by the support system to accommodate pipe accessibility and for adjustment to load and pitch.

2.1.3.6 Supplementary Steel

Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, design and fabricate such supplementary steel in accordance with AISC 325.

2.1.4 Piping Specialties

2.1.4.1 Pressure Gages

Ensure that the pressure gages conform to ASME B40.100 and to the requirements specified herein. Provide a pressure gage size of 4-1/2 inches nominal diameter for system pressures less than 350 psi, and 8 inches nominal diameter for all higher pressures. Provide cast-aluminum cases. Equip all gages with adjustable red marking pointer and damper screw adjustment in the inlet connection. Ensure that the Bourdon tubes have a bleeding device to facilitate cleaning and bleeding the trapped gas.

Provide gage cases with a one-piece solid front with a safety-release back cover. Ensure that the windows are shatterproof glass and the gage dials are white with dual seals. Ensure that the outer scale has red markings graduated in SI units and that the inner scale has black markings graduated in psi units.

2.1.4.2 Receiver Gages

Install indicating gages with 6-inch white background dial face and black lettering that are suitable for indicating transmitted air pressure in the range from 3 to 15 psi. Provide an adjustable micrometer pointer. Provide overload and underload stops. Ensure that the Bourdon tube and movement are AISI Type 316 and 300 series stainless steel, respectively. Ensure that the connection is 1/4-inch ips or tube size, depending on the system makeup. Ensure that the case is black-finish cast aluminum for indicated mounting. Ensure that the accuracy is within 0.5 percent of scale range.

Provide a gage scale range as indicated.

2.1.4.3 Pneumatic Transmitters

Provide a nonsuppressed, nonindicating transmitter complete with sensitive relay, dual Bourdon tube-actuated motion balance system, zero and span adjustment, and accessories. Provide a weatherproof case that is kept free of foreign particulate matter by purging air and that is constructed of manufacturer's standard-finish steel base with a safety blowout disk and an aluminum cover.

Install phosphor bronze Bourdon tubes with brass tips and connections. Ensure that the unit inlets are screened.

Ensure Bourdon tubes, tips, and connections are AISI Type 316 corrosion-resistant steel. Ensure that the unit inlets are screened.

Ensure that the unit is self-compensating under varying ambient temperature conditions. Minimum speed of response is the capability to raise pressure from 3 to 15 psi through 500 feet of 3/16-inch inside diameter tubing with a time constant of 4 seconds. Ensure that the accuracy is within 0.5 percent of scale range. Ensure that the sensitivity is within 0.1 percent of pressure range.

Ensure that the unit range is as indicated. Provide an output range of 3 to 15 psi. Provide one pneumatic transmitter for each pressure-receiver gage, unless otherwise specified.

Provide a pipe-type pneumatic-transmitter assembly mounting.

Provide the manufacturer's standard pressure-rated filter-regulator assembly and a 2-inch dial face for both supply air and transmitted air pressure gages.

2.1.4.4 Thermometers

Ensure that the thermometers conform to ASTM E1 and to requirements specified herein. Provide industrial-pattern thermometers Type 1, Class 3. All thermometers that are installed 6 feet or higher above the floor require an adjustable-angle body. Provide a scale that is at least 7 inches long. Provide a case face manufactured from manufacturer's standard polished aluminum or AISI 300 series polished corrosion-resistant steel. Thermometer range is as indicated. Ensure all thermometers have AISI Type 316 corrosion-resistant steel separable wells.

2.2 MATERIALS

2.2.1 Underground Piping

2.2.1.1 Type BCS-PS-6000

For pipe or tube 1/2 through 3 inches, provide XXS, seamless, black carbon steel conforming to ASTM A106/A106M, Grade B and ASME B36.10M, sheathed with thermoplastic (polyethylene).

For fittings 1/2 through 1-1/2 inches: 9,000-pound, provide socket-welded, forged carbon steel conforming to ASTM A105/A105Mand ASME B16.11

For fittings 2 through 3 inches, provide XXS, long-radius, butt-welded, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9.

For thermoplastic sheaths for pipe and fittings, ensure that sheath joints with thermally fitted shrinking sleeves are applied with factory-approved shrinking devices. Make taped fitting protection and repairs in accordance with the manufacturer's instructions. Electrical flaw detection testing at the factory requires 10,000 volts to be impressed across the sheath. Sheath breakdown voltage cannot be less than 13,000 volts.

2.2.1.2 Type BCS-PS-2000

For pipe or tube 1/2 through 3 inches, provide Schedule 40, seamless, black carbon steel conforming to ASTM A106/A106M, Grade B, and ASME B36.10M, sheathed with thermoplastic (polyethylene).

For fittings 1/2 through 1-1/2 inches: 3,000-pound, provide socket-welded, forged carbon-steel, conforming to ASTM A105/A105M, and ASME B16.11.

For fittings 2 through 3 inches, provide Schedule 40, long-radius, butt-weld, black carbon-steel conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9.

For thermoplastic sheaths for pipe and fittings, ensure that sheath joints with thermally fitted shrinking sleeves are applied with factory-approved shrinking devices. Make taped fitting protection and repairs in accordance with the manufacturer's instructions. Electrical flaw detection testing at the factory requires 10,000 volts to be impressed across the sheath. Sheath breakdown voltage cannot be less than 13,000 volts.

2.2.1.3 Type BCS-PS-350

For pipes or tubes 1/2 through 24 inches, provide Schedule 40, seamless, black carbon-steel conforming to ASTM A106/A106M, Grade B, and ASME B36.10M sheathed with thermoplastic (polyethylene).

For fittings 1/2 through 1-1/2 inches: 3,000-pound, provide socket-welded, forged carbon steel fittings, conforming to ASTM A105/A105M and ASME B16.11.

For fittings 2 through 24 inches, provide Schedule 40, long-radius, butt-welded, black carbon-steel conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9.

For thermoplastic sheaths for pipe and fittings, ensure that sheath joints with thermally fitted shrinking sleeves are applied with factory-approved shrinking devices. Make taped fitting protection and repairs in accordance with the manufacturer's instructions. Electrical flaw detection testing at the factory requires 10,000 volts to be impressed across the sheath. Sheath breakdown voltage cannot be less than 13,000 volts.

2.2.1.4 Type SS-PS-6000

For pipes or tubes 1/2 through 3 inches, provide XXS, seamless, corrosion-resistant steel conforming to ASTM A312/A312M, Grade TP 316, and ASME B36.19M, sheathed with thermoplastic (polyethylene).

For fittings 1/2 through 1-1/2 inches: 9,000-pound, provide socket-welded, forged, corrosion-resistant steel conforming to ASTM A182/A182M, Grade F 316, and ASME B16.11.

For fittings 2 through 3 inches, provide XXS, long-radius, butt-welded, corrosion-resistant steel conforming to ASTM A403/A403M, WP 316, and ASME B16.9.

For thermoplastic sheaths for pipe and fittings, ensure that sheath joints with thermally fitted shrinking sleeves applied with factory-approved shrinking devices. Make taped fitting protection and repairs in accordance with the manufacturer's instructions. Electrical flaw detection testing at the factory requires 10,000 volts to be impressed across the sheath. Sheath breakdown voltage cannot be less than 13,000 volts. Use adhesives that do not contain free chloride ions.

2.2.1.5 Type SS-PS-2000

For pipes or tubes 1/2 through 3 inches, provide Schedule 40S, seamless, corrosion-resistant steel conforming to ASTM A312/A312M, Grade TP 316, sheathed with thermoplastic (polyethylene).

For fittings 1/2 through 1-1/2 inches: 3,000-pound, provide socket-welded, forged, corrosion-resistant steel conforming to ASTM A182/A182M, Grade F 316, and ASME B16.11.

For fittings 2 through 3 inches, provide Schedule 40S, long-radius butt-welded, corrosion-resistant steel conforming to ASTM A403/A403M, and WP 316, and ASME B16.9, sheathed with thermoplastic (polyethylene).

For thermoplastic sheaths for pipe and fittings, ensure that sheath joints with factory-approved shrinking sleeves are applied with factory-approved shrinking devices. Make taped fitting protection and repair in accordance with the manufacturer's instructions. Electrical flaw detection testing at the factory requires 10,000 volts to be impressed across the sheath. Sheath breakdown voltage cannot be less than 13,000 volts. Use adhesives that do not contain free chloride ions.

2.2.1.6 Type SS-PS-350

For pipes or tubes 1/2 through 10 inches, provide Schedule 40, seamless, corrosion-resistant steel conforming to ASTM A312/A312M, Grade TP 316, and ASME B36.19M, sheathed with thermoplastic (polyethylene).

For fittings 1/2 through 1-1/2 inches: 3,000-pound, provide socket-welded, forged corrosion-resistant steel conforming to ASTM A182/A182M, Grade F316, and ASME B16.11.

For fittings 2 through 24 inches, provide Schedule 40, long-radius, butt-welded, corrosion-resistant steel conforming to ASTM A403/A403M, WP 316, and ASME B16.9.

For thermoplastic sheaths for pipe and fittings, ensure that sheath joints with thermally fitted shrinking sleeves are applied with factory-approved shrinking devices. Make taped fitting protection and repairs in accordance with the manufacturer's instructions. Electrical flaw detection testing at the factory requires 10,000 volts to be impressed across the sheath. Sheath breakdown voltage cannot be less than 13,000 volts. Use adhesives that do not contain free chloride ions.

2.2.2 Aboveground Piping

2.2.2.1 Type BCS-6000

For pipes or tubes 1/2 through 3 inches, provide XXS, seamless, black carbon steel conforming to ASTM A106/A106M, Grade B, and ASME B36.10M.

For fittings 1/2 through 1-1/2 inches: 9,000-pound, provide socket-welded, forged carbon-steel conforming to ASTM A105/A105M and ASME B16.11.

For fittings 2 through 3 inches, provide XXS, long-radius, butt-welded, black carbon-steel conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9.

Provide 2,500-pound, 6,000-pounds-per-square-inch (psi) forged carbon steel welding neck flanges conforming to ASTM A105/A105M and ASME B16.5, with raised face and concentric serrated finish.

Provide gaskets that are spiral-wound, nonasbestos-filled, carbon-steel, with centering provisions, conforming to ASME B16.5, Group 1.

Provide alloy-steel bolt studs conforming to ASTM A193/A193M, Grade B7, and semifinished heavy hexnuts conforming to ASTM A194/A194M, Grade 2H.

2.2.2.2 Type BCS-2000

For pipes or tubes 1/8 through 3 inches, provide Schedule 40, seamless, black carbon-steel conforming to ASTM A106/A106M, Grade B, and ASME B36.10M.

For fittings 1/8 through 1-1/2 inches: 3,000-pound, provide socket-welded, forged carbon steel conforming to ASTM A105/A105M, and ASME B16.11.

For fittings 2 through 3 inches, provide Schedule 40, long-radius, butt-welded, black carbon steel conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9.

Provide 1 through 3 inches: 900-pound, 2,160-psi forged carbon steel, welding neck flanges conforming to ASTM A105/A105M and ASME B16.5, with raised face and concentric serrated finish.

Provide alloy-steel bolt studs con-forming to ASTM A193/A193M, Grade B7, and semifinished heavy hex nuts conforming to ASTM A194/A194M, Grade 2H.

2.2.2.3 Type BCS-350

For pipes or tubes 1/8 through 10 inches, provide Schedule 40, seamless, black carbon steel, conforming to ASTM A106/A106M, Grade B, and ASME B36.10M.

For fittings 1/8 through 1-1/2 inches: 3,000-pound, provide socket-welded, forged carbon steel conforming to ASTM A105/A105M, ASME B16.11.

For fittings 2 through 10 inches, provide Schedule 40, long-radius, butt-welded, black carbon steel conforming to ASTM A234/A234M, Grade WPB and ASME B16.9.

Provide 1 through 10 inches: 300-pound, 720 psi, forged carbon steel welding neck flanges conforming to ASTM A181/A181M, Class 70 and ASME B16.5, with raised face and concentric serrated finish.

Provide gaskets that are spiral-wound, nonasbestos-filled materials, carbon steel, with centering provisions, conforming to ASME B16.5, Group 1.

Provide heavy hex-head carbon steel bolts or bolt studs conforming to ASTM A307, and semifinished heavy hex nuts conforming to ASTM A563, Grade A. Square-head bolts are not acceptable.

2.2.2.4 Type SS-6000

For pipes or tubes 1/2 through 3 inches, provide XXS, seamless, corrosion-resistant steel, conforming to ASTM A312/A312M, Grade TP 316, and ASME B36.10M.

For fittings 1/2 through 1-1/2 inches: 9,000-pound, provide socket-welded, forged corrosion-resistant steel conforming to ASTM A182/A182M, Grade F 316, and ASME B16.11.

For fittings 2 through 3 inches, provide XXS, long-radius, butt-welded, corrosion-resistant steel conforming to ASTM A403/A403M, WP 316, ASME B16.9, and ASME B36.10M.

Provide 1 through 3 inches: 2,500-pound, 6,000-psi, forged corrosion-resistant steel, welding neck flanges conforming to ASTM A182/A182M, Grade F 316, and ASME B16.5, with raised face and concentric serrated finish.

Provide gaskets that are spiral-wound, chloride-ion-free, nonasbestos-filled, corrosion-resistant steel conforming to ASME B16.5, Group 1, with centering provisions.

Provide alloy-steel bolt studs conforming to ASTM A193/A193M, Grade B8, and semifinished heavy hex nuts conforming to ASTM A194/A194M, Grade 8F.

2.2.2.5 Type SS-2000

For pipes or tubes, provide Schedule 40S seamless, corrosion-resistant steel conforming to ASTM A312/A312M, Grade TP 316, and ASME B36.19M.

For fittings 1/2 through 1-1/2 inches: 3,000-pound, provide socket-welded, forged corrosion-resistant steel conforming to ASTM A182/A182M, Grade F 316, and ASME B16.11.

For fittings 2 through 3 inches, provide Schedule 40S, long-radius, butt-welded, corrosion-resistant steel conforming to ASTM A403/A403M, WP 316, and ASME B16.9, and ASME B36.19M.

Provide 1 through 3 inches: 900-pound, 2,160-psi, forged corrosion-resistant steel welding neck flanges conforming to ASTM A182/A182M, Grade F 316 and ASME B16.5, with raised face and concentric serrated finish.

Provide gaskets that are spiral-wound, chloride-ion-free, nonasbestos-filled, corrosion-resistant steel conforming to ASME B16.5, Group 1, with centering provisions.

Provide corrosion-resistant steel bolt studs conforming to ASTM A193/A193M, Grade B8, and semifinished heavy hex nuts conforming to ASTM A194/A194M, Grade 8A.

2.2.2.6 Type SS-350

For pipes or tubes 1/2 through 10 inches, provide Schedule 40S, seamless, corrosion-resistant steel conforming to ASTM A312/A312M, Grade TP 316, and

ASME B36.19M.

For fittings 1/2 through 1 inch: 3,000-pound, provide socket-welded, forged corrosion-resistant steel conforming to ASTM A182/A182M, Grade F 316, and ASME B16.11.

For fittings 1 through 10 inches, provide Schedule 40, long-radius, butt-welded, corrosion-resistant steel conforming to ASTM A403/A403M, WP 316, and ASME B16.9.

Provide 1 through 10 inches: 300-pound, 720-psi, forged corrosion-resistant steel welding neck flanges conforming to ASTM A182/A182M, Grade F 316, and ASME B16.5, with raised face and concentric serrated finish.

Provide gaskets that are spiral-wound, chloride-ion-free nonasbestos-filled, corrosion-resistant steel conforming to ASME B16.5, Group 1, with centering provisions.

Provide heavy hex-head, corrosion-resistant steel bolts or bolt studs conforming to ASTM A193/A193M, Grade B8, and semifinished, heavy hex nuts conforming to ASTM A194/A194M, Grade 8A. Square-head bolts are not acceptable.

2.2.3 Miscellaneous Materials

2.2.3.1 Bolting

For general-purpose bolting, use hex-head bolts conforming to ASTM A307. Ensure that heavy hex nuts conform to ASME B18.2.2. Square-head bolts and nuts are not acceptable.

2.2.3.2 Elastomer Caulk

Use a two-component, polysulfide- or polyurethane-base, elastomer caulking material conforming to ASTM C920.

2.2.3.3 Escutcheons

Manufacture chrome-plated escutcheons from nonferrous metals except when AISI 300 series corrosion-resistant steel is provided. Ensure that the metals and finish conform to FS WW-P-541.

Use one-piece or split-pattern escutcheons. Ensure that the escutcheons have provisions for internal spring-tension devices or setscrews to maintain a fixed position against a surface.

2.2.3.4 Flashing

Provide sheet lead conforming to ASTM B749, Grade B, C, or D, and weighing not less than 4 pounds per square foot.

Provide sheet copper conforming to ASTM B370, and weighing not less than 16 ounces per square foot.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General

Fabricate and install piping systems in accordance with the requirements of the following codes and standards except as supplemented and modified by these specifications:

a. ASME B31.3

b. MSS SP-69

c. ASME BPVC SEC II-C, for applicable materials and procedures not specified herein

d. AWS WHB-2.9, for applicable materials and procedures not specified herein

Strict compliance is required for all systems work except where the drawings and specification require better materials and methods of installation than the minimum requirements set forth in the code or standard. In all cases, the drawings and specifications supersede code and standards requirements.

Ensure that the installation of piping systems materials conforms to the published or written instructions of the manufacturer for the project application except as otherwise specified herein.

When proposing to deviate from specified instructions, submit the proposed deviation to the Contracting Officer for approval.

Conduct work in the presence of the Contracting Officer. Notify the Contracting Officer 48 hours before start of the work.

Ensure that piping is permanently identified in accordance with PFI ES 11. Locate identification at points designated by the Contracting Officer and ensure that identification is marked legibly and conspicuously with yellow fluorescent aerosol paint.

Coordinate the exact location of piping among trades so that there is no interference with lighting fixtures, piping, ducts, or other construction.

Fabricate pipe to measurements established on the job, and carefully work the piping into place without springing or forcing. Make adequate provision for absorbing all expansion and contraction without undue stress in any part of the system.

Ensure that pipes, tubing, fittings, valves, equipment, and accessories are clean and free of all foreign material before installed in their respective systems. Clean pipe by hammering, shaking, or swabbing, or by a combination of those methods. Purge lines with dry, oil-free compressed air after erection, but do not rely on purging for removing all foreign matter. Purge the lines at a velocity in excess of the maximum normal-flow velocity and as approved by the Contracting Officer. During the progress of construction, properly protect open ends of pipes, fittings, and valves at all times to prevent the admission of foreign matter. Place plugs and caps in the ends of installed work at all times, except when connections are being made. Provide commercially manufactured plugs and caps, unless otherwise approved by the Contracting Officer.

3.1.2 Underground Piping Systems

Install compressed-air systems in accordance with the requirements specified herein.

Ensure that the excavations are dry and clear of extraneous materials when pipe is being laid.

Blocking and wedging of the pipe is not permitted.

For underground piping that is below a supported or suspended slab, support the pipe from the slab with a minimum of two supports per length of pipe. Protect supports with a coating of bitumen.

Pipes passing through walls below grade and the ground floor slab require pipe sleeves as indicated.

Where pipe penetrates earth or concrete grade, expose to view at least 12 inches of polyethylene-coated Type BCS-PS pipe. Provide additional piping protection for concrete penetration points as indicated.

Install Type BCS-PS materials in accordance with the applicable requirements specified herein for underground piping and aboveground piping. Palletize pipe in padded pallets at the factory and handle from pallet to final position with padded gear. Protect surfaces from the sun with black polyethylene sheeting. Before lowering pipe into a trench, check sheeting for continuity with 10,000 volts applied by a continuity detector with an audible alarm. In the trench, after joints and fittings are made, check previously untested surfaces for continuity. Where discontinuities in thermoplastic sheeting are found, remove and replace at least 12 inches of material upstream and downstream of the fault.

Distinctly mark and promptly remove defective materials from the site.

3.1.3 Aboveground Piping Systems

Install piping straight and true with approved offsets around obstructions, expansion bends, or fitting offsets and as necessary to increase headroom or to avoid interference with the building construction, electric conduit, or facilities equipment.

Make branch connections with either welding tees or forged branch outlet fittings, within the limitations of the cited codes and standards. Ensure that branch outlet fittings, where used, are forged, flared for improved flow where attached to the run, reinforced against external strains, and designed to withstand full pipe-bursting strength requirements.

Provide horizontal piping with a grade of 1 inch per 100 feet.

Use eccentric reducers where required to permit proper drainage of pipe lines. Bushings are not permitted for this purpose. Provide drain valves where indicated.

Install piping in a manner that prevents stresses and strains from being imposed upon connected equipment.

3.1.3.1 Pipe Bending

Configure expansion bends as indicated. Construct expansion U-bends that are cold-sprung and welded into the line. Anchor the expansion U-bend before removing the spreader. Ensure that the amount of cold spring is as indicated.

Use standard long-sweep pipe fittings for changes in direction. No mitered joints or unapproved pipe bends are permitted.

Shop-make pipe bends by the sand-filled, hot-bending process provided:

a. Bend radius is not less than 6 times the nominal pipe diameter.

b. Fabrication tolerances are in accordance with PFI ES 3 for the applicable wall thickness.

c. Preheat and postheat treatment procedures, where applicable, are in accordance with cited standards.

d. After bending operations, piping is cleaned with a turbine cutter assembly followed by shot or sand-blasting

e. All operations are performed to preclude detrimental wall thickness reduction.

f. The fabricating shop is a member of the Pipe Fabricating Institute and is approved by the Contracting Officer.

3.1.3.2 Joints

Ensure that field-welded joints conform to the requirements of the AWS WHB-2.9 and ASME B31.3.

Piping systems rated at 2,000 psi and higher require butt weld joints made with consumable insert rings, using inert-gas tungsten-arc root pass welding together with inert-gas purging of inside diameter of pipe. Ensure that consumable insert ring materials are compatible with all materials being joined. Ensure that joint configuration conforms to PFI ES 21. Provide root pass joint preheat treatment at temperatures necessary to avoid cracking.

Piping systems rated at 350 psi and lower require butt weld joints made with backing rings. Ensure that the backing ring materials are compatible with materials being joined. Ensure that the joint configuration conforms to ASME B16.25.

Perform preheat and postheat treatment of welds in accordance with ASME BPVC SEC IX.

Perform preheat and postheat treatment of welds in accordance with ASME B31.3.

Assemble flanged joints with appropriate flanges, gaskets, and bolting. Create sufficient clearance between flange faces to ensure that the connections can be gasketed and bolted tight without imposing undue strain on the piping system. Ensure that flange faces are parallel and the bores concentric; center gaskets on the flange faces without projecting into the bore. Lubricate bolting with oil and graphite before assembly to ensure uniform bolt stressing. Draw up and tighten flange bolts in staggered sequence in order to prevent unequal gasket compression and deformation of the flanges. After testing the piping system, retighten bolts to provide required gasket stress.

3.1.3.3 Supporting Elements Installation

Provide supporting elements in accordance with the requirements of cited codes and standards, except as supplemented or modified herein.

Hang piping from building construction. Hang no piping from the roof deck or from other piping.

Ensure that attachment to building construction concrete is by approved cast-in concrete inserts or by built-in anchors. Where attachment by either of the above methods is not practical, specified masonry anchor devices may be used upon receipt of written approval from the Contracting Officer.

Embed fish plates in the concrete to transmit hanger loads to the reinforcing steel where hanger rods exceed 7/8 inch in diameter.

Construct masonry anchors selected for overhead applications of ferrous materials only.

Pneumatic tools are not allowed. Select percussive-action electric hammers, and combination rotary-electric hammers used for the installation of self-drilling anchors in accordance with the following guide:

a. Anchor devices, with nominal sizes 1/4 through 1/2 inch, may be hammer-type only or combination rotary-hammer type and rated at load to draw not more than 5.0 to 5.5 amperes when operating on 120-volt, 60-hertz power.

b. Anchor devices, with nominal sizes 5/8 inch and larger, hammer-type only, rated at load to draw not more than 8.0 amperes when operating on 120-volt, 60-hertz power. Ensure that combination rotary-hammer tools on the same power supply have a full-load current rating not to exceed 10 amperes.

Size the inserts and anchors for the total stress applied. Use a safety factor as required by applicable codes, but in no case have a safety factor of less than 4. Submit complete shop drawings.

Insert anchor devices into concrete sections at least twice the overall length of the device, and locate the anchor devices at least the following distance from any side or end edge or centerline of adjacent anchor service:

Anchor Bolt Size	1/4	5/16	3/8	1/2	5/8	3/4	7/8	Inches
Minimum Edge *	3-1/4	3-1/2	4	5	6	7	8	Space Inches

* Except where manufacturer requires greater distance.

In special circumstances, with prior written approval of the Contracting Officer, the center-to-center distance may be reduced to 50 percent of the given distance, provided that the load on the device is reduced in direct proportion to the reduced distance.

Run new piping parallel with the lines of the building. Space and install the piping and components so that there is at least 1/2 inch of clear space between the finished surface and other work and between the finished surfaces of parallel adjacent piping.

For installation of parallel pipe runs, allow for a tool space around mechanical connections. Where it is necessary to avoid any transfer of load from support to support or onto connecting equipment, use constant-support pipe hangers.

Weld anchors and pipe-alignment guides to the piping in accordance with requirements specified herein, and attach them to the building structure in a manner indicated or approved by the Contracting Officer.

Brace piping against reaction, sway, and vibration. Bracing consists of hydraulic and spring devices, brackets, anchor chairs, rods, and structural steel.

Locate pipe lines, when supported from roof purlins, not greater than one-sixth of the purlin span from the roof truss. The load per hanger cannot exceed 400 pounds when support is from a single purlin, or 800 pounds when a hanger load is applied halfway between purlins by means of auxiliary support steel supplied by the piping Contractor. When support is not halfway between purlins, the allowable hanger load is the product of 400 times the inverse ratio of the longest distance to purlin-to-purlin spacing.

When the hanger load exceeds the above limits, furnish and install reinforcing of the roof purlins or additional support beam(s). When an additional beam is used, ensure that the beam bears on the top chord of the roof trusses, and the bearing is over the gusset plates of the top chord. Stabilize the beam by connection to the roof purlin along the bottom flange.

Install hangers and supports for piping at intervals specified herein at locations not more than 3 feet from the ends of each runout and not over 25 percent of specified interval from each change in direction of piping.

Base the load rating for all pipe hanger supports on weight and forces imposed on all lines. Deflection per span cannot exceed the slope gradient of the pipe. Ensure that Schedule 40 and heavier pipe supports are in accordance with the following minimum rod size and maximum allowable hanger spacing; concentrated loads reduce the allowable span proportionately:

PIPE SIZE INCHES	ROD SIZE INCHES	HANGER SPACING FEET
1/2 and smaller	3/8	5
3/4 to 1	3/8	6
1-1/4 to 1-1/2	3/8	9
2	1/2	10

PIPE SIZE INCHES	ROD SIZE INCHES	HANGER SPACING FEET
2-1/2 to 3	1/2	12
4 to 5	5/8	15
6	3/4	16
8 to 12	7/8	20

Support vertical risers independently of connected horizontal piping wherever practical, and guide for lateral stability. Provide only one rigid support for risers subject to expansion.

After the piping systems have been installed, tested, and placed in satisfactory operation, tighten hanger rod nuts and jam nuts to prevent any loosening.

3.1.3.4 Sound Stopping

Provide effective sound stopping and adequate operating clearance to prevent structure contact where pipes penetrate walls, floors, or ceilings. Where penetrations occur from pipe chases into occupied spaces, provide a special acoustic treatment of the ceiling. Occupied spaces include space above ceilings where no special acoustic treatment of ceiling is provided. Ensure the penetrations are compatible with the surface being penetrated.

Lead wool and viscoelastic damping compounds may be proposed for use where other sound-stopping methods are not practical, provided that the temperature and fire resistance characteristics of the compound are suitable for the service.

3.1.3.5 Sleeves

Supply and install sleeves where the piping passes through roofs, through masonry or concrete walls, and through floors.

Where pipe sleeves are required after slabs and masonry are installed, make holes to accommodate these sleeves with core drills. Set sleeves in place with a two-component epoxy adhesive system approved by the Contracting Officer. Ensure that no load is carried by such sleeves unless approved by the Contracting Officer.

Install sleeves flush with ceilings and where indicated.

Install sleeves flush with the floor in finished spaces, and extend sleeves 2 inches above the floor in unfinished spaces.

Continuously weld or braze sleeves passing through steel decks to the deck.

For sleeves extending through floors, roofs, load-bearing walls, and fire barriers, ensure that the sleeves are continuous and fabricated from Schedule 40 steel pipe with welded anchor lugs. Form other sleeves from molded linear polyethylene liners or similar removable materials. Ensure that the diameter of the sleeve is large enough to accommodate the pipe, isolation, and sealing materials with a minimum of 3/8-inch clearance. Install the sleeves to accommodate the mechanical and thermal motion of pipe.

Pack solid the space between a pipe and the inside of a pipe sleeve, or a construction surface penetration, with a mineral fiber conforming to ASTM C553, wherever the piping passes through firewalls, equipment room walls, floors, and ceilings connected to occupied spaces, and other locations where sleeves or construction surface penetrations occur between occupied spaces. Where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces, fill the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration with an elastomer caulk to a depth of 1/2 inch. Ensure that all caulked surfaces are oil- and grease-free.

Caulk the exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed metal components.

3.1.3.6 Escutcheons

Provide escutcheons at all pipe penetrations into finished areas. Where finished areas are separated by partitions through which piping passes, provide escutcheons on both sides of the partition. Where suspended ceilings are installed, provide plates at the underside only of such ceilings. In all occupied spaces, provide chrome-plated escutcheons that fully conceal openings in building construction. Firmly attach all escutcheons, preferably with setscrews.

3.1.3.7 Flashings

Provide all required flashings where mechanical systems penetrate building boundaries as indicated.

3.2 FIELD QUALITY CONTROL

3.2.1 System Pressure Test

Before acceptance of the work, pressure-test the completed systems in the presence of the Contracting Officer.

Perform pneumatic tests using dry, oil-free compressed air, carbon dioxide, or nitrogen as specified for the system under test. Conduct pressure testing in two stages; i.e. preliminary and acceptance.

Perform hydrostatic tests. Use only potable water for testing. The Government will supply testing water at a location determined by the Contracting Officer, but the Contractor is responsible for the approved disposal of contaminated water. Ensure that the temperature of the water used for testing does not cause condensation on system surfaces. Provide supplementary heat if necessary.

Do not perform pressure tests in excess of 5 psi until personnel not directly involved in the tests are evacuated from the area.

Contractor may conduct tests for its own purposes, but preliminary tests and acceptance tests are conducted as specified herein.

System testing includes preliminary tests by applying internal pressures exceeding 5 psi, swabbing all joints under test with a high-film-strength soap solution, and observing for bubbles.

If testing reveals that leakage exceeds specified limits, isolate and repair the leaks, replace defective materials where necessary, and retest the system until specified requirements are met. Remake leaking gasket joints with new gaskets and new flange bolting. Do not use removed bolting and gaskets again.

Regardless of the amount of measured leakage, immediately repair visible leaks or defects in the pipeline.

Only use standard piping flanges, plugs, caps, and valves for sealing off piping for test purposes.

Vent compressed air trapped during high-pressure hydrostatic testing to preclude injury and damage. If purging or vent valves are not provided, the Contracting Officer may require the removal of any system component, such as plugs and caps, in order to verify that water has reached all parts of the system.

Remove components from piping systems before testing whenever the component would otherwise sustain damage due to test pressure.

Check piping system components such as valves for proper operation under system test pressure.

Add no test media to a system during a test for a period as specified or to be determined by the Contracting Officer.

The test duration will be determined by the Contracting Officer. Test may be terminated by direction of the Contracting Officer at any point during a 24-hour period after it has been determined that the permissible leakage rate has not been exceeded.

Upon completion of testing, drain the dry piping system and purge it with dry air. Verify system dryness by hygrometer comparison with purging air.

3.2.1.1 Acceptance Pressure Testing

Conduct testing during steady ambient temperature conditions.

3.2.1.2 Test Report

Prepare, maintain, and submit test records of piping systems tests for approval. Ensure that records show Government and Contractor test personnel responsibilities, dates, test gage identification numbers, ambient temperatures, pressure ranges, rates of pressure drop, and leakage rates. Each acceptance test will be signed by the Contracting Officer. Deliver two record copies to the Contracting Officer after acceptance.

3.2.2 Test Gages

Ensure that the test gages conform to ASME B40.100 and have a dial size 8 inches or larger. The maximum permissible scale range for a given test is such that the pointer has a starting position at midpoint of the dial or within the middle third of the scale range. Ensure that the certification of accuracy and correction table bear a date within 90 calendar days before the test date and show the test gage number and the project number, unless otherwise approved by the Contracting Officer.

3.2.3 Support Element Testing

Test systems containing hydraulic or spring shock absorbers for the ability to accommodate system forces by manipulation of system components as directed by the Contracting Officer. Include results with the piping system test report.

-- End of Section --

SECTION 22 15 14.00 40

GENERAL SERVICE COMPRESSED-AIR SYSTEMS, LOW PRESSURE
11/17

PART 1 GENERAL

Section 40 17 30.00 40 WELDING GENERAL PIPING applies to work specified in this section.

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.18.1/CSA B125.1	(2018) Plumbing Supply Fittings
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.1	(2020) Power Piping
ASME B31.3	(2020) Process Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASME BPVC	(2010) Boiler and Pressure Vessels Code
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C504	(2015) Standard for Rubber-Seated Butterfly Valves

AMERICAN WELDING SOCIETY (AWS)

AWS WHB-2.9	(2004) Welding Handbook; Volume 2, Welding Processes, Part 1
AWS-03	(2011) Welding Handbook, Volumes 1 thru 4

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A197/A197M	(2000; R 2019) Standard Specification for Cupola Malleable Iron
ASTM A216/A216M	(2021) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A278/A278M	(2001; R 2020) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A395/A395M	(1999; R 2018) Standard Specification for

	Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM A436	(1984; R 2020) Standard Specification for Austenitic Gray Iron Castings
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A666	(2015) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B61	(2015; R 2021) Standard Specification for Steam or Valve Bronze Castings
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B148	(2014) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B370	(2022) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B584	(2014; R 2022) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B733	(2015) Standard Specification for Autocatalytic (Electroless) Nickel-Phosphorus Coatings on Metal
ASTM B749	(2020) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C592	(2022a) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2239	(2012) Standard Specification for

	Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

CAGI B19.1	(2010) Safety Standard for Compressor Systems

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2017; Errata 1 2017) Butterfly Valves
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1922	(Rev A; Notice 3) Shield, Expansion (Caulking Anchors, Single Lead)
CID A-A-1923	(Rev A; Notice 3) Shield, Expansion (Lag, Machine and Externally Threaded Wedge Bolt Anchors)
CID A-A-1924	(Rev A; Notice 3) Shield, Expansion (Self Drilling Tubular Expansion Shell Bolt Anchors
CID A-A-55614	(Basic; Notice 2) Shield, Expansion (Non-Drilling Expansion Anchors)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G[, [____]]

SD-03 Product Data

Equipment and Performance Data; G[, [____]]

Underground Piping Materials; G[, [____]]

Aboveground Piping Materials; G[, [____]]

Piping Specialties; G[, [____]]

Supporting Elements; G[, [____]]

Air Compressors; G[, [____]]

Valves; G[, [____]]

Accessories; G[, [____]]

Miscellaneous Materials; G[, [____]]

SD-05 Design Data

Design Analysis and Calculations; G[, [____]]

SD-06 Test Reports

Piping System Test Report

SD-07 Certificates

Underground Piping Materials

Aboveground Piping Materials

Supporting Elements

Valves

Miscellaneous Materials

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 QUALITY CONTROL

1.3.1 Predictive Testing and Inspection Technology Requirements

This section contains systems or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with the RCBEA GUIDE to ensure that building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit installation drawings for low-pressure compressed air systems in accordance with the paragraphs titled ABOVEGROUND PIPING MATERIALS and UNDERGROUND PIPING MATERIALS.

Accompany drawings with curves indicating that an essentially flat reduced-pressure curve for the capacity demand of the system is met by the proposed valves.

In lieu of separate hangers, a shop drawing of trapeze hangers with solid or split-ring clamps may be submitted for approval.

2.1.1 Design Requirements

Provide equipment and performance data submitted for piping systems showing conformance with ASME Code.

Provide design analysis and calculations for low-pressure compressed air systems that have flow rates, air distribution, pressure, and insulation that meet the requirements of the standards cited in this section.

2.2 EQUIPMENT

2.2.1 Piping Specialties

2.2.1.1 Air-Pressure-Reducing Stations

Install a pressure-reducing station complete with a relieving pressure-reducing valve, valve bypass, particle filter, pressure indicator upstream of station, pressure indicator downstream of station, and regulated air-pressure relief valve.

Construct the pressure regulator body of zinc or aluminum die castings that are rated for the service. Use a diaphragm material that is a reinforced air-, oil-, and water-resistant elastomer. Ensure that all components exposed to the fluid stream being controlled are made of [nonferrous] [suitable nonmetallic] materials. Ensure that valves are a balanced construction-relieving type that will automatically prevent excess pressure buildup.

Construct filters of [zinc] [aluminum] die castings, rated for the service, and furnished with iron pipe size (ips) connections. Ensure that bowl materials are aluminum and that the filter is serviceable by bowl quick-disconnect devices. Equip the bowl with a manual drain cock.

Separate liquid particles by centrifugal and quiet zone action. Remove solid particles up to 15 micrometers by filter elements of [sintered bronze] [corrosion-resistant steel] mesh.

[Combination manual drain filter-regulator units conforming to the above requirements are acceptable in lieu of separate units.

] Provide pressure-relief valves rated for the pressure experienced on the high-pressure side and sized for the full installed capacity of the pressure regulating station at the pressure experienced on the low-pressure side. Set the valve so that the pressure does not exceed the correct low-side pressure by greater than [20] [_____] percent. Rate and label the valve. Ensure that the seat material is suitable for the service.

2.2.1.2 Air Line Lubricators

Install air line lubricators that feed the lubricant in pulses and that have a pickup tube, polycarbonate resin bowl, large fill opening, metering rod flow adjuster, sight ball, and drain cock.

Use lubricators suitable for 200 psig at 165 degrees F.

2.2.1.3 Compressed-Air Receivers

Ensure that the compressed air receivers conform to the sizes and capacities specified. Design such vessels for working pressures and service in accordance with the ASME BPVC SEC VIII D1, and label the receivers with this information.

Provide complete vessels, with connections for drain, supports, and other required accessories.

2.2.1.4 Grooved Pipe Couplings and Fittings

Fabricate the housing for couplings in at least [two] [_____] parts of [malleable] [ductile] iron castings. Provide molded synthetic rubber coupling gaskets conforming to ASTM D2000. Provide oval-neck track-head coupling bolts with hexagonal heavy nuts, conforming to ASTM A183.

Fabricate pipe fittings used with couplings of [malleable] [ductile] iron castings. Where a manufacturer's standard size [malleable] [ductile] iron fitting pattern is not available, use fabricated fittings.

Fabricate fittings from[Schedule 40][0.375-inch wall] in accordance with ASTM A53/A53M, Grade B, seamless steel pipe. Ensure that the wall thickness of the long-radius seamless welding fittings match the wall thickness of the pipe, and conform to ASTM A234/A234M and ASME B16.9.

2.2.1.5 Pressure Gages

Ensure that the pressure gages conform to ASME B40.100 and are Type I, Class 1, (pressure) for the pressures indicated. Provide a pressure gage size that is 3 1/2 inches. Ensure the cases are constructed of corrosion-resistant steel conforming to [the AISI 300 series] [ASTM A666] with an ASM No. 4 standard commercial polish or better. Equip the gages with a damper screw adjustment in the inlet connection.

[Equip the gages with an adjustable, red marking indicator.

]2.2.1.6 Thermometers

Provide the thermometers that conform to ASTM E1 and that are industrial pattern Type I, Class 3. Ensure that thermometers installed [6] feet [_____] or higher above the floor have an adjustable angle body. Ensure the scale is at least [7]-inches [_____] long. Ensure the case face is constructed of [the manufacturer's standard polished aluminum] [AISI 300 series polished corrosion-resistant steel]. Ensure that the thermometer range meets the service requirements. Provide a thermometer with nonferrous separable wells.

2.2.1.7 Line Strainers

Provide [Y-type] [T-type grooved end] strainers with a removable basket. Ensure that strainers of 2 inch ips or smaller have screwed ends and that strainers of 2 1/2 inch ips or larger have flanged ends. Ensure that the body working pressure rating exceeds the maximum service pressure of the system by at least 50 percent. Ensure that the body has cast-in arrows to indicate the direction of flow. Ensure that the strainer bodies fitted with screwed screen retainers have straight threads and are gasketed with nonferrous metal. Ensure that the strainer bodies fitted with bolted-on screen retainers have offset blowdown holes. Fit strainers larger than 2 1/2 inches with the manufacturer's standard blowdown valve. Provide [cast bronze conforming to ASTM B62] [cast iron conforming to ASTM A278/A278M Class 30] [ductile iron conforming to ASTM A536] body material. Where the system material is nonferrous, provide a nonferrous strainer body material.

Ensure the minimum free-hole area of the strainer element is equal to at least [3.4] [_____] times the internal area of connecting piping. Ensure that the strainer screens for air service have a mesh cloth smaller than [0.006] inch [_____] and that the screens have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Ensure that the strainer element material is [AISI Type [304] [316] corrosion-resistant steel] [Monel metal].

2.2.2 Air Compressors

Provide a standard piston air compressor complete with air tank, [air dryer,][air cooler,] and other appurtenances. Ensure that the compressor and installation conforms to CAGI B19.1. Ensure that the compressor capacity is as required for service and provide continuous control air when operating on a 1/3-on 2/3-off cycle. Provide an oil-level sight indicator on the compressor and a coalescing oil filter on the compressor discharge line. [Provide [continuous-duty silica-gel air dryers with reactivation] [mass-refrigerated air dryer] that maintain the air in the system with a dew point low enough to prevent condensation at 13 degrees F at 18 psi main pressure. Locate the air dryer at the outlet of the tank.] Ensure that the control air delivered to the system conforms to ISA 7.0.01.

2.2.3 Valves

2.2.3.1 Ball Valves (BAV)

Ensure that ball valves conform to MSS SP-72 and are Style [1] [3].

Ensure that grooved end ball valves are used only if the manufacturer certifies valve performance in accordance with MSS SP-72.

Provide valves rated for service at [175] [_____] or more psi at [200]

[_____] degrees F.

For valve bodies of 2 inch ips or smaller, use screwed end connections constructed of Class A copper alloy.

For valve bodies in sizes 2 1/2 inch ips or larger, use flanged-end connections constructed of Class [D] [E] [F] material.

Provide balls and stems for valves 2 inch or smaller ips are [the manufacturer's standard Class A copper alloy with 900 Brinell hard chrome plating finish] [Class C corrosion-resistant steel alloy with hard chrome plate]. Ensure that electroless nickel plating conforms to ASTM B733.

Provide balls and stems for valves 2-1/2 inch or larger ips are the manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome plate. For valves 6 inch or larger ips, ensure that balls are Class D with 900 Brinell hard chrome plate. Ensure electroless nickel plating conforms to ASTM B733.

Design valves that allow flow from either direction and that will seal equally tight in either direction.

Ensure that valves have flow areas that are the same size as the pipe flow area.

Do not provide valves with ball seals kept in place by spring washers. Ensure that all valves have adjustable packing glands. Use tetrafluoroethylene seats and seals.

Ensure that valve body construction is such that torque from a pipe with a valve in installed condition does not tend to disassemble the valve by stripping setscrews or by loosening body end inserts or coupling nuts. Ensure that torque from a pipe is resisted by a one-piece body between end connections or by bolts in shear where the body has a mating flange or surface-bolted construction.

2.2.3.2 Butterfly Valves (BUV)

Ensure that butterfly valves conform to MSS SP-67.

Use grooved end butterfly valves in services to 230 degrees F provided the manufacturer certifies valve performance in accordance with MSS SP-67.

For mounting between specified flanges, use wafer type butterfly valves that are rated for 150 psig shutoff and nonshock working pressure. Select a cast ferrous metal body conforming to ASTM A126, Class B, and to ASME B16.1 for body wall thickness.

Provide valves installed in insulated piping systems with extended bonnets, placing the operator beyond the specified insulation.

Ensure that butterfly valves used in buried piping systems conform to requirements of AWWA C504, Class 150B, with integrally cast flanges and a manual worm gear operator. [Design and construct valves for buried or 20-foot head submerged service in brackish water.]Ensure that flanged ends conform to the requirements of ASME B16.1. Ensure that valve operation requires at least [20] [_____] turns for full closure of the valve with an input effort of [50] [_____] foot-pounds of torque. Coat the external surfaces with a bituminous sealer conforming to AWWA C104/A21.4.

Ensure that the valve boxes are at least [3/16] inch [_____] thick-cast-iron construction with locking cover with an identification legend. Install adjustable extension boxes with a [screw] [slide] adjustment. Fit valves 3 inches and under with a 4 1/4 inch diameter shaft and valves 4 inches or larger, fitted with a 5 1/4 inch shaft. Fit the bases to the valve. Ensure that the fullyextended length of the box exceeds the depth of cover by at least 4 inches. Supply one valve operating wrench for each size valve nut. Provide guide rings where operating rods are longer than 6 feet. Coat internal and external surfaces with a bituminous sealer in accordance with AWWA C104/A21.4.

Ensure that the disk is free of external ribs and streamlined. Fabricate the disk from cast [ferrous] [nonferrous] alloys conforming to [ASTM A126 for Class B, cast iron] [ASTM A436 for Type [1] [2] copper-free austenitic cast iron] [ASTM A216/A216M for Grade WCB cast steel] [ASTM A395/A395M and ASTM A536 for ductile iron] [ASTM B62] [ASTM B584] [ASTM B148].

Do not use taper pins to secure the valve disk to the shaft.

Fabricate shafts from [AISI 300 series] [17-4 PH corrosion-resistant steel] [nickel copper alloy conforming to ASTM B164]. Shafts may be [one-piece] [stub-shaft]. Extend stub shafts into the disk hub to at least 1-1/2 times the shaft diameter except where angle disk construction is used. Design the connection between the valve shaft and disk so that it transmits shaft torque equivalent to at least [75] [_____] percent of the torsion strength of the minimum required shaft diameter. Ensure that the minimum nominal shaft diameter for all valves is in accordance with the following:

VALVE SIZE INCHES	SHAFT DIAMETER INCHES	VALVE SIZE INCHES	SHAFT DIAMETER INCHES
2 1/2	7/16	10	1 1/8
3	1/2	12	1 1/4
4	5/8	14	1 1/2
5	11/16	16	1 5/8
6	3/4	18	1 7/8
8	7/8	20	2 1/8

Use resilient elastomer seats and seals designed for field removal and replacement. Provide [Buna-N] [ethylene propylene terpolymer] [chloroprene] [_____] elastomers formulated for continuous immersion service at [225] degrees F [_____] minimum. Apply at least [10] [_____] percent below the maximum continuous service temperature. Apply bonding adhesives that comply with elastomer temperature requirements and that have an effective life equal to or greater than that of the elastomer.

Design seals to be used on 20 inch and smaller valves with [standard split V packing] [dual O-rings] [quad rings] [an adjustable pulldown].

If seats are installed in the valve body or on the disk, do not use circular cross-section O-ring construction.

Ensure that seat or disk mating surfaces are corrosion-resistant material, and are [welded to substrate and ground] [mechanically retained]. Do not use plated or similarly applied surfacing materials.

Ensure that bearings are the permanently lubricated sleeve type of [manufacturer's standard corrosion-resistant steel][bronze][nickel-copper alloy][nylon][filled tetrafluoroethylene]. Ensure that the bearings are designed for [a pressure not exceeding the published design load for the bearing material] [one-fifth of the compressive strength of the bearing or shaft material]. Provide the operating end of the shaft with [dual inboard bearings] [a single inboard and an outboard bearing in or beyond the operator].

Provide a padlocking feature to make the valve tamperproof.

For balancing service, ensure that valve operators are capable of infinite position locking.

Provide manual nonchain-operated valves up to 8 inches with lever lock handles that have at least nine positions and that do not exceed [18] inches [_____] in length.

Provide manual valves with gear operators when the valves are 10 inches or larger, or smaller if the application torque exceeds a pull of [80] pounds [_____].

Where valves are indicated to be chain-operated, equip all sizes with gear operators, and ensure that the chain lengths are suitable for proper stowage and operation.

Use worm-gear operators. Totally enclose the operator in a cast-iron housing suitable for grease or oil lubrication. Ensure that the gears are "hobcut." Ensure that cast-iron-housed traveling-nut operators conform to AWWA C504. Size the operators to provide the required static or dynamic torque, with a maximum manual pull of [80] pounds [_____] on the handwheel or chain wheel.

Provide modulating or remotely actuated two-position service valves with pneumatic operators, pilot positioners, valve position indicators, and boosters and relays.

Maximum load on a pneumatic operator cannot exceed [85] [_____] percent of rated operator capacity.

2.2.3.3 Diaphragm Control and Instrument Valves (DCIV)

Ensure that 1/4 and 3/8 inch diaphragm valves have a forged brass body with a reinforced tetrafluoroethylene diaphragm, AISI 300 series corrosion-resistant steel spring.

2.2.3.4 Gage Cocks (GC)

Provide T-head or lever handle ground key gage cocks, with washer and screw, constructed of polished ASTM B62 bronze, and rated for125 psi saturated steam service. Ensure that end connections suit the service, with or without a union and nipple.

2.2.3.5 Gate Valves (GAV)

Ensure that gate valves 2 inches or smaller conform to MSS SP-80. Ensure that the packing is woven nonasbestos material that is at least [25][_____] percent, by weight, impregnated with tetrafluoroethylene resin.

Provide gate valves 2 1/2 inches or larger that are Type I, Class 1, conforming to MSS SP-70. Install flanged valves, with bronze trim and outside screw and yoke (OS&Y) construction. Ensure that the packing is woven nonasbestos material that is at least [25][_____] percent, by weight, impregnated with tetrafluoroethylene resin.

2.2.3.6 Globe and Angle Valves (GLV and ANV)

Ensure that globe and angle valves 2 inches and smaller conform to MSS SP-80. For tunnels, equipment rooms, or factory-assembled equipment, provide union-ring bonnet, screwed-end valves. Ensure that the disk is free to swivel on the stem in all valve sizes. A composition seating surface disk construction may be substituted for all metal disk construction.

Ensure that the globe and angle valves 2 1/2 inches and larger conform to MSS SP-80. Provide valve bodies of cast iron conforming to ASTM A126, Class A, as specified for Class 1 valves under MSS SP-70. Provide flange valve ends that conform with ASME B16.1, and ensure that outside stem and yoke (OS&Y) valves are used.

For packing, use a woven material that is at least 25 percent, by weight, impregnated with tetrafluoroethylene resin.

2.2.3.7 Eccentric Plug Valves (EPV)

Provide eccentric plug valves in sizes 2 inches and smaller constructed of [manufacturer's standard brass] [bronze materials conforming to [ASTM B61] [ASTM B62]] [cast iron conforming to ASTM A126, Class B]. Ensure that the valves are rated for service at 175 psi maximum nonshock pressure at 200 degrees F. Use a valve body with [screwed] [grooved] ends. Coat eccentric plug surfaces in contact with flow with a 60 to 70 Shore A durometer hardness elastomer resistant to compressed air.

Ensure that material for eccentric plug valves in sizes 2 1/2 inches or larger consists of [Type 2 nickel alloy iron conforming to ASTM A436] [cast iron conforming to ASTM A126]. Ensure that the valves are rated for service at 175 psi maximum nonshock pressure at200 degrees F. Use valve bodies with [screwed] [grooved] ends. Coat eccentric plug surfaces with a 60 to 70 Shore A durometer hardness elastomer that is resistant to compressed air. For specified applications, in sizes to 5 inch ips, the cross-sectional area of the valve bore, when open, equals the pipe inlet area. Ensure that the valves used for combination shutoff and balancing service are fitted with a memory device. Provide a memory device or mechanism that permits a valve set at a balance point to be opened or closed, but not beyond the balance point. Fit valves up to 6 inch ips with a removable lever operator. Fit valves of 6 inch ips or larger, with a totally enclosed flood-lubricated worm gear drive such that the operating torque does not exceed [50] [_____] foot-pounds.

2.3 MATERIALS

2.3.1 Underground Piping Materials

2.3.1.1 Piping Types

Ensure that BCS-PS black carbon steel piping with a polyethylene sheath conforms to ASTM A53/A53M, Type [E] [S], in sizes through 10 inch ips. For pipe in sizes 12 inches and larger, select Schedule 40 or be 0.375 inch thick.

Make sheath joints with a thermally fitted shrinking sleeves applied with factory-approved shrinking devices. Make taped fitting protection and repairs in accordance with manufacturer's instructions. Ensure that the electrical flaw detection testing at the factory requires 10,000 volts to be impressed across the sheath. Sheath breakdown voltage is at least 13,000 volts.

2.3.1.2 Fittings

Provide long-radius butt-weld carbon steel fittings conforming to ASTM A234/A234M and ASME B16.9 to match pipe wall thickness. Do not use pipe bending. Ensure that aboveground terminal fittings are 150-pound working steam pressure (wsp) forged-steel weld-neck flanges to match the wall thickness, conforming to ASME B16.5 and ASTM A181/A181M Class 60.

2.3.2 Aboveground Piping Materials

2.3.2.1 Compressed Air Systems 125 Psig And Less

a. Type BCS Black Carbon Steel

For pipe 1/8 through 1 1/2 inches provide Schedule 40, furnace butt welded, black carbon steel, conforming to ASTM A53/A53M, Type F, Grade A.

For pipe 2 through 10 inches, provide Schedule 40, [seamless] [electric resistance welded], black carbon steel, conforming to ASTM A53/A53M, Grade B, Type [E] [S]. Use Grade A pipe for permissible field bending.

For pipe 12 inches and over use a a 0.375 inch wall, [provide seamless, black carbon steel, conforming to ASTM A53/A53M, Grade B, Type [E] [S]].

For fittings 2 inches and under, provide 150 (psig) wsp, banded, black malleable iron, screwed, conforming to ASTM A197/A197M and ASME B16.3.

For unions 2 inches and under, provide 250 psig wsp, female, screwed, black malleable iron, with brass-to-iron seat and a ground joint conforming to ASME B16.39. Use ductile iron conforming to ASTM A536 for grooved pipe couplings.

For couplings 2 inches and under, provide [standard weight, screwed, black carbon steel] [ductile iron conforming to ASTM A536].

For fittings 2 1/2 inches and over, provide [steel, butt welded, to match pipe wall thickness, conforming to ASTM A234/A234M and ASME B16.9] [ductile iron conforming to ASTM A536].

For flanges 2 1/2 inches and over, provide 150-psig wsp, forged steel, welding neck to match pipe wall thickness, conforming to ASME B16.5.

For grooved pipe couplings and fittings 2 1/2 inches and over, use malleable iron couplings and fittings conforming to the paragraph PIPING SPECIALTIES.

b. Type GCS Galvanized Carbon Steel

For pipe 1/2 through 10 inches, provide Schedule 40, [seamless] [electric resistance welded], galvanized steel, conforming to ASTM A53/A53M, Grade B, Type [E] [S]. Type F is acceptable for sizes less than 2 inches.

For fittings 2 inches and under, provide 150-psig wsp, [banded, galvanized, malleable iron, screwed, conforming to ASTM A197/A197M, ASME B16.3] [ductile iron conforming to ASTM A53/A53M and ASTM A536].

For fittings 2 1/2 inches and over, provide 125 psig wsp, cast-iron flanges and [flanged fittings, conforming to ASTM A126, Class A, and ASME B16.1] [ductile iron conforming to ASTM A53/A53M and ASTM A536].

For unions 2 inches and under, provide 300 psig wsp, female, screwed, galvanized, malleable iron with a brass-to-iron seat and a ground joint.

2.3.2.2 Control and Instrumentation Tubing, to 30 psig

a. Copper

For tubing with a 1/4 inch minimum outside diameter use [hard-drawn] [annealed] seamless copper, in accordance with ASTM B280.

Provide solder joint wrought copper fittings conforming to ASME B16.22.

Use a compression ball sleeve, [rod] [forged brass], conforming to SAE [72] [88], UL-approved, with a minimum pressure rating of 200 psi at 100 degrees F.

Use solder that is 95-5 tin-antimony, alloy Sb 5, conforming to AWS WHB-2.9.

Copper tubing systems may be installed using bolted mechanical pipe couplings with a central cavity design pressure responsive gasket. Groove copper pipe and fittings in accordance with the coupling manufacturer's recommendations.

b. Polyethylene

Use tubing constructed of black virgin polyethylene, conforming to ASTM D2239, Type I, Grade 2, Class C, and conforming to stress-crack tests performed in accordance with ASTM D1693. Ensure that multitube harnesses with polyester film barrier and vinyl jacket are at least [0.062] inch [_____] thick.

Use compression ball sleeve fittings that are manufactured from [brass] [aluminum] [acetal resin].

2.4 ACCESSORIES

2.4.1 Miscellaneous Materials

2.4.1.1 Bolting

For flange and general-purpose bolting, use hex-head bolts and conform to ASTM A307, Grade B. Ensure that the heavy hex-nuts conform to ASME B18.2.2. Square-head bolts are not acceptable.

For grooved couplings, use heat-treated carbon steel bolts and nuts conforming to ASTM A183.

2.4.1.2 Elastomer Caulk

Provide a two-component [polysulfide] [polyurethane-base] elastomer caulking material conforming to ASTM C920.

2.4.1.3 Escutcheons

Provide escutcheons manufactured from nonferrous metals and [chrome plated] [hot-dipped galvanized] except when AISI 300 series corrosion-resistant steel is provided. Select the metals and finish in accordance with ASME A112.18.1/CSA B125.1.

Provide [one-piece] [split-pattern] escutcheons. Ensure that escutcheons maintain a fixed position against a surface by means of internal spring tension devices or setscrews.

2.4.1.4 Flashing

Ensure that the sheet lead conforms to ASTM B749, Grade [B] [C] [D] and weighs at least [4] [_____] pounds per square foot.

Ensure that the sheet copper conforms to ASTM B370 and weighs at least [16] [_____] ounces per square foot.

2.4.1.5 Flange Gaskets

Ensure that the compressed non-asbestos sheet conforms to ASTM F104, Type 1, and is coated on both sides with [graphite] [_____].

Ensure that the gasketing for grooved flange adapters is a pressure-responsive elastomer conforming to ASTM D2000.

2.4.1.6 Pipe Thread Compounds

Use tetrafluoroethylene tape at least [2] [3] mils thick for pipe sizes to and including 1 inch ips.

Tetrafluoroethylene dispersions and other suitable compounds may be used for other applications upon approval by the Contracting Officer.

2.4.2 Supporting Elements

Provide all necessary piping system components and miscellaneous required supporting elements. Ensure that supporting elements are suitable for stresses imposed by system pressures and temperatures, and natural and other external forces.

Ensure that the supporting elements are [FM-approved] [UL-listed] and conform to requirements of ASME B31.3, and MSS SP-58, except as otherwise noted. Type devices specified herein are defined in MSS standards unless otherwise noted.

2.4.2.1 Building Structure Attachments

Use concrete and masonry anchor devices that conform to requirements of CID A-A-1922, CID A-A-1923, CID A-A-1924, CID A-A-55614.

Install cast-in floor-mounted equipment anchor devices that provide adjustable positions.

Use built-in masonry anchor devices, unless otherwise approved by the Contracting Officer.

Do not use power-actuated anchoring devices to support mechanical systems components.

Ensure that beam clamps are center-loading Type [21] [28] [29] [30], UL-listed, cataloged, and load-rated, and commercially manufactured.

[Do not use C-clamps.]

[Use clamps to support piping that is 1 1/2 inches and smaller. Provide FM-approved and UL-listed C-clamps with hardened cup tip, setscrew, locknut, and retaining strap. Use a retaining strap section of at least [1/8 by 1] inch [_____]. Ensure that the thickness of beam flanges to which clamps are attached does not exceed 0.60 inch.

][Construct concrete inserts in accordance with the requirements of MSS SP-58 for Type 18 hangars. When applied to piping of 2 inch ips or larger and where otherwise required by imposed loads, insert a 1-foot length of 1/2-inch reinforcing rod that is wired through wing slots. Proprietary designs for continuous inserts may be used upon approval by the Contracting Officer.

]2.4.2.2 Horizontal Pipe Attachments

Use Type 6 solid malleable-iron pipe rings to support piping in sizes to and including 2 inch ips. Split-band rings may be used for piping up to 1 inch ips.

Use Types [1] [3] [4] attachments to support piping in sizes through 8 inch ips.

Use Type [41] [49] pipe rolls to support piping in sizes larger than 8 inch ips.

Use trapeze hangers fabricated from approved structural steel shapes, and use U-bolts in congested areas and where multiple pipe runs occur. Structural steel shapes [conform to supplementary steel requirements] [are a commercially available, proprietary-design, rolled steel].

2.4.2.3 Vertical Pipe Attachments

Use Type 8 vertical pipe attachments.

2.4.2.4 Hanger Rods and Fixtures

Use only circular cross-section rod hangers to connect building structure attachments to pipe support devices. Pipe, straps, or bars of equivalent strength may be used for hangers only where approved by the Contracting Officer.

Provide turnbuckles, swing eyes, and clevises as required by support system to accommodate pipe accessibility and adjustment for load and pitch.

2.4.2.5 Supplementary Steel

Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, design and fabricate such supplementary steel in accordance with AISC 360.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Underground Piping System

3.1.1.1 Compressed Air System Installation

Install compressed air systems in accordance with the manufacturer's instructions. Conduct installation in the presence of the Contracting Officer. Notify the Contracting Officer [48] [_____] hours in advance of the work.

Conduct excavations in accordance with Section 31 00 00 EARTHWORK.

Lay piping at the beginning at the low point of a system, and when the piping is in the final position, ensure that the piping is true to the grades and aligns with unbroken continuity of invert.

[Blocking and wedging is not permitted.

] Ensure that pipes that pass through the walls are below grade and that ground floor slabs pass through pipe sleeves.

In fill areas, ensure that pipe passing under or through building grade beams have at least [4] inches [_____] clearance in all directions.

Where pipe penetrates earth or concrete grade, ensure that at least [12] inches [_____] of polyethylene-coated Type BCS-PS pipe is exposed to view.

Install Type BCS-PS materials in accordance with the applicable requirements for underground piping and aboveground piping. Palletize the pipe in padded pallets at the factory and use padded gear to handle the pipefrom pallet to final position. Protect surfaces from the sun by using black polyethylene sheeting. Before lowering pipe into a trench, check the sheathing for continuity with 10,000 volts applied by a continuity detector. In the trench, after joints and fittings are made, check previously untested surfaces for continuity. Where discontinuities in thermoplastic are found, discard at least [12] inches [_____] of material upstream and downstream of fault.

[After valves, valve operators, and valve boxes have been inspected and at least [48] [_____] hours before lowering these items into a trench, coat external surfaces with a compatible bituminous coating for protection against brackish ground water. Apply a single coat in accordance with the manufacturer's instructions, produces a dry-film thickness of at least [12] mils [_____].

]3.1.1.2 Valve Boxes

Set valves and valve boxes plumb. Center valve boxes on the valves.

[Install a 4 inch thick concrete slab to protect valve boxes.

]3.1.2 Aboveground Piping System

3.1.2.1 Piping Systems

Fabricate and install piping systems in accordance with ASME B31.3, MSS SP-58, ASME BPVC, and applicable AWS requirements.

Fabricate pipe to measurements established on the job and carefully work the pipe into place without springing or forcing the pipe.

Ensure that pipe, tubing, fittings, valves, equipment, and accessories are clean and free of all foreign material before installation. Clean pipe by a method approved by the Contracting Officer. Purge lines with dry, oil-free compressed air after erection, but do not rely on purging for removing all foreign matter. Purge lines at a velocity equal to 1 1/2 times the maximum normal flow velocity. During construction, protect the open ends of pipe, fittings, and valves at all times to prevent foreign matter from entering the pipe. Except when connections are actually underway, install plugs or caps on all pipe and component openings. Use plugs or caps that are commercially manufactured products.

Install piping straight and true, with approved offsets around obstructions and with necessary expansion bends or fitting offsets essential to a satisfactory installation and as may be necessary to increase headroom or to avoid interference with the building construction, electric conduit, or facilities equipment.

Use standard long sweep pipe fittings for changes in direction. Do not use mitered joints or unapproved pipe bends.

Pipe bends in seamless pipe may be made with hydraulic benders in the field for pipe sizes to 4 inch ips, upon approval from the Contracting Officer. Ensure that the radius of pipe bends is at least [five] [_____] times the nominal pipe diameters.

Make tee connections with screwed tee fittings or grooved tee fittings. Where pipe is being welded, make branch connections with either welding tees or forged branch outlet fittings, either of which is acceptable without size limitations. Provide branch outlet fittings that are forged, flared for improved flow where attached to the run, reinforced against external strains, and designed to withstand full burst-pressure strength requirements. Provide tool space between parallel piping runs whenever threaded unions or couplings are installed.

Install horizontal piping with a grade of [1 inch per 100 feet] [_____].

Use eccentric reducers where required to permit proper drainage of pipe lines. Do not permit bushings for this purpose. Provide drain valves in piping systems at low points. Use pipe drains that consist of 1/2 inch globe valves with renewable disks and a 3/4 inch hose adapter.

Install piping in a manner that does not stress or strain connected equipment.

Make expansion bends in steel pipe from pipe sections and long-radius welding elbows that are 1 inch or larger. Ensure that expansion U-bends are cold-sprung and welded into the line. Anchor the line before removing the spreader from the expansion U-bend.

3.1.2.2 Joints

Ream pipe ends before joint connections are made.

Make up screwed joints with joint compound.

Apply joint compounds to the male thread only, and exercise care to prevent the compound from reaching the interior of the pipe.

Provide screwed unions, welded unions, or bolted flanges wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system.

Assemble flanged joints with appropriate flanges, gaskets, and bolting. Provide clearance between flange faces such that the connections can be gasketed and bolted tight without putting undue strain on the piping system. Ensure that flange faces are parallel and that the bores are concentric. Center gaskets on the flange faces without projecting into the bore. Lubricate bolting with oil and graphite before assembly to ensure uniform bolt stressing. Draw up and tighten flange bolts in a staggered sequence to prevent unequal gasket compression and deformation of the flanges. Wherever a flange with a raised face is joined to a companion flange with a flat face, machine the raised face to a smooth matching surface, and use a full-face gasket. After the piping system has been tested and is in service at its maximum temperature, tighten bolts again. Use only hex-head nuts and bolts. Provide fresh stock gasket material, 1/16-inch thick.

Ensure that field-welded joints conform to the requirements of AWS-03 and ASME B31.3.

Use square-cut copper tubing for solder joints and use cutting and reaming tools to remove burrs. Clean the inside surfaces of fittings and the outside surfaces of tubes in the joint area before assembly of the joint. Apply the joint flux, solder, and heat source in accordance with the manufacturer's instructions, using capillary action to fill the socket space and achieve 100 percent of the shear-line strength capability. Ensure that the valves in copper piping have screwed ends with end adapters to suit mechanical connections, unless solder joining is specified for a given application. Remake copper joints that fail pressure tests with new materials, including pipe or tubing fittings and filler metal.

Use square-cut, tubing for mechanical joints and remove burrs. Exercise care to avoid work-hardened copper surfaces and cut off or anneal tube ends. Meet heating temperature and air-cooling requirements in accordance with the manufacturer's instructions.

3.1.2.3 Control and Instrument Air Tubing

Conceal tubing, except in mechanical rooms or areas where other piping is exposed.

Use hard-drawn copper tubing in exposed areas. Do not use annealed copper in concealed locations.

For supply system copper tubing, use wrought copper solder joint-type fittings, except at the connection to the apparatus where brass mechanical and ips thread adapter fittings are used. Tool-made bends in lieu of fittings are acceptable. Neatly nest multiple tube runs.

[Use fittings for plastic tubing in accordance with the manufacturer's instructions.

][Plastic tubing, sheathed or unsheathed, may be used in lieu of copper tubing, provided:

a. Plastic tubing is not exposed to ultraviolet light and continuous ambient temperatures in excess of 120 degrees F at any point along run.

b. Plastic tubing is free from danger of mechanical damage and readily accessible for replacement with a minimum of tools and without the need to remove plaster, furring, equipment, and similar permanent construction.

c. Plastic tubing is not embedded in concrete or concealed within the walls of a structure or in hot pipe and duct chases.

d. Plastic tubing is enclosed within control panel cabinets or concealed behind control panels.

e. Routing has prior approval of the Contracting Officer.

Install [color] [number] code tubing installed inside or behind control panels. Neatly tie and support tubing. Neatly fasten connections bridging the cabinet and its door along the hinge side and protect the connections against abrasion.

When the tubing run is less than 12 inches, plastic tubing may be used. Otherwise, use hard-drawn copper tubing for the terminal single line.

] Mechanically attach tubing to supporting surfaces. Do not use adhesive to attach supports.

For copper tubing horizontal supports with less than 3 tubes use a rigid 1-inch by 3/8-inch metal channel, use a proprietary metal tube race for 3 or more tubes.

[Run exposed plastic tubing in mechanical rooms or spaces where copper tubing is exposed within adequately supported [metal raceway] [metallic or plastic electric conduit] [pipe].

][Use a multiple-tube plastic harness or sheathing in place of single plastic tubes where a number of plastic tubes run to the same points.

][Multiple-tube plastic harness or sheathing may be imbedded in concrete or run in soil below concrete provided it is jointless, contains 30 percent spares, and prior approval of the Contracting Officer has been obtained.

] For runs imbedded in concrete, use annealed copper tubing protected with [metallic] [plastic] electric conduit.

Ensure that copper-tubing runs in soil are jointless. Protect the copper tubing from brackish ground water and leaching concrete alkali with 12-mil thick [bituminous coating] [equivalent polyvinylchloride (PVC) tape wrapping].

Make tubing penetrations of concrete surfaces through minimum 1 inch ips, Schedule 40, rigid unplasticized PVC pipe sleeves, except that multitube harness 1 1/2 inches outside diameter or larger need not have additional protection. Extend sleeve [6] inches [_____] above floors and [1] inch [_____] below the grade surfaces of slabs. Where water or vapor-barrier sealing is required, apply a 1/2 inch deep elastomer caulk to surfaces that are free from oil and other deleterious substances.

Systematically purge tubing with [dry, oil-free compressed air] [nitrogen] to rid the system of impurities [generated during joint-making and installation] and atmospheric moisture before connection to control instruments.

3.1.2.4 General Service Valve Locations

Provide valves to permit isolation of branch piping and each equipment item from the balance of the system, to allow safe and convenient access without moving equipment, and to require a minimum of piping and equipment disassembly.

Provide valves in piping mains and branches at equipment and equipment items.

Provide riser and downcomer drains above piping shutoff valves in piping 2 1/2 inches or larger. Tap and fit shutoff valve body with a 1/2 inch plugged globe valve.

Provide three-valve bypass around each pressure-regulating valve.

Provide access panels for valves unavoidably located in furred or other normally inaccessible places.

3.1.2.5 Bypass Throttling Valves

Install globe valves with a [metallic] [composition] disc.

3.1.2.6 Supporting Elements Installation

Provide supporting elements in accordance with the requirements of ASME B31.1, and MSS SP-58. Hang piping from building construction. Do not hang piping from the roof deck or from other pipe.

Whenever possible, use approved cast-in concrete inserts to attach to structures made of concrete. Use built-in anchors to attach to structures made of solid masonry. Where attachment by either of the above methods is not possible, specified masonry anchor devices may be used with written approval from the Contracting Officer.

Embed fish plates in the concrete to transmit hanger loads to the reinforcing steel where hanger rods exceed 7/8 inch diameter.

Use masonry anchors only for overhead application of ferrous material.

Install masonry anchors conforming to CID A-A-1922, CID A-A-1923, CID A-A-1924, CID A-A-55614 in rotary, nonpercussion, electric-drilled holes. Group III self-drilling anchors may be used provided masonry drilling is done with electric hammers that do not cause concrete spalling or cracking, whether the defects are visible or invisible. Do not use pneumatic tools

Use percussive-action electric hammers, and combination rotary-electric hammers to install self-drilling anchors selected in accordance with the following guide:

a. For anchor devices of 1/4 through 1/2 inch, use a hammer only or a combination rotary tool-hammer rated at load to draw not more than 5.0 amperes when operating on 120-volt, 60-hertz power.

b. For anchor devices of 5/8 inch or larger, use a hammer rated at load to draw not more than 8.0 amperes when operating on 120-volt, 60-hertz power. Ensure that combination rotary-hammer tools used on the same power supply have a full-load current rating that does not exceed 10 amperes.

Size inserts and anchors for the total stress to be applied with a safety factor as required by applicable codes but in no case less than [4] [_____].

Insert anchor devices into concrete sections at least twice the overall length of the device. Locate the devices so that they are at least the following distances from any side or end edge or the centerline between adjacent anchor:

Anchor Bolt Length (Inches)	Minimum Edge Space (Inches)
1/4	3 1/2
5/16	3 3/4
3/8	4
1/2	5
5/8	6
3/4	7
7/8	8

In special circumstances, upon prior written approval of the Contracting Officer, the center-to-center distance may be reduced up to 50 percent of the given distance, provided the load on the device is reduced in direct proportion to the reduced distance.

Run piping parallel with the lines of the building. Space and install piping and components so that a threaded pipe fitting may be removed between adjacent pipes and so that there is at least [1/2] inch [_____] of clear space between the finished surface and other work and between the finished surface and parallel adjacent piping. Arrange hangers on adjacent service lines so that the hangers run parallel with each other and parallel to the lines of the building.

Place identical service systems piping, where practical, at the same elevation and hang the piping on trapeze hangers adjusted for the proper pitch.

Where piping is grouped in parallel runs, space trapeze hangers at the closest interval required for any size pipe supported.

Where it is necessary to avoid transfer of load from support to support or onto connecting equipment, use constant support pipe hangers.

Provide approved pipe alignment guides, attached in an approved manner to the building structure, to control pipe movement in true alignment in the piping adjacent to and on each side of all pipe expansion loops.

Use a welding method approved by the Contracting Officer to incorporate anchors into piping systems for the purpose of permanently attaching the pipe to the building structure.

Brace piping in a way that prevents sway and vibration. Use bracing that consists of brackets, anchor chairs, rods, and structural steel for vibration isolation.

[Locate pipe lines supported from roof purlins not farther than [one-sixth] [_____] of the purlin span from the roof truss. The load per hanger cannot exceed [400] pounds [_____] when support is from a single purlin, and cannot exceed [800] pounds [_____] when the hanger load is applied to the purlins halfway between the purlins by means of auxiliary support steel installed by the Contractor.] When support is not provided halfway between purlins,ensure that the allowable hanger load is the product of [400] [_____] times the inverse ratio of the longest distance in the purlin-to-purlin spacing.

When the hanger load exceeds the above limits, furnish and install reinforcing for the roof purlins or additional support beams. When an additional beam is used, ensure that the beam bears on the top chord of the roof trusses, and that the bearing is over the gusset plates of the top chord. Stabilize the beam by a connection to the roof purlin along the bottom flange.

Install hangers and supports for piping at intervals specified herein at locations not more than [3] feet [_____] from the ends of each runout and not over [25] [_____] percent of the specified interval from each change in direction of piping.

Ensure that the load rating for all pipe hanger supports is based on weight and forces imposed on all lines. Ensure that deflection per span does not exceed the slope gradient of pipe. Ensure that Schedule 40 and heavier pipe supports are in accordance with the following minimum rod sizes. Maximum allowable hanger spacing and concentrated loads reduces the allowable span proportionately:

PIPE SIZE INCHES	ROD SIZE INCHES	STEEL PIPE FEET
Up to 1	3/8	8
1 1/4 to 1 1/2	3/8	10
2	3/8	12
2 1/2 to 3 1/2	1/2	12
4 to 5	5/8	16
6	3/4	16

PIPE SIZE INCHES	ROD SIZE INCHES	STEEL PIPE FEET
8 to 12	7/8	20

Where possible, support vertical risers at the base at the intervals specified and guide the risers for lateral stability. Place clamps under fittings wherever possible. Support carbon steel pipe at each floor at not more than 15 foot intervals for pipe 2 inches and smaller and at not more than 20 foot intervals for pipe 2 1/2 inches and larger.

After the piping systems have been installed, tested, and placed in satisfactory operation, tighten the hanger rod nuts and jam nuts to prevent movement.

3.1.2.7 Sound Stopping

Provide effective sound stopping and provide an operating clearance that is sufficient to prevent the piping from making contact with the structure where the piping penetrates walls, floors, or ceilings in occupied spaces adjacent to equipment rooms, where similar penetrations occur between occupied spaces, and where penetrations occur from pipe chases that penetrate occupied spaces. Occupied spaces includes the space above ceilings where no special acoustic treatment of the ceiling is provided. Create finished penetrations compatible with the surface being penetrated.

Ensure that sound stopping materials and procedures are the same as those specified under the paragraph SLEEVES.

[Ensure that sound stopping and vapor barrier sealing of pipe shafts and large floor and wall openings are accomplished by packing properly supported mineral fiber to high density, or, where ambient or surface temperatures do not exceed 120 degrees F, by foaming in place with self-extinguishing, 2-pound density polyurethane foam to a depth of at least [6] inches [_____]. Finish foam with a rasp. Ensure the vapor barrier consists of at least a [1/8] inch [_____] thickness of vinyl coating applied to visible and accessible surfaces. Where high temperatures and fire-stopping are a consideration, use only mineral fiber. In addition, cover openings with [16]-gage [_____] sheet metal.

] Ensure that all mineral materials conform to the requirements specified under the paragraph SLEEVES in this section.

Leadwool and viscoelastic damping compounds may be proposed for use where other sound-stopping methods are not practical, provided temperature and fire-resistance characteristics of the compounds are suitable for the service.

3.1.2.8 Sleeves

Provide sleeves where piping passes through roofs, through masonry or concrete walls, or through floors.

Lay out and set sleeve work before placement of slabs or construction of walls and roof. Furnish the sleeves needed to complete the work.

Where pipe sleeves are required after slabs and masonry are installed, create holes to accommodate these sleeves with core drills. Set the sleeves in place with a two-component epoxy adhesive system approved by the Contracting Officer. Carry no load by such sleeves unless approved by the

Contracting Officer.

Ensure that the sleeves are flush with all ceilings.

Ensure that the sleeves are flush with the floor in finished spaces and extend [2] inches [_____] above the floor in unfinished spaces.

Ensure that sleeves passing though steel decks are continuously [welded] [brazed].

Fabricate sleeves that continuously extend through floors, roofs, and load-bearing walls, and sleeves that run through fire barriers, from Schedule 40 steel pipe with welded anchor lugs. Other sleeves may be formed by molded linear polyethylene liners or similar materials that are removable. Ensure that the sleeve diameter is large enough to accommodate pipe, insulation, and jacketing without touching the sleeve and provide at least [3/8] inch [_____] clearance. Select a sleeve size that will accommodate mechanical and thermal motion of pipe in order not to transmit vibration to walls and generate noise.

Solidly pack the space between a pipe, bare or insulated, and the inside of a pipe sleeve or a construction surface penetration with a mineral fiber conforming to ASTM C592, Form B, Class 8. Provide similar packing whenever the piping passes through firewalls, equipment room walls, floors and ceilings connected to occupied spaces, and other locations where sleeves or construction surface penetrations occur between occupied spaces. Where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces, fill the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration with an elastomer caulk to a depth of [1/2] inch [_____]. Ensure that the caulked surfaces are oil- and grease-free.

[Caulk watertight with lead and oakum] [Make watertight with mechanically expandable chloroprene inserts with mastic sealed metal components] exterior wall sleeves.

Ensure that the sleeve extends [12] inches [_____] above the surface of the roof.

3.1.2.9 Escutcheons

Provide escutcheons where piping penetrates finished areas. Where finished areas are separated by partitions through which piping passes, provide escutcheons on both sides of the partition. In areas where suspended ceilings are installed, provide plates only on the underside of such ceilings. In areas where insulated pipes are used, install plates large enough to fit around the insulation. In occupied spaces, use chrome-plated escutcheons that are large enough to conceal openings in building construction. Firmly attach escutcheons with setscrews.

3.1.2.10 Flashings

Provide flashings at locations where mechanical systems penetrate the building boundaries.

3.1.3 Compressed-Air Systems Identification

Protect and keep identification plates clean. Replace damaged and illegible identification plates at no additional expense.

Label and arrow piping at each point of entry and exit of piping passing through walls; at each change in direction, such as at elbows and tees; and in congested or hidden areas, at each point required to clarify service or indicate a hazard. Label each riser.

In long, straight runs, locate labels at distances that allow a label to be seen from the location of another label, but in no case allow the distance between labels to exceed [75] feet [_____]. Ensure that labels are legible from the primary service and operating area.

3.2 FIELD QUALITY CONTROL

3.2.1 Compressed-Air Systems Testing

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

Prior to acceptance of the work, pressure-test completed systems in the presence of the Contracting Officer.

[Conduct testing in two stages: preliminary stage and acceptance stage, including gage tests.

][Perform no testing until personnel not directly involved in the test have been evacuated from the area.

][Contractor may conduct tests for their own purposes in addition to the preliminary test and the acceptance test specified below.

]3.2.1.1 Preliminary Stage Tests

[Conduct pneumatic tests with dry, oil-free compressed air. Use carbon dioxide or nitrogen in metallic systems.

][Ensure that each system test includes a preliminary test in which the joints under test are swabbed with a standard high-strength film soap solution, so that bubbles, if any exist, can be observed at internal pressures of 5 psi or less.

] When testing reveals that leakage exceeds specified limits, isolate and repair the leaks, replace defective materials where necessary, and retest the system until specified limits are met. Remake leaking gaskets with new gaskets and new flange bolting, and discard used bolting and gaskets.

Other than standard piping flanges, plugs, caps and valves, only use commercially manufactured expandable elastomer plugs for sealing off piping for test purposes. Ensure that the published safe test pressure rating of any plug used is at least three times the actual test pressure being applied. During pneumatic testing or hydrostatic testing, evacuate personnel from areas where plugs are used.

Remove components that could be damaged by test pressure from the piping systems to be tested.

Perform valve-operating tests and drainage tests according to cited standards.

Check piping system components, such as valves, for proper operation under the system test pressure.

Do not add test media to a system during a test for a period specified or determined by the Contracting Officer.

Duration of a test is determined by the Contracting Officer and will be for a minimum of [15] [_____] minutes with a maximum of [24] [_____] hours. Test may be terminated by direction of the Contracting Officer at any point after it has been determined that the leakage rate is within limits.

[Only use potable water for hydrostatic testing. Government will supply testing water at a location determined by the Contracting Officer. Contractor is responsible for approved disposal of contaminated water. Ensure that the temperature of water used for testing is not low enough to cause condensation of atmospheric moisture on system surfaces. Provide supplementary heat when necessary.

][To preclude injury and damage, take necessary precautions by venting the expansive force of compressed air trapped during high-pressure hydrostatic testing. When purging or vent valves are not provided, the Contracting Officer may require the removal of system component such as plugs or caps to verify that the water has reached all parts of the system.

][Upon completion of testing, drain and purge the system with dry air. Verify system dryness by hygrometer comparison with purging air.

][Immediately repair visible leaks or defects in the pipeline.

]3.2.1.2 Test Gages

Ensure that test gages conform to ASME B40.100 and have a dial size of 8-inches or larger. The maximum permissible scale range for a given test is such that the pointer during a test has a starting position at midpoint of the dial or within the middle third of the scale range. Ensure that the certification of accuracy and correction table bears a date no more than [90] [_____] calendar days before the gage is used in a test, and that it indicated the test gage number and the project number, unless otherwise approved by the Contracting Officer.

3.2.1.3 Acceptance Pressure Testing

Ensure that the testing takes place during steady-state ambient temperature conditions.

Test ferrous piping systems at [1-1/2] [_____] times the maximum operating pressure. Maintain test pressure for at least [2] [_____] hours with an allowable pressure drop of [2] psi [_____] during that time unless otherwise approved by the Contracting Officer.

Test control and instrumentation tubing systems at [30] psi [_____]. Maintain the test pressure for at least [24] [_____] hours with essentially no pressure drop during that time.

Each acceptance test requires the signature of the Contracting Officer. Deliver [two] [_____] record copies to the Contracting Officer after acceptance.

3.2.1.4 Piping System Test Report

Prepare and maintain test records of all piping systems tests. Ensure the records show the responsibilities of Governmental and Contractor test personnel, dates, test gage identification numbers, ambient temperatures, pressure ranges, rates of pressure drop, and leakage rates. Submit reports to the Contracting Officer.

3.3 ADJUSTING AND CLEANING

Remove rust and dirt from the bore and exterior surface of all piping and equipment. Clean pipeline strainers, temporary and permanent, during purging operations, after startup, and immediately prior to final acceptance by the Government.

Flush and clean new steel piping with a suitable degreasing agent, [____], until visible grease, dirt, and other contaminants have been removed. Dispose of degreased waste material including the degreaser itself in accordance with written instructions received from the Environmental Authority having jurisdiction through the Contracting Officer and in accordance with all local, State, and Federal Regulations.

3.4 CLOSEOUT ACTIVITIES

Submit [6] [_____] copies of the operation and maintenance manuals [30] [_____] calendar days prior to testing the low-pressure compressed air system. Update and resubmit data for final approval no later than [30] [_____] calendar days prior to contract completion.

-- End of Section --

SECTION 22 15 19.13 20

LARGE NONLUBRICATED RECIPROCATING AIR COMPRESSORS (OVER 300 HP)
11/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Std 618	(2007; R 2016) Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 9	(1970; R 1997) Displacement Compressors, Vacuum Pumps and Blowers (for historical reference only)

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel

	Hardware
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B111/B111M	(2018) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B171/B171M	(2012) Standard Specification for Copper-Alloy Plate and Sheet for Pressure Vessels, Condensers and Heat Exchangers
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-7.1	(2011) Commodity Specification for Air; 5th Edition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 112	(2017) Standard Test Procedure for Polyphase Induction Motors and Generators

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2151	(2004) Acoustics - Noise Test Code for Compressors and Vacuum Pumps - Engineering Method (Grade 2)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation

MIL-T-19646 (1990; Rev A; Notice 1 2021) Thermometer, Gas Actuated, Remote Reading

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219 Mechanical Power Transmission Apparatus

1.2 GENERAL REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section except as specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Air Compressor System

Include wiring diagrams of the air compressor system with all accessories. The minimum acceptable scale is [1/4 inch to one foot] [_____].

SD-03 Product Data

Air Compressor

Inlet Air Filters

Inlet Line Silencer

Air Flow Rate and Pressure Recorder

[Carbon Monoxide Monitor

] Filter Housing

Submit manufacturer's catalog data for compressor and auxiliary equipment in the format provided in API Std 618, Appendix A. For air compressors, include aftercooler, intercoolers, oil cooler, lubrication system, and control valves. Submit air compressor intercooler, and aftercooler performance curves at specified summer design conditions.

SD-05 Design Data

Intake and Discharge Pipe Calculations

SD-06 Test Reports

Air Compressor Performance Tests

Sound Level and Run-In Tests

Obtain approval prior to shipping compressor.

Air Compressor Performance Tests

Instrumentation Test

Sound Level Tests

Air Compressor System Test

The test supervisor shall certify performance by test to be in compliance with specifications.

SD-07 Certificates

Work Plan

Factory Test Procedures

Factory Testing Certification

Qualifications of Field Supervisors

Field Test Procedures

Training Material

Air Compressor System

Air Compressor System Installation

SD-10 Operation and Maintenance Data

Air Compressor System, Data Package 3

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted Operating Instructions for Air Compressor

Submit text.

1.4 QUALITY ASSURANCE

1.4.1 Intake and Discharge Pipe Calculations

Submit intake and discharge pipe calculations to show intake and discharge piping are not subject to damaging resonance pulsations. Include effects of pulsation dampers and surge chambers, if required to limit pulsation.

1.4.2 Work Plan

Submit a written schedule of dates of installation, start-up, checkout, and test of equipment.

1.4.3 Factory Testing Certification

Submit a statement that the air compressor factory is equipped to perform all required factory tests. Submit in accordance with paragraph MANUFACTURER'S CERTIFICATIONS.

1.4.4 Qualifications of Field Supervisors

Submit the name and certified written resume of the engineer or technician, listing education, factory training and installation, start-up, and testing supervision experience for at least two projects involving compressors similar to those in this contract.

1.4.5 Training Material

Submit a detailed training program syllabus for training of government personnel, including instructional materials at least three weeks prior to start of tests.

1.4.6 System Installation

Submit certification of air compressor system performance conforming to ASME PTC 9. Submit certification of proper system installation in accordance with paragraph SUPERVISION.

1.4.7 Air Compressor System

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Air compressor system data shall contain information required for maintenance and repair and shall contain no evidence that proprietary maintenance arrangements with the manufacturer will be necessary. Compressors which will require proprietary maintenance arrangement with the manufacturer require Government review and approval. The compressors may be disapproved if circumstances do not justify approval of compressors with limited availability of maintenance.

1.5 SAFETY

Construct all components of the unit in accordance with the requirements of OSHA 29 CFR 1910.219. Requirements include shaft coupling guards as specified in Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, insulation and jacketing with manufacturer standard covering or aluminum sheet of all surfaces at 125 degrees F and higher within a height of 7 feet from floor level, and use of electrical safety devices. Thermal insulation, furnished by equipment manufacturer, shall conform to ASTM C553, Type I (flexible resilient), Class B-5 (up to 400 degrees F), 2 pcf nominal. Cement insulation to surface with MIL-A-3316, Class 2, adhesive and fasten with 16 gage wire bands at maximum 16 inches on center spacing. Cover insulation with ASTM B209 sheet aluminum jacket.

1.6 EQUIPMENT ARRANGEMENT

Arrangement selected shall maintain 3 foot clearance for access passage and 4 foot clearance for personnel to operate equipment. There are substantial physical and connection point differences among the several air compressors which comply with this specification. The Contractor shall be responsible for selecting equipment and submitting arrangement drawings covering required changes for approval by the Contracting Officer. Changes from the equipment arrangement shown on the contract drawings shall be performed by the Contractor at no additional cost to the Government.

1.7 ELECTRICAL REQUIREMENTS

Comply with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM,[and [_____]].

1.8 SUPERVISION

The Contractor shall obtain the services of a qualified engineer or technician from the compressor manufacturer to supervise installation, start-up, and testing of the compressor. After satisfactory installation of the equipment, the engineer or technician shall provide a signed certification that the equipment is installed in accordance with the manufacturer's recommendations.

1.9 DEFINITIONS

API Std 618 and the following:

Compressor power is shaft power at shaft coupling, including all losses and connected appurtenances.

1.10 INSULATION

Thermal and acoustical insulation shall have flame spread rating not higher than 75, and smoke developed rating not higher than 150 when tested in accordance with ASTM E84.

1.11 POSTED OPERATING INSTRUCTIONS

Provide for air compressor. Include start-up and shutdown sequence instructions.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment complete with accessories shall be selected by the Contractor for performance compatibility.

2.2 AIR COMPRESSOR

The air compressors shall be positive displacement, reciprocating, double-acting compressors delivering oil-free air. No lubricant shall be used within the compression cylinders. Include air compressor, electric motor driver, coolers, lubrication system, and regulation and control systems mounted on a common base frame, and, if required, completely enclosed for noise control.

2.2.1 Manufacturer's Certifications

The manufacturer shall certify that the air compressors proposed are of the same design, construction, size, and of equal or not more than 10 percent smaller in capacity as compressors which have been in satisfactory continuous service for at least 2 years at not less than two locations. Furnish the name of the owner, the address of the installation, and the name of a person at the installation who can be contacted for verification. The manufacturer shall also certify that the factory is equipped to perform all required factory tests.

2.2.2 Guaranteed Performance

a. Net compressed air output (All packing and seal losses shall be considered internal and not included in the net output) (plus or minus 2 percent): [_____] SCFM

b. Output pressure immediately downstream of aftercooler (minus zero plus 4 percent): 125 psig

c. Output air maximum temperature downstream of aftercooler: 100 degrees F

d. Inlet air pressure at first stage: [_____] psig

e. Inlet air temperature at first stage: [_____] degrees F

f. Inlet air filtration efficiency: 99.9 percent of 0.5 micron size

g. Barometric pressure: [_____] psig

h. Relative humidity: [_____] percent

i. Cooling water inlet temperature: [_____] degrees F

j. Total cooling water flow rate: [_____] gpm

k. Maximum cooling water pressure drop through the compressor and any intercooler, aftercooler, or oil cooler: [_____] [8 psi]

l. Maximum compressor power required. (Plus or minus 4 percent): [_____] hp

m. Unloaded compressor horsepower (max.): [_____] hp

n. Maximum sound levels one meter horizontal from compressor and 5 feet above floor as measured per ISO 2151: 84 dBA, 90 dB for any octave band.

o. Maximum compressor speed: 550 rpm

p. Maximum piston speed: 590 fpm

q. Maximum power per 100 ACFM: 22 hp.

2.2.3 Additional Performance Requirements

2.2.3.1 Air Quality

Air at compressor intake will be considered breathing air quality conforming to CGA G-7.1, Type I, Grade D or better. Air compressors shall introduce no material, gases, or particles, or chemically alter any materials that will adversely affect or reduce the quality of the air passing through the unit.

2.2.3.2 Ambient and Inlet Conditions Operating Ranges

Allowing for rational engineering performance adjustments due to variations in ambient and inlet conditions, the compressor shall be designed, equipped, and furnished to be fully operational without abnormal wear throughout the entire range between and including the limits of the winter and summer design conditions specified.

a. Summer design conditions:

Inlet air: [_____] degrees F dry bulb and [_____] degrees F wet bulb temperatures, [_____] percent relative humidity Inlet cooling water: [_____] degrees F, Ambient compressor room temperature: [_____] degrees F, Barometric pressure: [_____] psig

b. Winter design conditions:

Inlet air: [_____] degrees F dry bulb and [_____] degrees F wet bulb temperatures, [_____] percent relative humidity Inlet cooling water: [_____] degrees F, Ambient compressor room temperature: [_____] degrees F, Barometric pressure: [_____] psig.

2.2.3.3 Critical Speeds

API Std 618, paragraph 2.5.1.

2.2.4 Electrical Service Conditions

2.2.4.1 Air Compressor Drive Motor

[_____] Volts, 3 phase, 3 wire, 60 hertz electrical service.

2.2.4.2 Accessory electrical Service

See Table I.

TABLE I - COMPRESSOR ACCESSORY ELECTRICAL SERVICE SCHEDULE

Item	Voltage	Phase	Frequency
Control Power and Motors under 1/2	120	1	60 Hz
Accessory Power	460	3	60 Hz

2.2.5 Compressor Controls

Provide a complete load regulation and control system with the compressor. Provide additional electrical, electro-pneumatic, or solid state electronic controls for other specified control and monitor functions. All electrical controls shall conform to NEMA ICS 2 as selected by the compressor manufacturer. Control system enclosure shall conform to NEMA ICS 6. Controls shall be suitable for individual operation of the compressor or parallel operation with one or more other compressors.

2.2.5.1 Compressor Start-Up

The compressor shall start unloaded. The manual starting circuit for the compressor shall have interlocks to prevent the compressor drive motor from starting until pre-lubrication pump (if provided), oil pressure, and cooling water pump water flow have been established to the required values for safe operation as determined by the compressor manufacturer.

2.2.5.2 Load Regulation

The compressor shall operate continuously at constant speed after being started. Provide means to load and unload the compressor automatically at preset minimum and maximum pressure settings. Minimum pressure shall be 100 psig, and maximum pressure shall be 125 psig. Loading and unloading shall be accomplished by a minimum of[three steps (full load, one-half load, and no load).][five steps (full load, three-quarter load, one-half load, one-quarter load, and no load).] Unloading shall be accomplished by suction valve unloading, clearance pockets, or a combination of both suction valve unloading and clearance pockets. Input power at fully unloaded operation shall not exceed 15 percent of full load input.

2.2.5.3 Monitor and Safety Controls

Supplementary electric, electro-pneumatic, or solid state electronic controls shall be provided to provide alarm and shutdown requirements, plus interlocks with accessories. Requirements are as follows:

a. Shutdown requirements shall cause the controlled compressor to shut down, energize alarms, and light labeled red lights.

b. Alarm only requirements shall not cause the controlled compressor to shut down, but shall sound the same alarms and light labeled amber lights.

c. Light only requirements shall not cause the controlled compressor to shut down, but shall light labeled amber lights.

d. The individual monitor and safety controls shall be as shown on Table 2.

TABLE 2 - MONITOR AND SAFETY CONTROL SCHEDULE

Item	Light and Shutdown	Indicating Alarm	Light Only
1. High Discharge Air Temperature 275 degrees F	Yes	Yes	-
2. High Intercooler Discharge Water Temperature, Each Intercooler	No	Yes	-
3. High Aftercooler Discharge Water Temperature	No	Yes	-
4. High Cooling Water Supply Temperature	No	Yes	-
5. High Lube Oil Temperature	Yes	Yes	-
6. Low Lube Oil Pressure	Yes	Yes	-
7. Low Oil Reservoir Level	No	Yes	-

8. High Condensate Level Intercooler (wired to one light)	Yes	Yes	-
9. High Motor Stator Temperature	Yes	Yes	-
10. High Condensate Level Aftercooler	No	No	Yes
11. High Inlet Pressure Drop Across Inlet Air Filters (combined, 3 stage)	No	Yes	-
12. High CO Level	Yes	Yes	-

2.2.5.4 Monitoring Instruments

Provide the following monitoring instruments in addition to the monitor and safety controls. Pressure gages shall conform to ASME B40.100, 4 1/2 inch diameter, red marking pointer, single bourdon tube, brass case, black enamel finish. Provide pressure gages with a pressure snubber and a stainless steel barstock needle isolation valve. Thermometers shall be extended stainless steel sheathed bimetallic stem, 3 1/2 inch dial, and separable 4 inchstainless steel wells. Temperature measurements at inaccessible locations shall be made with remote reading thermometers conforming to MIL-T-19646, Class C separable well of Type 304 stainless steel. Select pressure and temperature gage ranges to give a normal operating reading near the midpoint of the scale range.

a. Oil cooler outlet temperature gages for oil.

b. Oil cooler inlet and outlet temperature gages for water.

c. Lubrication oil pump discharge pressure gage.

d. Inlet air filter differential pressure gage with 8, zero, 8 inch water gage. Provide selector valve, tubing, and tap to measure static gage pressure downstream of each filter stage.

e. Total running time readout.

f. Interstage air pressure gages for each interstage.

g. Cooling water supply to compressor pressure gage.

h. Cooling water return from compressor pressure gage.

i. Compressed air pressure downstream of aftercooler pressure gage.

j. Compressed air temperature downstream of aftercooler temperature gage.

k. Interstage air temperature after intercooler of each stage temperature gages.

l. Compressor inlet air temperature gage.

m. Cooling water to compressor temperature gage.

n. Cooling water outlet temperature at outlet of each intercooler and aftercooler temperature gages.

2.2.6 Compressor Design Features

The compressor shall be a multistage, nonlubricated, oil-free reciprocating, double-acting compressor, with a minimum of two compressor stages and water-cooled cylinders and heads. The cylinder arrangement may be horizontal, vertical, V-type, radial, or semi-radial, which will fit in space indicated. An intercooler shall be provided between stages, and aftercooler shall be provided after the final stage of compression. Silencers, lubricating system, cooling system, control system, and driver shall be mounted as part of the package. Provide a common base frame for the compressor system and driver.[Provide a sound enclosure over the compressor and driver.] Equipment shall be designed for economical and rapid maintenance. Frame, cylinders, cylinder heads, bearing housings, and other major parts shall be shouldered, dowelled, or designed with other provisions, to facilitate accurate alignment or reassembly. Packing, seals, and bearings shall be accessible for inspection or replacement with a minimum of disassembly.

2.2.6.1 Frame

Frame shall be one-piece cast iron, ribbed for strength, and shall provide support for crankshaft main bearings and crossheads, and a sump or reservoir for lubricating oil. The frame shall be completely enclosed and provided with gasketed access covers for inspection and maintenance.

2.2.6.2 Crankshaft and Main Bearings

Crankshaft shall be one-piece solid forged steel, heat treated, machined, and ground, with hardened bearing surfaces. Counterweights may be removable. Passages for pressure lubrication shall be rifle drilled into the crankshaft. The crankshaft shall be free of sharp corners with drilled holes or changes in section finished with generous radii and highly polished. Main bearings shall be steel backed babbit type or anti-friction, roller type. Crankshaft shall be counterweighted and balanced.

2.2.6.3 Connecting Rod

Connecting rod shall be of heat treated forged steel, drilled for pressure lubrication, and removable without removing crankshaft. The crankpin bearings shall be the steel backed babbit type. The crosshead pin bearings shall be bronze. Crosshead pin shall be full floating.

2.2.6.4 Crossheads

Crossheads shall be box type, cast iron or steel with babbitted wearing surfaces or shoes which are adjustable and replaceable unless means of adjustment are provided in the crosshead guides.

2.2.6.5 Distance Pieces

Distance pieces shall be extra long, single compartment, and of sufficient length to prevent oil carryover. No part of the piston rod shall alternately enter the crankcase (crosshead housing) and the air compression cylinder stuffing box. The rod shall be fitted with an oil slinger or wiper to prevent oil loss from the crankcase, preferably of a split design for easy access to the piston rod packing. Access openings of adequate size shall be provided to permit removal of the assembled packing case.

2.2.6.6 Pistons and Piston Rods

a. Pistons shall be lightweight castings of anodized aluminum alloy or cast iron. Cast iron pistons shall be chromium plated or otherwise treated for corrosion resistance. Pistons shall be fitted with not less than two fluorocarbon compression rings in individual ring grooves. Wear bands of fluorocarbon material, if required, shall be of one-piece construction. Pistons which are removable from the rod shall be attached to the rod by a shoulder and lock nut design. The nuts on the end of the rod must be positively locked in place. The rod shall be positively locked to the crosshead to prevent rotation.

b. Piston rods: Piston rods shall be of SAE 4140 alloy steel as a minimum with rolled or ground threads. Rods shall be surface hardened to 50 Rockwell C hardness in the packing or other wear areas and nondestructively tested for cracks by the magnetic particle or liquid penetrant methods. Rod finish in the packing area shall be 10 to 20 microinches, except that for carbon packing the finish shall be 6 to 8 microinches. Piston rods shall be hard chrome plated.

2.2.6.7 Piston Rod Packing

The piston rod shall be sealed against air leakage by floating, self-adjusting seal rings. The packing box shall be water cooled. Packing box and packing gland clearances shall be adequate to prevent scoring of the piston rod, when maximum wear of the piston wear band occurs.

2.2.6.8 Cylinder and cylinder Heads

a. Cylinders and cylinder heads shall be cast iron with integral cooling water passages. Air-cooled cylinders shall not be permitted. Cylinders shall be spaced and arranged to permit access to all openings and components, including water jacket opening covers, distance piece covers, packing, valves, unloaders, or other controls mounted on the cylinder, without removing the cylinders, the cylinder head, or major piping. Water jackets shall be arranged so that there are no gasketed joints which might allow water to enter the cylinder.

b. Cylinder liners or provisions for reboring: Replaceable hardened stainless steel cylinder liners shall be provided or the cylinder walls shall be of thickness to permit reboring to a radial depth of at least 1/16 inch without encroaching on the maximum allowable working pressure or the maximum allowable rod load. Cylinder walls or liners using fluorocarbon rings and wear bands shall be honed to a finish of 10 to 20 microinches and fluorocarbon burnished.

c. Fasteners: Cylinder heads, stuffing boxes for packing, clearance pockets, and valve covers shall be secured with studs. Cylinder lips supporting these devices shall be fabricated so that overtorquing studs or nuts will not cause lip failure. Studs shall be ASTM A307, Grade B, and shall have each end chamfered to remove the first one-and-a-half threads. Studs shall be secured into tapped holes by interference fit or other approved means.

d. Cylinder coolant system: Cylinder and cylinder head coolant systems shall be designed for not less than [_____] [175 psig] working pressure and for a [_____] [10 psig] maximum pressure drop. Recommended flow rates shall be based on no more than a 10 degree F temperature rise and a 0.002 fouling factor on the coolant side. Provisions shall be made for complete drainage of coolant.

2.2.6.9 Valves

a. Valves shall be alloy steel selected for long life, and shall be ring, plate, or leaf form, direct or pilot pressure actuated. Suction valves shall be provided with unloading devices for capacity control regulation. Each individual unloading device shall be provided with a visual indication of its position and its load (loaded or unloaded) condition.

b. The valve design (including that for double-decked valves) shall be such that valve assemblies cannot be inadvertently reversed, nor a suction valve assembly be fitted into a discharge port.

c. Valve seats shall be removable. Valve seat-to-cylinder gaskets and valve cover-to-cylinder gaskets shall be solid metal. Nonmetallic gaskets shall not be used.

d. The valve and cylinder designs shall be such that the valve cage or the assembly bolting (or both) cannot fall into the cylinder even if the valve assembly bolting breaks or unfastens.

e. The ends of coil valve springs shall be squared and ground to protect the plate against damage by the spring ends.

f. Valve hold-downs shall bear at not less than three points on the valve cage. The bearing points shall be arranged as symmetrically as possible.

g. Metal valve discs or plates, when furnished, shall be suitable for installation with either-side sealing and shall be lapped on both sides. Edges shall be suitably finished to remove stress risers. Valve seats shall also be lapped.

2.2.6.10 Compressor Connections

Flanged compressor connections shall conform to ASME B16.1 or ASME B16.5. Threaded connections shall conform to ASME B1.20.1.

2.2.6.11 Intercoolers, Aftercooler, and Oil Coolers

Intercoolers, aftercooler, and oil cooler shall include ASTM B111/B111M admiralty brass or other corrosion resistant tubes in ASTM B171/B171M admiralty or steel tube sheets and baffles for optimum cooling and fouling resistance using [fresh] [_____] water. Provide intercoolers between stages of compression either integral with unit or factory assembled on unit base with piping. The aftercooler shall be mounted separately from the unit base. Intercoolers, aftercooler, and oil cooler shall be factory tested at 1.5 times operating pressure. External intercoolers and aftercooler shall be constructed in accordance with ASME BPVC SEC VIII D1 requirements and be ASME code stamped for [_____] [175 psig] working pressure. Intercoolers and aftercooler shall be capable of one piece bundle removal. Intercoolers and aftercooler shall be equipped with an integral or direct connected moisture separator with condensate trap assembly. Design intercoolers and aftercooler for 20 and 15 degrees F approach, respectively; however, the approach temperature used to size the coolers shall be reduced if required to meet aftercooler maximum air outlet temperature specified. Nonstandard coolers shall be provided if required to meet the aftercooler maximum air outlet temperature requirement. All coolers shall be of counter-flow design, with a fouling factor of 0.002 for both sides of the coolers.

2.2.6.12 Lubrication System

Include an integral sump, shaft driven positive displacement pump, oil cooler, and duplex filter/strainer (readily replaceable cartridges while operating). System shall be factory assembled and tested. Lubricating oil shall conform to recommendations of the compressor manufacturer. Bearings and crosshead shoes shall be pressure lubricated. Provide the oil sump with a level indicator and drain and fill connections.

Lube oil heater: Provide thermostatically controlled electric heater in lubrication oil sump of sufficient capacity to heat up and maintain manufacturer's recommended oil temperature when unit is cold at [_____] [32 degrees F] ambient. Provide low level indicator with light for protection of the heater.

2.2.6.13 Pulsation Control

If pulsation problems exist, provide pulsation dampers or surge chambers.

2.2.7 Electric Motors

Efficiency and losses shall be determined in accordance with IEEE 112. Unless otherwise specified horizontal polyphase squirrel cage motors rated one to 125 horsepower shall be tested by dynamometer Method B as described in Section 6.4 of IEEE 112. Motor efficiency shall be calculated using Form B of IEEE 112 calculation procedure.

Polyphase motors larger than 125 horsepower shall be tested in accordance with IEEE 112 with stray load loss determined by direct measurement or indirect measurement (test loss minus conventional loss).

The efficiency shall be identified on the motor nameplate by the caption NEMA Nominal efficiency or NEMA Nom eff.

2.2.7.1 Main Electric Drive Motor

The main drive motor for each compressor shall be a polyphase [induction][or][synchronous] motor, [_____] horsepower, with a continuous service factor of 1.0. Size the motor so that the nameplate horsepower rating is not exceeded under the entire range of operating conditions specified.[Design of induction motor shall be high efficiency type, rated not less than 95 percent, based on IEEE 112 testing and labeling.] Electrical service will be as specified. Motor shall be designed for reduced voltage starting [at [50] [65] [80] percent of full voltage], allowing for characteristics of the connected load, and shall start without undervoltage tripping. Provide resistance temperature detectors (RTD) attached to or imbedded in motor winding for control system. The motor shall meet the requirements of NEMA MG 1 with Class F insulation. Provide space heaters for protection of windings during motor shutdowns.

2.2.7.2 Accessory and Related Equipment Motors

Motors less than 1/2 horsepower shall be single phase induction motors and shall conform to NEMA MG 1. Motors 1/2 through 5 horsepower shall be three-phase induction motors and shall conform to NEMA MG 1. Single-phase and three-phase motors shall have bimetallic disk thermostats attached to or imbedded in the motor winding. Motors shall have NEMA MG 1, Class B insulation.

2.2.8 Control Panel

Control unit panel shall conform to NEMA ICS 6, floor or frame mounted, factory designed, and assembled, and shall be provided complete. The panel shall be fabricated of formed stretcher leveled sheet steel, reinforced, and assembled into a rigid unit. Gasketed access doors shall be provided as required. Panel shall be factory finish painted. The panel shall meet NEMA 12 requirements.

a. Panel shall contain electric and safety control work required, including either alarm annunciator or individual labeled pilot lights arranged in a group. Panel shall contain alarm device with light and silencing. Generalized arrangement in accordance with drawings.

b. Panel shall contain start and stop buttons (the latter with lockout feature), discharge air pressure gage, control test switch and lights, reset button, green unit running light, and control selector switch.

c. Oil pressure gages shall be mounted separately from panel.

2.2.9 Accessories

Required accessories include:

2.2.9.1 Compressor Air Inlet

Compressor air inlet shall be piped to the outside of the building and consist of the following:

a. Intake weather hood with rain hood and bird screen. Material shall be galvanized steel or aluminum alloy, minimum 20 gage.

b. Intake pipe, ASTM A36/A36M steel, ASTM A123/A123M or ASTM A153/A153M galvanized, 12 gage or Schedule 5 minimum, from intake weather hood to filter housing flange, welded construction.

c. Filter housing by filter manufacturer to include filter frames, access door(s). Material for housing shall be 0.065 inch thick Class 5000 aluminum alloy. Unit shall be rigid and free from distress with all seams sealed.

d. Intake pipe from filter enclosure to compressor: Steel pipe, ASTM A53/A53M, seamless or welded, 0.250 inchminimum wall thickness. Fittings butt welding, ASME B16.9, 0.250 inch minimum wall thickness. Flanges: ASME B16.5, Class 150, welding neck or slip-on, flat-faced.

2.2.9.2 Compressor Air Outlet

Compressor air outlet flexible connection of stainless steel bellows with braided steel cover jacket, with stainless steel liner sleeve, 18 inch nominal length bellows, flanged ends, Class 150.

2.2.10 Inlet Air Filters

Provide a three-stage filter system, complete with mounting racks (horizontal flow), interstage seals, and replaceable filters. Filter unit shall be provided complete including enclosure or housing, and frames. Enclosure shall be Class 5000 aluminum alloy with inlet and outlet flanges. Construction shall be welded or, where welding is not practical, close riveted and caulked, weathertight, with access doors for filter replacement and cleaning. Access doors shall be reinforced, fully gasketed with continuous flexible neoprene gaskets, corrosion-resistant continuous hinges and quarter-turn latches to ensure tightness. All internal ferrous surfaces, including galvanized, shall receive a factory-applied epoxy prime and finish coat for corrosion resistance. Filters shall consist of three separate stages and sized to fit the available space.

2.2.10.1 First-Stage Filter

First-stage filter shall be flat, 2 inch thickness, replaceable media, and rated for the required air quantity at 500 FPM nominal face velocity, friction clean 0.25 inch water gage, efficiency 98 percent of 15 microns and 90 percent of 5 microns.

2.2.10.2 Second-Stage Filter

Second-stage filter shall be deep pleated type, 9 inchesnominal depth and rated for the required air quantity at 350 FPM nominal face velocity, friction clean 0.20 inch watergage, efficiency 98 percent of 5 microns and 90 percent of 3 microns.

2.2.10.3 Third-Stage Filter

Third stage filter shall be deep pleated type 12 inchesminimum depth and rated for the required air quantity at 350 FPM nominal face velocity, friction clean 0.30 inch watergage, efficiency 99.9 percent of 0.5 micron.

2.2.10.4 Filter Media

Filter media shall be rated and listed UL Class 2. Filter efficiencies shall be based on National Bureau of Standards (NBS) type discoloration gravimetric test method using atmospheric dust.

2.2.11 Inlet Line Silencer

An inlet line silencer shall be furnished with each compressor as selected by compressor manufacturer for sufficient noise attenuation to meet OSHA sound level criteria but not greater than 84 dBA measured at an elevation of 5 feet, and 10 feet horizontally from silencer.

2.2.12 Sound Attenuating Enclosure

The compressor package, including the driver motor, shall be contained within a noise reducing enclosure. Design of the enclosure shall be such as to limit noise transmission to 84 dBA or less at a distance of one meter from the compressor in any direction.

2.2.12.1 Enclosure Frame

The enclosure frame shall be designed to support the weight of the sound suppression panels and to be easily demountable. Connections to the base frame shall be designed to allow the enclosure frame to be detached and lifted away without damage to the connections, enclosure frame or base frame, and to allow accessibility and replacement of any component.

2.2.12.2 Panels

The panels shall be of rigid construction to allow repeated access without damage or distortion. Sound absorbing material shall be mineral fiber, treated to preclude shedding of fibers. Other approved insulation may be used except that polyurethane foam shall not be permitted. Top panels shall be secured to the enclosure frame with quick disconnect fittings and fabricated to allow easy hand removal for maintenance. End and side panels shall be hinged or lift out with positive closure latches. Panels shall be designed to allow the maximum access area when opened. Provide acoustic seals as required. Controls and instrumentation mounted on the panels shall have flexible connections for panel opening and disconnects for enclosure removal. Disconnects shall be of the male-female plug type. Panels shall split around all piping connections to allow enclosure removal without detaching piping. Controls shall be visible and operable from outside the enclosure.

2.2.12.3 Ventilation

Fan(s) and sound baffled ventilation grilles shall be provided as part of the enclosure. Ventilation shall be sufficient to limit interior temperature to that required for cooling the motor.

2.3 AIR FLOW RATE AND PRESSURE RECORDER MEASUREMENT

Provide a complete flow and pressure measurement and recording package. Provide orifice flanges with pressure taps, square edged stainless steel paddle orifice plate. The orifice plate shall be concentric type, of 0.125 inch thickness and shall meet ASME Standards. Orifice shall be sized for 40 inch water column differential at a full scale flow rate of [_____] SCFM at compressor based on 120 psig upstream pressure. Static gage pressure measurement device of the recorder shall have a range of zero to 200 psig. Provide copper interconnecting tubing between the pressure taps and the recorder as part of this measurement and recording package. Provide a two-pen recorder for the measurement station. Pens shall record pressure (0 to 200 psig range) and air flow (0 to [_____] SCFM). Recorder shall be electric drive and housed in dust-tight steel cabinet. Charts shall be 12 inchdiameter with evenly divided graduations. Drive shall be 7 day circle. Provide continuous flow integration of a 7 digit counter type. Pens shall be supplied with long-life cartridges and capillary supply. Chart case shall be internally illuminated. Access to charts shall be through front access window door. Calibrated overall accuracy of the recorded measurements shall be within plus or minus 1.0 percent of full scale. Furnish a supply of 400 charts with the recorder.

2.4 CARBON MONOXIDE MONITOR

The carbon monoxide (CO) monitor unit shall be of the pressure type with attached sampling system. The unit shall be solid state type operation, 2 to 50 ppm range, CO indicating, with provisions for milliamp signal to remote recorder, adjustable set point, and normally open/normally closed contacts for remote signal. Power shall be 120 volt, single phase, 60 hertz with power cord and plug. Response time normally 2 minutes per sample/purge. Unit shall be mounted in a gasketed enclosure with face gage indicating CO readings.

2.4.1 Sampling System

Sampling system shall include shutoff valve filter/regulator, pressure gage, manual drainer, and line humidifier set at 50 percent. Draw sample from compressor discharge.

2.4.2 Test System

Test system shall include calibration gas (20 ppm CO) cylinder test gas (200 ppm CO) cylinder, and calibration connectors with quick disconnect.

2.5 SOURCE QUALITY CONTROL

2.5.1 Factory Test Procedures

The completely assembled air compressor package including the actual contract drive motor, intercooler, lubrication system, and control panel shall be subjected to air compressor performance tests and sound level and run-in tests. Unit shall comply with guarantee requirements applying engineering adjustments to guarantee conditions. Test shall be certified by the manufacturer. Test may be run on the manufacturer's test stand using driver for this contract. Tests shall be in accordance with ASME PTC 9 format. Full-range performance tests shall indicate performance at maximum rated flow, rating point, and unloaded conditions. All accessory performance conditions shall be reported, including intercoolers, aftercoolers, and lubrication and control systems. Completed unit shall be factory tested with sound meters in accordance with ISO 2151. Location shall be one horizontal meter from unit at 1.5 meters above the floor. Test shall include readings at each octave band midpoint and the "A" scale, and shall not exceed 84 dBA and 90 decibels at any octave band. Results of test shall be included in the factory test report on the ISO 2151 format. Factory test data may be corrected to the levels of an equivalent background noise level of 60 dBA showing calculations for reference use.

2.5.2 Supervision of Testing

System and components testing shall be conducted or supervised by either a designated authorized and factory trained representative of the compressor manufacturer supplying the unit or a registered Mechanical Engineer experienced in such work.

2.5.3 System Test

Testing of system shall conform to requirements outlined and shall be witnessed by the Contracting Officer.

2.5.4 Approval of Testing Procedure

Proposed testing procedure shall be approved by the Contracting Officer and the individual in charge of testing prior to conducting tests.

2.5.5 Certification of Performance Tests

The test supervisor shall certify performance by test to be in compliance with specifications.

PART 3 EXECUTION

3.1 INSTALLATION

The Contractor shall install the air compressors and accessories in accordance with manufacturer's recommendations and as indicated on the drawings. All equipment shall be installed plumb and level and anchored to structure, matching holes provided. Install the compressor under the direct supervision of an authorized representative of the manufacturer.

3.2 GENERAL REQUIREMENTS FOR INSTALLING AIR COMPRESSORS

Air compressors with contract motor and accessories shall be factory assembled, run in, and tested complete before shipment to job site.[The Contractor is advised that there are limitations to door opening sizes and available crane lifting capacity. Crane unit is specified to permit single lifts of complete compressor under special approval only.] Should the unit require disassembly for installation, reassembly shall be under the direct supervision of the compressor manufacturer's authorized representative. Complete unit shall be mounted on a rigid single or equivalent mechanically joined steel or iron base. Submit installation sequence plans to the Contracting Officer for approval prior to installation.[Any building materials removed to accomplish installation shall be reinstalled if undamaged, by removal procedures; or if damaged, shall be replaced with new materials to match original configuration.]

3.2.1 Prompt Installation

The Contractor is advised that any compressor received shall be installed and placed in operation promptly to prevent time deterioration when not installed. Should the Contractor sustain a delay exceeding 90 days prior to actual installation, the Contracting Officer shall have the option of requiring breakdown and reassembly to inspect and clean prior to placing in operation. This work shall be at no additional cost to the Government.

3.2.2 Start-Up Services

The Contractor shall furnish the services of a compressor manufacturer's authorized representative to supervise prestart checkout, initial start-up, performance testing, and operator instruction. Time available shall be as required to properly start up but not less than three consecutive days for the compressor.

3.3 FIELD QUALITY CONTROL

3.3.1 Field Test Procedures

Complete field performance testing of the total system shall be performed by the Contractor and witnessed by the Contracting Officer. Air compressor system test shall be conducted by either a compressor manufacturer's factory trained and authorized representative approved by the Contracting Officer or a qualified registered Mechanical Engineer. Tests may be run on individual components or on the system as a whole at Contractor option. Field tests require use of the actual compressor drive motor. Test shall include operation at rated capacity for not less than 4 hours.

3.3.1.1 Performance Tests

Complete performance test shall be run at maximum load, rated load, at point of unload but prior to unload, and unloaded condition. Data shall be recorded listing:

a. Air flow, inlet pressure and temperature, humidity; discharge pressure and temperature.

b. Intercooler water flows, temperatures, and pressures.

c. Aftercooler water flow, temperatures, and pressures.

d. Lube oil cooling water flow, temperatures, and pressures.

e. Lube oil flow, pressures, and temperature.

f. Cooling water pump flow, pressures, and motor amperage.

g. [Cooling tower][Closed circuit cooler]air flow, water and air temperatures, water pressure, and motor amperage.

h. Electrical load in volts and amperes for compressor motor (loaded and unloaded) and compressor auxiliaries.

i. Intake filter pressure differential (clean).

j. Start-up sequence, alarm signals and automatic system shutdown.

k. Test compressor intake and discharge for conformance to CGA G-7.1. Compressor discharge shall show no increase in contaminants.

3.3.1.2 Instrumentation Test

The Contractor may use instrumentation provided in the contract and instrumentation provided by the Contractor to conduct the test. The testing procedure and instrumentation shall be submitted to the Contracting Officer for approval prior to conducting tests. The format of ASME PTC 9 is required. It is intended that a full field test be performed. However, in lieu of precise instrumentation, the Contractor may use certified cooling water pump curves[and[cooling tower][closed circuit cooler] fan curves]. Shutdown signals shall be caused by throttling selected fluids. Test data, such as air intake temperature and humidity, shall be mathematically corrected to performance test requirement levels.

3.3.1.3 Sound Level Tests

Sound level tests shall be conducted concurrently. Broad Band "A" scale readings and Octave Band readings shall be taken and recorded at the same positions as on the factory testing. Maximum permissible level shall be 84 decibels one horizontal meter from the compressor and 1.5 meters above the floor, with unit in operation and all other significant equipment not required for test within the same building bay shutdown at the same location previously described. A background noise correction to 60 decibels is permissible.

3.3.1.4 Operational Deficiencies

Any operational deficiencies noted in the tests shall be promptly corrected and affected portions of the test rerun.

3.3.1.5 Field Test Tolerances

A tolerance of plus or minus 2 percent on flow, plus or minus 4 percent on power, or plus or minus 5 percent on any other variable for each item of equipment or fluid with all others conforming is permissible on field test results when compared to factory test data and to guarantee performance data except that compressor air flow, discharge pressure, and motor power shall be met.

3.3.2 Approval of Testing Procedure

Proposed testing procedure shall be approved by the Contracting Officer and the individual in charge of testing prior to conducting tests.

3.4 TRAINING OF GOVERNMENT PERSONNEL

During start-up and field testing, train Government station personnel in the operation and maintenance of compressor,[cooling tower,][closed circuit cooler,] associated equipment, and all control and safety devices. Training shall not commence until equipment is operational and station personnel are in attendance. At least one day of classroom training and one day of field training shall be furnished for each designated Government personnel. When factory training is required by the compressor manufacturer for proper maintenance and overhaul of the compressor, such training will be furnished by the compressor manufacturer at no additional cost to the Government. The Government will bear the cost of travel and living expenses for Government personnel as necessary for the factory training.

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SECTION 22 15 19.19 20

NONLUBRICATED ROTARY SCREW AIR COMPRESSORS (100 HP AND LARGER)
05/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9 (2015) Load Ratings and Fatigue Life for Ball Bearings

ABMA 11 (2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 2011 (2014B) Cylindrical Wormgearing Tolerance and Inspection Methods

ANSI/AGMA 2009 (2001B; R 2008) Bevel Gear Classification, Tolerances, and Inspection Methods

AMERICAN PETROLEUM INSTITUTE (API)

API Std 619 (2010) Rotary-Type Positive Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.5 (2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B40.100 (2013) Pressure Gauges and Gauge Attachments

ASME BPVC SEC VIII D1 (2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASME PTC 9 (1970; R 1997) Displacement Compressors, Vacuum Pumps and Blowers (for historical reference only)

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM B111/B111M	(2018) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B171/B171M	(2012) Standard Specification for Copper-Alloy Plate and Sheet for Pressure Vessels, Condensers and Heat Exchangers
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-7.1	(2011) Commodity Specification for Air; 5th Edition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 112	(2017) Standard Test Procedure for Polyphase Induction Motors and Generators

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2151	(2004) Acoustics - Noise Test Code for Compressors and Vacuum Pumps - Engineering Method (Grade 2)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-T-19646	(1990; Rev A; Notice 1 2021) Thermometer, Gas Actuated, Remote Reading

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219 Mechanical Power Transmission Apparatus

1.2 GENERAL REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section except as specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Air Compressor System

SD-03 Product Data

Air Compressor

Inlet Air Filters

Line Silencer

Air Flow Rate and Pressure Recorder

[Carbon Monoxide Monitor

] Filter Housing

Submit manufacturer's catalog data for compressor and auxiliary equipment in the format provided in API Std 619, Appendix A. For air compressors, include intercoolers, oil cooler, lubrication system, and control valves. Submit air compressor, intercooler, aftercooler, and bypass cooler performance curves at specified summer and winter design conditions. For electric motors include overall physical features dimensions, ratings, service requirements, efficiency, and weight of equipment.

SD-06 Test Reports

Air compressor performance tests

Sound Level Tests

Obtain approval prior to shipping compressor.

Government shall have the option to observe test procedures and vendor will provide two (2) copies of test results and two (2) copies of maintenance manuals.

Air Compressor Performance Tests

Instrumentation Test

Sound Level and Run-in Tests

Air Compressor System Test

The test supervisor shall certify performance by test to be in compliance with specifications.

SD-07 Certificates

Work Plan

Factory Test Procedures

Factory Testing Certification

Qualifications of Field Supervisors

Field Test Procedures

Training Material

Air Compressor System

Air Compressor System Installation

SD-10 Operation and Maintenance Data

Air Compressor System, Data Package 3

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Data shall contain information required for maintenance and repair and shall contain no evidence that proprietary maintenance arrangements with the manufacturer will be necessary. Compressors which will require proprietary maintenance arrangement with the manufacturer require Government review and approval. The compressors may be disapproved if circumstances do not justify approval of compressors with limited availability of maintenance.

SD-11 Closeout Submittals

Posted Operating Instructions for Air Compressor

Submit text.

1.4 QUALITY ASSURANCE

1.4.1 Work Plan

Submit a written schedule of dates of installation, start-up, checkout, and test of equipment.

1.4.2 Factory Testing Certification

Submit a statement that the air compressor factory is equipped to perform all required factory tests. Submit in accordance with paragraph entitled "Manufacturer's Certifications."

1.4.3 Qualifications of Field Supervisors

Submit the name and certified written resume of the engineer or technician, listing education, factory training and installation, start-up, and testing supervision experience for at least two projects involving compressors similar to those in this contract.

1.4.4 Training Material

Submit a detailed training program syllabus for training government personnel, including instructional materials at least three weeks prior to start of tests.

1.4.5 System Installation

Submit certification of performance conforming to ASME PTC 9 and ASME BPVC SEC VIII D1. Submit certification of proper installation in accordance with paragraph entitled "Supervision."

1.5 SAFETY

Construct all components of the unit in accordance with the requirements of OSHA 29 CFR 1910.219. Requirements include shaft coupling guards as specified in Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS insulation and jacketing with manufacturer standard covering or aluminum sheet of all surfaces at 125 degrees F and higher within a height of 7 feet from floor level, and use of electrical safety devices. Thermal insulation, furnished by equipment manufacturer, shall conform to ASTM C553, Type I (flexible resilient), Class B-5 (up to 400 degrees F), 2 pcf nominal. Cement insulation to surface with MIL-A-3316, Class 2, adhesive and fasten with 16-gage wire bands at maximum 16 inches on center spacing. Cover insulation with ASTM B209 sheet aluminum jacket. However, insulation is not required for hot piping inside sound enclosure.

1.6 EQUIPMENT ARRANGEMENT

Arrangement selected shall maintain 3 foot clearance for access passage and 4 foot clearance for personnel to operate equipment. There are substantial physical and connection point differences among the several air compressors which comply with this specification. The Contractor shall be responsible for selecting equipment and submitting arrangement drawings covering required changes for approval by the Contracting Officer. Changes from the equipment arrangement shown on the contract drawings shall be performed by the Contractor at no additional cost to the Government.

1.6.1 Air Compressor System

Include wiring diagrams of the air compressor with all accessories. The minimum acceptable scale is [1/4 inch to one foot] [_____].

1.7 ELECTRICAL REQUIREMENTS

Comply with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM [and [_____]].

1.8 SUPERVISION

The Contractor shall obtain the services of a qualified engineer or technician from the compressor manufacturer to supervise installation, start-up, and testing of the compressor. After satisfactory installation of the equipment, the engineer or technician shall provide a signed certification that the equipment is installed in accordance with the manufacturer's recommendations.

1.9 DEFINITIONS

Conform to API Std 619 and the following:

Compressor power is shaft power at shaft coupling, including all losses and connected appurtenances.

1.10 INSULATION

Thermal and acoustical insulation shall have flame spread rating not higher than 75, and smoke developed rating not higher than 150 when tested in accordance with ASTM E84.

1.11 POSTED OPERATING INSTRUCTIONS

Provide for air compressor. Include start-up and shutdown sequence instructions.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment complete with accessories shall be selected by the Contractor for performance compatibility.

2.2 AIR COMPRESSOR

The air compressors shall be packaged, positive displacement rotary screw compressors capable of delivering oil-free air. No lubricant shall be used within the compression chamber. Include air compressor, electric motor driver, coolers, lubrication system, and regulation and control systems mounted on a common base frame, and completely enclosed for noise control.

2.2.1 Manufacturer's Certifications

The manufacturer shall certify that the air compressors proposed are of the same design, construction, size, and of equal or not more than 10 percent smaller in capacity as compressors which have been in satisfactory continuous service for at least 2 years at not less than two locations. Furnish the name of the owner, the address of the installation, and the name of a person at the installation who can be contacted for verification. The manufacturer shall also certify that the factory is equipped to perform all required factory tests.

2.2.2 Guaranteed Performance

a. Net compressed air output (All seal losses shall be considered internal and not included in the net output) (plus or minus 2 percent): [_____] SCFM

b. Output pressure immediately downstream of aftercooler (minus zero plus 4 percent): 125 psig

c. Output air maximum temperature downstream of aftercooler: 100 degrees F

d. Inlet air pressure at first stage: [_____] psig

e. Inlet air temperature at first stage: [_____] degrees F

f. Inlet air filtration efficiency: 99.9 percent of 0.5 micron size

g. Barometric pressure: [_____] psig

h. Relative humidity: [_____] percent

i. Cooling water inlet temperature: [_____] degrees F

j. Total cooling water flow rate: [_____] gpm

k. Maximum cooling water pressure drop through the compressor and any intercooler, aftercooler, or oil cooler: [_____] [8 psig]

l. Maximum compressor power required. (Plus or minus 4 percent): [_____] hp

m. Unloaded compressor power (maximum): [_____] hp

n. Maximum sound levels one meter horizontal from compressor and 1.5 meters above floor as measured per ISO 2151 Test Code for the Measurement of Sound from Pneumatic Equipment: 84 dBA, 90dB for any octave band.

2.2.3 Additional Performance Requirements

2.2.3.1 Air Quality

Air at compressor intake will be considered breathing air quality conforming to CGA G-7.1, Type I, Grade D or better. Air compressors shall introduce no material, gases, or particles, or chemically alter any materials that will adversely affect or reduce the quality of the air passing through the unit.

2.2.3.2 Ambient and Inlet Conditions Operating Ranges

Allowing for rational engineering performance adjustments due to variations in ambient and inlet conditions, the compressor shall be designed, equipped, and furnished to be fully operational without abnormal wear throughout the entire range between and including the limits of the winter and summer design conditions specified.

a. Summer Design Conditions:

Inlet Air: [_____] degrees F dry bulb and [_____] degrees F wet bulb temperatures, [_____] percent relative humidity, Inlet Cooling Water: [_____] degrees F, Ambient Compressor Room Temperature: [_____] degrees F, Barometric Pressure: [_____] psig

b. Winter Design Conditions:

Inlet Air: [_____] degrees F dry bulb and [_____] degrees F wet bulb temperatures, [_____] percent relative humidity, Inlet Cooling Water: [_____] degrees F, Ambient Compressor Room Temperature: [_____] degrees F, Barometric Pressure: [_____] psig.

2.2.3.3 Critical Speeds

Actual critical speeds shall not encroach upon operating speed ranges at specified loads ranges. Rotors shall be of a stiff shaft construction with the first actual rotor bending critical speed at least 120 percent of the maximum operating speed.

2.2.3.4 Vibration and Balance

Major parts of rotating elements, such as rotors, gears, and similar items shall be individually dynamically balanced. During the factory and site tests of the assembled machine at operating speed, the double amplitude of vibration in any plane measured on the shaft adjacent and relative to a radial bearing shall not exceed the limits of API Std 619, paragraph 2.7.2.5. For shafts which are not accessible, the manufacturer shall submit a testing procedure to the Contracting Officer for approval.

2.2.4 Electrical Service Conditions

2.2.4.1 Air Compressor Drive Motor

[_____] volts, 3 phase, 3 wire, 60 hertz electrical service.

2.2.4.2 Accessory electrical Service

See Table I.

TABLE I - COMPRESSOR ACCESSORY ELECTRICAL SERVICE SCHEDULE

Item	Voltage	Phase	Frequency
Control Power and Motors under 1/2	120	1	60 Hz
Accessory Power	460	3	60 Hz

2.2.5 Compressor Controls

Provide a complete load regulation and control system with the compressor. Provide additional electrical, electro-pneumatic, or solid state electronic controls for other specified control and monitor functions. All electrical controls shall conform to NEMA ICS 2 as selected by the compressor manufacturer. Control system enclosure shall conform to NEMA ICS 6. Controls shall be suitable for individual operation of the compressor or parallel operation with one or more other compressors.

2.2.5.1 Compressor Start-Up

The compressor shall start unloaded. The manual starting circuit for the compressor shall have interlocks to prevent the compressor drive motor from starting until pre-lubrication pump (if provided), oil pressure, and cooling water pump water flow have been established to the required values for safe operation as determined by the compressor manufacturer.

2.2.5.2 Load Regulation

The compressor shall operate continuously at constant speed after being started. Provide means to load and unload the compressor automatically at preset minimum and maximum pressure settings. Minimum pressure shall be 100 psig, and maximum pressure shall be 125 psig. Unloading shall be accomplished by a combination of closing the inlet valve and bypassing or venting the outlet of the compressor; however, input power at fully unloaded operation shall not exceed 20 percent of full load input. Bypassed air shall be cooled by the bypass cooler and if returned to the inlet of the first stage through an internal loop and shall be limited to the minimum flow required to maintain compressor cooling. Air vented to the atmosphere when unloading need not be cooled.

2.2.5.3 Monitor and Safety Controls

Provide supplementary electric, electro-pneumatic, or solid state electronic controls to provide alarm and shutdown requirements, plus interlocks with accessories. Requirements are as follows:

a. Shutdown requirements shall cause the controlled compressor to shut down, energize alarms, and light labeled red lights.

b. Alarm only requirements shall not cause the controlled compressor to shut down, but shall sound the same alarms and light labeled amber lights.

c. Light only requirements shall not cause the controlled compressor to shut down, but shall light labeled amber lights.

d. The individual monitor and safety controls shall be as shown on Table 2.

TABLE 2 - MONITOR AND SAFETY CONTROL SCHEDULE

Item	Light and Shutdown	Indicating Alarm	Light Only
1. High Discharge Air Temperature 275 degrees F	Yes	Yes	-
2. High Intercooler Discharge Water Temperature, Each Intercooler	No	Yes	-
3. High Aftercooler Discharge Water Temperature	No	Yes	-
4. High Cooling Water Supply Temperature	No	Yes	-
5. High Lube Oil Temperature	Yes	Yes	-
6. Low Lube Oil Pressure	Yes	Yes	-
7. Low Cooling Water Flow	No	Yes	-
8. Low Oil Reservoir Level	No	Yes	-

9. High Condensate Level Intercooler (wired to one light)	No	No	Yes
10. High Bleed-Off Air Pressure	Yes	Yes	-
11. High Motor Stator Temperature	Yes	Yes	-
12. High Condensate Level Aftercooler	No	No	Yes
13. High Inlet Pressure Drop Across Inlet Air Filters (combined, 3 stage)	No	Yes	-
14. High CO Level	Yes	Yes	-

2.2.5.4 Monitoring Instruments

Provide the following monitoring instruments in addition to the monitor and safety controls. Pressure gages shall conform to ASME B40.100, 4 1/2 inch diameter, red marking pointer, single bourdon tube, brass case, black enamel finish. Provide pressure gages with a pressure snubber and a stainless steel barstock needle isolation valve. Thermometers shall be extended stainless steel sheathed bimetallic stem, 3 1/2 inch dial, and separable 4 inchstainless steel wells. Temperature measurements at inaccessible locations shall be made with remote reading thermometers conforming to MIL-T-19646, Class C separable well of Type 304 stainless steel. Select pressure and temperature gage ranges to give a normal operating reading near the midpoint of the scale range.

a. Oil cooler outlet temperature gages for oil.

b. Oil cooler inlet temperature gages for water.

c. Lubrication oil bearing supply pressure gage.

d. Compressor seal air pressure gage (if applicable).

e. Inlet air filter differential pressure gage with 8, zero, 8 inch water gage. Provide selector valve, tubing, and tap to measure static gage pressure downstream of each filter stage.

f. Total running time readout.

g. Cooling water supply to compressor pressure gage.

h. Cooling water return from compressor pressure gage.

i. Interstage air pressure gages for each interstage.

j. Compressed air pressure downstream of aftercooler pressure gage.

k. Compressed air temperature downstream of aftercooler temperature gage.

l. Compressed air temperature at discharge of each stage of compression before cooling temperature gages.

m. Interstage air temperature after intercooler of each stage temperature gages.

n. Compressor inlet air temperature gage.

o. Cooling water to compressor temperature gage.

p. Cooling water outlet temperature at each outlet of each intercooler, aftercooler, and bypass air cooler temperature gages.

[2.2.5.5 Gages on Schematics

Certain pressure and temperature gages are designed on schematic flow diagrams in the drawings. Where a monitor gage satisfies the required location on a schematic, no additional gage needs to be furnished.

][2.2.5.6 Control Schematics

The drawings show a generalized overall control system for compressor, auxiliaries, remote panel transmitting and receiving, and remote panel. The system is shown using relay symbology. Contractor and equipment suppliers may use standard panel features to accomplish the total requirements using other methods of signal, solid state devices, or revised lamping. All wiring diagrams and required devices shall be approved by the Contracting Officer prior to installation.

]2.2.6 Compressor Design Features

The compressor shall be a multistage, oil-free rotary screw compressor, with a minimum of two compressor stages, flanged to an integral speed increaser. Each stage shall be driven from a common bull gear to ensure optimum speed and efficiency. An intercooler shall be provided between stages and aftercooler shall be provided after the final stage of compression. Silencers, lubricating system, cooling system, control system, and driver shall be mounted as part of the package. Provide a common base frame for the compressor system and driver. Provide a sound enclosure over the compressor and driver. Equipment shall be designed for economical and rapid maintenance. Casing components, bearing housings, and other major parts shall be shouldered, dowelled, or designed with other provisions to facilitate accurate alignment or reassembly. Shaft seals and bearings shall be accessible for inspection or replacement with a minimum of disassembly; however, compressors with compression elements (air end) provided as a factory-assembled not repairable in the field may be approved by the Contracting Officer if determined to be in the interest of the Government.

2.2.6.1 Casings

Casings shall be cast iron, ductile iron, cast steel, or fabricated steel. Casing stresses shall be within the limits allowed by ASME BPVC SEC VIII D1. Casings, supports, and baseplates shall be designed and fabricated to preclude excessive and injurious distortion from temperatures, pressures, and forces encountered in service conditions. Provide jackscrews, lifting lugs, eyebolts, guide dowels, and casing alignment dowels to facilitate disassembly and reassembly. When using jackscrews for parting contacting faces, relieve one of the faces by counterboring or recessing to prevent marring the face, which result in leaking or improper fit. Provide lifting lugs or eyebolts for removable portions of the casings. Flanged casing connections for external piping shall conform to ASME B16.1 or ASME B16.5. Threaded connections for external piping shall conform to ASME B1.20.1. Air compression portion of the casing shall be one-piece and shall be provided with integral coolant passages and a large inlet port. Gear cases shall be enclosed, accessible, force lubricated, and designed with seals and slingers to keep oil out of air system.

2.2.6.2 Shafts

Shafts shall be of forged or rolled alloy steel and shall have a machined finish throughout their entire length. All rotating components shall be positively secured to shafts by approved mechanical means or interference shrink fits.

2.2.6.3 Rotors

Rotors shall be steel, and of one-piece construction, with an asymmetric profile to minimize leakage losses, and ensure high efficiency. Rotors shall be treated for corrosion resistance. It rotors are welded to the shaft, the assembly shall be stress relieved and heat treated for proper strength. Rotors shall be dynamically balanced to ensure vibration-free operation.

2.2.6.4 Gears

Gears shall be of alloy steel, ANSI/AGMA 2009 and AGMA 2011 Quality Number 12 or better for both bull and pinion gears. Gears shall be hardened to 275 Brinell for bull gear and 320 Brinell for pinion, unless otherwise approved. Gears shall be ground to the required contours, checked for proper contact during assembly at the factory, and shall not require a break-in period in the field for proper operation. All gears shall be pressure lubricated.

Timing gears shall be provided on the rotor shafts to maintain the rotors in correct relative position. The compressor design shall allow the timing gears to absorb no more than 10 percent of the total input power at full load.

2.2.6.5 Seals

Separate air and oil shaft seals shall be provided to confine air in the casing and prevent contamination of the air stream by lubricating oil. Shaft seals shall be the restrictive ring type. The seal rings shall be stainless steel, brass, or carbon, and retainers shall be made of stainless steel. Provide an air space vented to the atmosphere between the air and oil seals. Seals shall be suitable for all operating conditions including suction throttling, start-up, and shutdown.

2.2.6.6 Thrust Bearings

Thrust bearings shall be anti-friction ball or roller type or hydrodynamic (fluid film) type. Anti-friction bearings shall have an L-10 life of 80,000 hours in accordance with ABMA 9 or ABMA 11. Axial rotor thrusts due to air compression shall be absorbed by main thrust bearings or transferred to auxiliary thrust bearings by a load balancing arrangement. Hydrodynamic thrust bearings shall be Kingsbury type or other approved type and shall be adequate to accommodate all operating conditions. Speed increaser bull gear thrust bearings shall be sized for equal thrust in both directions and shall be adequate for any axial loads transmitted through the driver coupling.

2.2.6.7 Radial Bearings

Radial bearings shall be anti-friction roller or ball type or hydrodynamic type. Anti-friction bearings shall have an L-10 life of 40,000 hours in accordance with ABMA 9 or ABMA 11. Hydrodynamic bearings shall be precision bored sleeve or pad type, designed for easy replacement by a split design or axially removable arrangement. High speed hydrodynamic pinion bearings shall be anti-oil whip, tilting pad type. Hydrodynamic bearing design shall provide low vibration and sufficient damping at rated speed and all operating modes, including rated capacity and unloading down to 20 percent of unloaded power.

2.2.6.8 Speed Increaser

The speed increaser shall be an integral part of the compressor unit and shall include the main drive shaft and bull gear. The main drive shaft shall be supported through anti-friction bearings.

2.2.6.9 Intercoolers, Aftercooler, Bypass Cooler, and Oil Coolers

Intercoolers, aftercooler, bypass cooler, and oil cooler shall include ASTM B111/B111M admiralty brass or other corrosion resistant tubes in ASTM B171/B171M admiralty or steel tube sheets and baffles for optimum cooling and fouling resistance using [fresh] [_____] water. Provide an intercooler between stages of compression factory assembled on unit base with piping. The aftercooler shall be mounted on the unit base. Intercoolers, aftercooler, bypass cooler, and oil cooler shall be factory tested at 1.5 times operating pressure. External intercoolers and aftercooler shall be constructed in accordance with ASME BPVC SEC VIII D1 requirements and be ASME code stamped for 150 psig working pressure. Intercoolers and aftercooler shall be capable of one piece bundle removal. Intercoolers and aftercooler shall be equipped with an integral or direct connected moisture separator with condensate trap assembly. Design intercoolers and aftercooler for 20 and 15 degrees F approach, respectively; however, the approach temperature used to size the coolers shall be reduced if required to meet aftercooler maximum air outlet temperature specified. Nonstandard coolers shall be provided if required to meet the aftercooler maximum air outlet temperature requirement. All coolers shall be of counter-flow design, with a fouling factor of 0.002 for both sides of the coolers.

2.2.6.10 Lubrication System

Include an integral sump, positive displacement pump, oil cooler, and twin filter\strainer (readily replaceable cartridges while operating). Provide a prelube lubrication oil pump for start-up and standby for hydrodynamic bearings or if required by the compressor design. System shall be factory assembled and tested. Lubricating oil shall conform to recommendations of the compressor manufacturer. Spray lubricate drive gear, anti-friction bearings, and timing gear in each stage. Pressure lubricate hydrodynamic bearings. Provide the oil sump with a level indicator and drain and fill connections.

a. Prelubrication pump, if required, or motor-driven main lubrication pump shall be sized by air compressor manufacturer for the requirements of the system, but shall meet the following requirements. Pump shall be positive displacement gear pump separately mounted with motor on a common base plate with drip lip and drain.

   (1) Performance: Pump shall have separate safety valve bypass set at [_____] [25 psi] above peak expected pressure.

(2) Materials shall be hardened steel gears and shaft, cast iron case, bronze bearings, mechanical seal.

(3) Flexible coupling with shaft guard shall be provided, except that these items are not required for a close-coupled pump.

(4) Motor shall be NEMA MG 1, Design A or B, Class B insulation, of open drip-proof type. Furnish combination type starter for motor.

b. Lube Oil Heater: Provide thermostatically controlled electric heater in lubrication oil sump of sufficient capacity to heat up and maintain manufacturer's recommended oil temperature when unit is cold at [_____] [32 degrees F] ambient. Provide low oil level indicator with light for protection of heater.

2.2.7 Electric Motors

2.2.7.1 Main Electric Drive Motor

The main drive motor for each compressor shall be [an induction,] [or] [a synchronous] motor, [_____] horsepower (hp), with a continuous service factor of 1.0. Size the motor so that the name plate hp rating is not exceeded under the entire range of operating conditions specified. Efficiency and losses shall be determined in accordance with IEEE 112. Unless otherwise specified horizontal polyphase squirrel cage motors rated one to 125 horsepower shall be tested by dynamometer Method B as described in Section 6.4 of IEEE 112. Motor efficiency shall be calculated using Form B of IEEE 112 calculation procedures. Polyphase motors larger than 125 horsepower shall be tested in accordance with IEEE 112 with stray load loss determined by direct measurement or indirect measurement (test loss minus conventional loss). The efficiency shall be identified on the motor nameplate by the caption NEMA Nominal efficiency or NEMA Nom eff. Electrical service will be as specified. Motor shall be designed for reduced voltage starting [at [50] [65] [80] percent of full voltage], allowing for characteristics of the connected load, and shall start without undervoltage tripping. Provide resistance temperature detectors (RTD) attached to or imbedded in motor winding for control system. The motor shall meet the requirements of NEMA MG 1 with Class F insulation. Provide space heaters for protection of windings during motor shutdowns.

2.2.7.2 Accessory and Related Equipment Motors

Motors less than 1/2 hp shall be single-phase induction motors and shall conform to NEMA MG 1. Motors 1/2 through 5 hp shall be three-phase induction motors and shall conform to NEMA MG 1. Single-phase and three-phase motors shall have bimetallic disk thermostats attached to or imbedded in the motor winding. Motors shall have NEMA MG 1 Class B insulation.

2.2.8 Control Panel

Control unit panel shall conform to NEMA ICS 6, floor or frame mounted, factory designed, and assembled, and shall be provided complete. The panel shall be fabricated of formed stretcher leveled sheet steel, reinforced, and assembled into a rigid unit. Gasketed access doors shall be provided as required. Panel shall be factory finish painted. The panel shall meet NEMA 12, requirements.

a. Panel shall contain electric and safety control work required, including either alarm annunciator or individual labeled pilot lights arranged in a group. Panel shall contain alarm device with light and silencing. Generalized arrangement in accordance with drawings.

b. Panel shall contain start and stop buttons (the latter with lockout feature), discharge air pressure gage, control test switch and lights, reset button, green unit running light, and control selector switch.

c. Oil pressure gages shall be mounted separately from panel.

2.2.9 Accessories

Required accessories include:

2.2.9.1 Control Valves

Pneumatically or hydraulically controlled valves on suction inlet of compressor and on bypass or vent line.

2.2.9.2 Intake Devices

Compressor air inlet shall be piped to the outside of the building and consist of the following:

a. Intake weather hood with rain hood and bird screen. Material shall be galvanized steel or aluminum alloy, minimum 20 gage.

b. Intake pipe, ASTM A36/A36M steel galvanized, 12 gage or Schedule 5 minimum, from intake weather hood to filter housing flange, welded construction.

c. Filter housing by filter manufacturer to include filter frames, access door(s). Material for housing shall be 0.065 inch thick, Class 5000 aluminum alloy. Unit shall be rigid and free from distress with all seams sealed.

d. Intake Pipe from Filter Enclosure to Compressor: Aluminum alloy ASTM B209, Alclad alloy 5052-H32 or equivalent, minimum 10 gage, flanged, welded with 5XXX welding rod using TIG method and including expansion bellows.

2.2.9.3 Outlet Connectors

Compressor air outlet flexible connection of stainless steel bellows with braided steel cover jacket, with stainless steel liner sleeve, 18-inch (457-mm) nominal length bellows, flanged ends, Class 150. If air bypass connects separately to the compressor from the outlet line, provide a second flexible connection of stainless steel bellows with braided jacket for the bypass.

2.2.10 Inlet Air Filters

Provide a three-stage filter system, complete with mounting racks (horizontal flow), interstage seals, and replaceable filters. Filter unit shall be provided complete including enclosure or housing, and frames. Enclosure shall be Class 5000 aluminum alloy with inlet and outlet flanges. Construction shall be welded or, where welding is not practical, close riveted and caulked, weathertight, with access doors for filter replacement and cleaning. Access doors shall be reinforced, fully gasketed with continuous flexible neoprene gaskets, corrosion-resistant continuous hinges and quarter-turn latches to ensure tightness. All internal ferrous surfaces, including galvanized, shall receive a factory-applied epoxy prime and finish coat for corrosion resistance. Filters shall consist of three separate stages and sized to fit the available space.

2.2.10.1 First-Stage

First-stage filter shall be flat, 2 inch thickness, replaceable media, and rated for the required air quantity at 500 FPM nominal face velocity, friction clean 0.25 inch water gage, efficiency 98 percent of 15 microns and 90 percent of 5 microns.

2.2.10.2 Second-Stage

Second-stage filter shall be deep pleated type, 9 inchesnominal depth and rated for the required air quantity at 350 FPM nominal face velocity, friction clean 0.20 inch watergage, efficiency 98 percent of 5 microns and 90 percent of 3 microns.

2.2.10.3 Third-Stage

Third-stage filter shall be deep pleated type 12 inchesminimum depth and rated for the required air quantity at 350 FPM nominal face velocity, friction clean 0.30 inch watergage, efficiency 99.9 percent of 0.5 micron.

2.2.10.4 Filter Ratings

Filter media shall be rated and listed UL Class 2. Filter efficiencies shall be based on National Bureau of Standards (NBS) type discoloration gravimetric test method using atmospheric dust.

2.2.11 Bypass or Vent Line Silencer

A bypass or vent line silencer shall be furnished with each compressor as selected by compressor manufacturer for sufficient noise attenuation to meet OSHA sound level criteria, but not greater than 84 dBA measured at an elevation of 5 feet, and 10 feethorizontally from silencer.

2.2.12 Sound Attenuating Enclosure

The compressor package, including the driver motor, shall be contained within a noise reducing enclosure. Design of the enclosure shall be such as to limit noise transmission to 84 dBA or less at a distance of one meter from the compressor in any direction.

2.2.12.1 Enclosure Frame

The enclosure frame shall be designed to support the weight of the sound suppression panels and easily demountable. Connections to the base frame shall be designed to allow the enclosure frame to be detached and lifted away without damage to the connections, enclosure frame or base frame, and to allow accessibility and replacement of any component.

2.2.12.2 Panels

The panels shall be of rigid construction to allow repeated access without damage or distortion. Sound absorbing material shall be mineral fiber, treated to preclude shedding of fibers. Other approved insulation may be used except that polyurethane foam shall not be permitted. Top panels shall be secured to the enclosure frame with quick disconnect fittings and fabricated to allow easy hand removal for maintenance. End and side panels shall be hinged or lift out with positive closure latches. Panels shall be designed to allow the maximum access area when opened. Provide acoustic seals as required. Controls and instrumentation mounted on the panels shall have flexible connections for panel opening and disconnects for enclosure removal. Disconnects shall be of the male-female plug type. Panels shall split around all piping connections to allow enclosure removal without detaching piping. Controls shall be visible and operable from outside the enclosure.

2.2.12.3 Ventilation

Fan(s) and sound baffled ventilation grilles shall be provided as part of the enclosure. Ventilation shall be sufficient to limit interior temperature to that required for cooling the motor.

2.2.13 Isolating Pad

If specifically recommended by the compressor manufacturer, each compressor steel or iron base frame shall be mounted on a neoprene waffle or rib type isolator pad which extends uniformly and continuously along the base mounting surface. The neoprene material shall be of bridge bearing pad quality neoprene and shall be formulated for 40 durometer hardness. The maximum bearing pressure on the isolating pad shall be 50 psi. The pads shall be composed of two layers or 5/16 inchneoprene bonded to and sandwiching 16 gage galvanized steel. Compressor bolt down through the pad shall be accomplished using 1/4 inchthick neoprene impregnated duck washers. Neoprene bushings are not acceptable.

2.3 AIR FLOW RATE AND PRESSURE RECORDER AND MEASUREMENT

Provide a complete flow and pressure measurement and recording package. Provide orifice flanges with pressure taps, square edged stainless steel paddle orifice plate. The orifice plate shall be concentric type, of 0.125 inch thickness and shall meet ASME Standards. Orifice shall be sized for 40 inch water column differential at a full scale flow rate of [_____] SCFM at compressor based on 120 psig upstream pressure. Static gage pressure measurement device of the recorder shall have a range of zero to 200 psig. Provide copper interconnecting tubing between the pressure taps and the recorder as part of this measurement and recording package. Provide a two-pen recorder for the measurement station. Pens shall record pressure (0 to 200 psig range) and air flow (0 to [_____] SCFM). Recorder shall be electric drive and housed in dust-tight steel cabinet. Charts shall be 12 inchdiameter with evenly divided graduations. Drive shall be 7 day circle. Provide continuous flow integration of a 7 digit counter type. Pens shall be supplied with long-life cartridges and capillary supply. Chart case shall be internally illuminated. Access to charts shall be through front access window door. Calibrated overall accuracy of the recorded measurements shall be within plus or minus 1.0 percent of full scale. Furnish a supply of 400 charts with the recorder.

2.4 CARBON MONOXIDE MONITOR

The carbon monoxide (CO) monitor unit shall be of the pressure type with attached sampling system. The unit shall be solid state type operation, 2 to 50 ppm range, CO indicating, with provisions for milliamp signal to remote recorder, adjustable set point, and normally open/normally closed contacts for remote signal. Power shall be 120 volt, single phase, 60 hertz with power cord and plug. Response time normally 2 minutes per sample/purge. Unit shall be mounted in a gasketed enclosure with face gage indicating CO readings.

2.4.1 Sampling System

Sampling system shall include shutoff valve filter/regulator, pressure gage, manual drainer, and line humidifier set at 50 percent. Draw sample from compressor discharge.

2.4.2 Test System

Test system shall include calibration gas (20 ppm CO) cylinder test gas (200 ppm CO) cylinder, and calibration connectors with quick disconnect.

2.5 SOURCE QUALITY CONTROL

2.5.1 Factory Test Procedures

The completely assembled air compressor package including the actual contract drive motor, intercooler, lubrication system, and control panel shall be subjected to performance tests and sound level and run-in tests. Unit shall comply with guarantee requirements applying engineering adjustments to guarantee conditions. Test shall be certified by the manufacturer. Test may be run on the manufacturer's test stand using driver for this contract. Tests shall be in accordance with ASME PTC 9 format. Full-range performance tests shall indicate performance at maximum rated flow, rating point, and unloaded conditions. Motor performance conditions shall be reported, including motor efficiency and losses, motor power factor, motor service factor, motor temperature rise, motor noise and balance, and motor torque at full load, locked rotor, pull up, and break down. Include intercoolers, aftercoolers, and lubrication and control systems performance. Completed unit shall be factory tested with sound meters in accordance with ISO 2151. Location shall be one horizontal meter from unit at 1.5 meters above the floor. Test shall include readings at each octave band midpoint and the "A" scale, and shall not exceed 84 dBA and 90 decibels at any octave band. Results of test shall be included in the factory test report on the ISO 2151 format. Factory test data may be corrected to the levels of an equivalent background noise level of 60 dBA showing calculations for reference use.

2.5.2 Supervision of Testing

System and components testing shall be conducted or supervised by either a designated authorized and factory trained representative of the compressor manufacturer supplying the unit or a registered Mechanical Engineer experienced in such work.

2.5.3 System Test

Testing of system shall conform to requirements outlined and shall be witnessed by the Contracting Officer.

2.5.4 Approval of Testing Procedure

Proposed testing procedure shall be approved by the Contracting Officer and the individual in charge of testing prior to conducting tests.

2.5.5 Certification of Performance Tests

The test supervisor shall certify performance by test to be in compliance with specifications.

PART 3 EXECUTION

3.1 INSTALLATION

The Contractor shall install the air compressors and accessories in accordance with manufacturer's recommendations and as indicated on the drawings. All equipment shall be installed plumb and level and anchored to structure, matching holes provided. Install the compressor under the direct supervision of an authorized representative of the manufacturer.

3.2 GENERAL REQUIREMENTS FOR INSTALLING AIR COMPRESSORS

Air compressors with contract motor and accessories shall be factory assembled, run in, and tested complete before shipment to job site. [The Contractor is advised that there are limitations to door opening sizes and available crane lifting capacity. Crane unit is specified to permit single lifts of complete compressor under special approval only.] Should the unit require disassembly for installation, reassembly shall be under the direct supervision of the compressor manufacturer's authorized representative. Complete unit shall be mounted on a rigid single or equivalent mechanically joined steel or iron base. Submit installation sequence plans to the Contracting Officer for approval prior to installation. [Any building materials removed to accomplish installation shall be reinstalled if undamaged, by removal procedures; or if damaged, shall be replaced with new materials to match original configuration.]

3.2.1 Prompt Installation

The Contractor is advised that any compressor received shall be installed and placed in operation promptly to prevent time deterioration when not installed. Should the Contractor sustain a delay exceeding 90 days prior to actual installation, the Contracting Officer shall have the option of requiring breakdown and reassembly to inspect and clean prior to placing in operation. This work shall be at no additional cost to the Government.

3.2.2 Start-Up Services

The Contractor shall furnish the services of a compressor manufacturer's authorized representative to supervise prestart checkout, initial start-up, performance testing, and operator instruction. Time available shall be as required to properly start up but not less than 3 consecutive days for the compressor.

3.3 FIELD QUALITY CONTROL

3.3.1 Field Test Procedures

Complete field performance testing of the total system shall be performed by the Contractor and witnessed by the Contracting Officer. Air compressor system test shall be conducted by either a compressor manufacturer's factory trained and authorized representative approved by the Contracting Officer or a qualified registered Mechanical Engineer. Tests may be run on individual components or on the system as a whole at Contractor option.

Field tests require use of the actual compressor drive motor. Test shall include operation at rated capacity for not less than 4 hours.

3.3.1.1 Air Compressor Performance Tests

Complete performance test shall be run at maximum load, rated load, at point of unload but prior to unload, and unloaded condition. Data shall be recorded listing:

a. Air flow, inlet pressure and temperature, humidity; discharge pressure and temperature.

b. Intercooler water flows, temperatures, and pressures.

c. Aftercooler water flow, temperatures, and pressures.

d. Bypass cooler water flow, temperatures, and pressures.

e. Lube oil cooling water flow, temperatures, and pressures.

f. Lube oil flow, pressures, and temperature.

g. Cooling water pump flow, pressures, and motor amperage.

h. [Cooling tower][Closed circuit cooler] air flow, water and air temperatures, water pressure, and motor amperage.

i. Electrical load in volts and amperes for compressor motor (loaded and unloaded), prelube oil pump motor, and compressor auxiliaries.

j. Intake filter pressure differential (clean).

k. Start-up sequence, alarm signals and automatic system shutdown.

l. Test compressor intake and discharge for conformance to CGA G-7.1. Compressor discharge shall show no increase in contaminants.

3.3.1.2 Instrumentation Test

The Contractor may use instrumentation provided in the contract and instrumentation provided by the Contractor to conduct the test. The testing procedure and instrumentation shall be submitted to the Contracting Officer for approval prior to conducting tests. The format of ASME PTC 9 is required. It is intended that a full field test be performed. However, in lieu of precise instrumentation, the Contractor may use certified cooling water pump curves[and [cooling tower] [closed circuit cooler] fan curves]. Shutdown signals shall be caused by throttling selected fluids. Test data, such as air intake temperature and humidity, shall be mathematically corrected to performance test requirement levels.

3.3.1.3 Sound Level Tests

Sound level tests shall be conducted concurrently. Broad Band "A" scale readings and Octave Band readings shall be taken and recorded at the same positions as on the factory testing. Maximum permissible level shall be 84 decibels one horizontal meter from the compressor and 1.5 meters above the floor, with unit in operation and all other significant equipment not required for test within the same building bay shutdown at the same location previously described. A background noise correction to 60 decibels is permissible.

3.3.1.4 Operational Deficiencies

Any operational deficiencies noted in the tests shall be promptly corrected and affected portions of the test rerun.

3.3.1.5 Testing Tolerances

A tolerance of plus or minus 2 percent on flow, plus or minus 4 percent on power, or plus or minus 5 percent on any other variable for each item of equipment or fluid with all others conforming is permissible on field test results when compared to factory test data and to guarantee performance data except that compressor air flow, discharge pressure, and motor power shall be met.

3.3.2 Approval of Testing Procedure

Proposed testing procedure shall be approved by the Contracting Officer and the individual in charge of testing prior to conducting tests.

3.4 TRAINING OF GOVERNMENT PERSONNEL

During start-up and field testing, train Government station personnel in the operation and maintenance of compressor, [cooling tower,] [closed circuit cooler,] associated equipment, and all control and safety devices. Training shall not commence until equipment is operational and station personnel are in attendance. At least one day of classroom training and one day of field training shall be furnished for each designated Government personnel. When factory training is required by the compressor manufacturer for proper maintenance and overhaul of the compressors, such training shall be furnished by the compressor manufacturer at no additional cost to the Government. The Government will bear the cost of travel and living expenses for Government personnel as necessary for the factory training.

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SECTION 22 15 26.00 20

HIGH AND MEDIUM PRESSURE COMPRESSED AIR PIPING
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

ANSI/AHRI 520	(2004) Performance Rating of Positive Displacement Condensing Units

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.20	(2017) Metallic Gaskets for Pipe Flanges
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping
ASME B36.10M	(2022) Welded and Seamless Wrought Steel Pipe
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME B46.1	(2020) Surface Texture, Surface Roughness, Waviness and Lay
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A182/A182M	(2021) Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A269/A269M	(2015; R 2019) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A312/A312M	(2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A351/A351M	(2018) Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A380/A380M	(2017) Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A403/A403M	(2022) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM B127	(2019) Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip
ASTM B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B165	(2019) Standard Specification for Nickel-Copper Alloy (UNS N04400)* Seamless

	Pipe and Tube
ASTM B564	(2022) Standard Specification for Nickel Alloy Forgings
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
ASTM E381	(2020) Standard Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FLUID POWER ASSOCIATION (NFLPA)

ANSI/NFLPA T3.12.3	(1992; Rev 2) Pneumatic Fluid Power - Pressure Regulator - Industrial Type

PIPE FABRICATION INSTITUTE (PFI)

PFI ES 22	(2016) Recommended Practice for Color Coding of Piping Materials

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 10/NACE No. 2	(2015) Near-White Blast Cleaning

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS7276	(2020; Rev J) Rings, Sealing Fluorocarbon (FKM) Rubber High-Temperature Fluid Resistant Low Compression Set 70 to 80
SAE AS4841	(2021; Rev D) Fittings, 37 Degree Flared, Fluid Connection
SAE AS4842	(2016; Rev A) Fittings and Bosses, Pipe Threaded, Fluid Connection
SAE AS4842/1	(2016; Rev A) Fittings, 37 Degree Flared to Pipe Threaded, Fluid Connection
SAE AS4843	(2016; Rev A) Fittings, Beaded, Fluid Connection
SAE AS4843/1	(2016; Rev A) Fittings, Beaded to 37 Degree Flared, Fluid Connection
SAE AS4843/2	(2016; Rev A) Fittings, Beaded to Pipe Threaded, Fluid Connection
SAE AS4875	(2016; Rev A) Fittings, Straight Threaded Boss, Fluid Connection
SAE AS4875/1	(2021; Rev B) Fittings, Straight Thread Boss or Flanged to 37 Degree Flared, Fluid Connection
SAE AS4875/2	(2016; Rev A) Fittings, Flanged to Beaded, Fluid Connection
SAE J514	(2012) Hydraulic Tube Fittings

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-C-15726	(1988; Rev F; Am 1 1991; Notice 1 2020) Copper-Nickel Alloy, Sheet, Plate, Strip, Bar, Rod, and Wire
MIL-T-16420	(1978; Rev K; Am 1 1988) Tube, Copper-Nickel Alloy, Seamless and Welded (Copper Alloy Numbers 715 and 706)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1689	(Rev B) Tape, Pressure-Sensitive Adhesive, (Plastic Film)
CID A-A-58092	(Basic; Notice 1; Notice 2) Tape, Antiseize, Polytetrafluoroethylene
CID A-A-60001	(Rev A) Traps, Steam

FS QQ-B-654	(Rev A; Notice 1; Notice 2) Brazing Alloys, Silver
FS WW-S-2739	(Basic; Notice 1; Notice 2) Strainers, Sediment: Pipeline, Water, Air, Gas, Oil, or Steam

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219	Mechanical Power Transmission Apparatus

U.S. NAVAL SEA SYSTEMS COMMAND (NAVSEA)

QPL-24109	(2014) Valve, Globe, Angle, Quick Change Cartridge Trim, High Pressure (H.P.) Hydraulic and Pneumatic (Sizes 1/8 - 1-1/4 Inches)

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

High Pressure Compressed Air System

SD-03 Product Data

Air Compressor

Air Dryer

Instrumentation and Controls

Air Receivers and Separators

Desiccant Air Dryers

Piping and Tubing

Fittings

Valves

Adapters

Pressure gages

Snubbers

Timed Solenoid Drain

Traps

Filters

Strainers

Unions

O-ring Gaskets

Flexible connections

Hangers and Supports

Valve box

Identification Labels For Piping

For receivers and separators include Manufacturer's Data Report Form U-1 or U-1A.

SD-06 Test Reports

Non-Destructive Examination (NDE) Report For Welding of Piping

Leak Tightness Test

SD-07 Certificates

Employer's Record Documents

Welding Procedures and Qualifications

SD-08 Manufacturer's Instructions

Air receivers and Separators

Include recommended certification test procedure and procedure for cleaning, external painting, and delivery preparation.

SD-10 Operation and Maintenance Data

Air Compressor, Data Package 4

Air Dryer, Data Package 4

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted Operating Instructions for Air Compressor

Posted Operating Instructions for Air Dryer

Posted Operating Instructions for Compressed Air Systems

1.4 QUALITY ASSURANCE

Provide all work specified in this section, including design, materials, fabrication, assembly, erection, installation, and examination, inspection and testing of compressed air systems in conformance with ASME B31.1, ASME BPVC SEC VIII D1 and ASME BPVC SEC IX ASME BPVC SEC IX and SMACNA 1981, as modified and supplemented by this specification section and accompanying drawings. In ASME B31.1, ASME BPVC SEC VIII D1 and ASME BPVC SEC IX, the advisory provisions shall be considered mandatory, as though the word "shall" had been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" and "owner" shall be interpreted to mean the Contracting Officer.

1.4.1 Equipment Data

Submit the following data for equipment listed for "Operation and Maintenance Instructions, Parts and Testing."

a. Name and address of authorized branch or service department.

b. Characteristic curves.

c. Following applicable data completely filled in:

Manufacturer and model number

Operating speed

Capacity (CFM)

Type of bearings in unit

Type of lubrication

Type and adjustment of drive

Capacity of tank

Electric motor: Manufacturer, frame and type

Motor speed RPM

Current characteristics and HP of motor Thermal cut-out switch: Manufacturer, type and model

Starter: Manufacturer: Type and model

1.4.2 High Pressure Compressed Air System

Show location, length, and type of welds or brazes, and indicate welding and brazing procedures to be used, preheat, postweld heat treatment, and nondestructive welding and brazing testing required.

1.4.3 Laboratory Test Reports and Material Control

Laboratory Test Reports and Material Control for high Pressure Compressed Air Systems:

1.4.3.1 Laboratory Test Reports

Furnish the following laboratory test reports for pipe, tube, fittings, valves, and other pressure containing components (except pressure gages) for each heat and lot of material.

a. Full chemical analyses.

b. Physical properties.

c. Etch test per ASTM E381 as modified for the alloy to verify pipe and tube are seamless and free of defects.

1.4.3.2 Material Control

Where more than one type of corrosion resistant alloy (stainless steel and copper-nickel or nickel-copper for example) is to be installed at project site, the Contractor shall implement and maintain a material control system with markings and/or tags to identify positively each piece as to the type of metal.

1.4.4 Welding Requirements

Provide all welding work specified in this section for compressed air piping systems and in conformance with ASME B31.1, as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, brazing procedures, welders, brazers, welding operators, brazing operators, inspection personnel, nondestructive examination personnel, maintenance of welding records, and examination methods for welds.

1.4.4.1 Butt Welded Joints

Butt welded joints shall be full penetration joints. Butt welded joints in systems with working pressures over 300 psig shall be full penetration welds with consumable inserts or backing rings.

1.4.5 Employer's Record Documents

Submit to the ROICC for his review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with ASME B31.1.

a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.

b. List of qualified welders, brazers, welding operators, and brazing operators that are proposed to be used to provide the work specified in this specification section.

c. List of qualified weld inspection personnel that are proposed to be used to provide the work specified in this specification section.

1.4.6 Welding Procedures and Qualifications

Determine performance qualification in accordance with ASME B31.1 and as specified.

1.4.6.1 Specifications and Test Results

Submit copies of the welding procedure

specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.

1.4.6.2 Certification

Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

1.4.6.3 Renewal of Qualification

Requalification of a brazer or brazing operator shall be required under any of the following conditions:

a. When a brazer or brazing operator has not used the specific brazing process for a period of 6 months.

b. There is specific reason to question his ability to make brazes that will meet the requirements of the specifications.

1.4.7 Experience for Installation and Testing

Experience for Installation and Testing Of Medium and High Pressure Air System: Install and test medium and high pressure air piping and equipment in accordance with ASME B31.1 and only with competent personnel specially trained and experienced in installation and testing of medium and high pressure air systems. The supervisors and personnel performing installation and testing shall have had previous experience in the satisfactory installation and testing of at least two medium and high pressure air systems. Submit data substantiating this experience to the Contracting Officer for approval prior to performing any work. Supervisors and personnel with experience not acceptable to the Contracting Officer will be prohibited from working on these systems. Experience data shall include the following.

a. Name of employee

b. Employer

c. List educational background and specialized training on installation and testing medium and high pressure systems, including safety precautions.

d. List at least two installations of each type of system worked on and installed and tested satisfactorily.

    (1) Type of system and operating or design pressure; for medium pressure 126 to 399 psig; for high pressure 400 psig and higher.

    (2) Company or owner.

    (3) Location.

(4) Name, address, and phone number of a person who can be contacted for verification at the installation.

e. If registered engineer, give the state in which registration is held, and branch of engineering. An engineer is required to supervise safety during testing of medium and high pressure air systems.

1.4.8 Qualification of Pressure Vessel (Receiver) Inspectors

State Certification of Competency and active commission from the National Board of Boiler and Pressure Vessel Inspectors (NBBI), Columbus, Ohio.

1.4.9 Training

Where special cleaning, flushing, material control, testing, and other special requirements are used on a contract, such as required for high pressure compressed air systems, conduct formal training programs for employees on the special requirements. Maintain records on such training which shall be available for inspection by the Contracting Officer. Certify that employees have satisfactorily completed the required training prior to performing work on the contract.

1.5 SAFETY PRECAUTIONS

1.5.1 Temperature Restriction

Compressors or other equipment shall not discharge compressed air to the piping systems above 100 degrees F unless approved by the Contracting Officer. Aftercoolers or other devices shall be provided to comply with the temperature restriction.

1.5.2 Rotating Equipment

Fully guard couplings, motor shafts, gears and other exposed rotating or rapidly moving parts in accordance with OSHA 29 CFR 1910.219. Provide rigid and suitably secured guard parts readily removable without disassembling guarded unit.

1.5.3 Welding and Brazing

Safety in welding, cutting, and brazing of pipe shall conform to AWS Z49.1.

PART 2 PRODUCTS

2.1 HIGH PRESSURE AIR COMPRESSOR

400 to 5000 psig system, multi-cylinder, multi-stage, air or water cooled, reciprocating, belt or direct-driven, base-mounted type, rated for continuous duty at 3000 psig and capacity indicated. Mount compressor, motor, controls, and instruments on a welded steel base plate. Provide means to adjust V-belt tension. Provide splash lubricated compressor not to exceed 1000 rpm, or pressure lubricated compressor not to exceed 1800 rpm. Provide three phase squirrel cage induction motor not exceeding 1800 rpm, with voltage characteristics as indicated, and open drip-proof enclosure. Crankshaft and connecting rods shall be steel. Frame (crankcase), cylinders, and cylinder heads shall be close grain cast iron. Fully enclose frame. Provide automatic unloaders to permit the compressor to start unloaded. Provide air or water cooled coolers after every stage of

compression to cool discharge air to within 20] degrees F of ambient air temperature. Provide automatic condensate drains to drain condensate during operation and when the compressor stops. Conform to NEMA MG 1for motor and NEMA ICS 2 and NEMA ICS 6 for controls.

2.1.1 Controls

Start-stop control compressors by means of pressure switches and arrange for a lead compressor and a lag compressor. Lead Compressor shall start when the pressure falls to 2,500 psig and stop when the pressure reaches 3,000 psig. When both compressors stop at cutout pressure, the lead and lag positions of compressors shall be interchanged automatically by means of an electric alternator.

Regulate compressor by dual control. Dual system shall consist of a combination of constant speed control and an automatic start-and-stop control by automatic or manual selector switch.

2.1.1.1 Start-and-Stop Control

When set for start-and-stop control, motor shall stop automatically when discharge pressure reaches maximum pressure setting and start automatically when discharge pressure falls to minimum setting. Cylinders shall unload during periods of motor shutdown.

2.1.1.2 Constant Speed Control

Compressor shall operate continuously at constant speed. Provide means to automatically load and unload compressor at preset minimum and maximum pressure settings, respectively. Provide means for automatic release of pressure within cylinders when the unit is operating without load. Also provide means for manual or automatic unloading of cylinders during starting of unit. Equip compressor with a timed control to stop compressor after a 10-minute unloaded period if air is not used.

2.1.2 Safety Controls

Provide safety controls to shutdown each compressor on high discharge air temperature or low oil pressure for pressure lubricated compressor and low oil level for splash lubricated compressor. Set high temperature shutdown at 130 degrees F. Indicate each shutdown condition by a light on the compressor control panel.

2.1.3 Accessories

Provide pressure gages and relief valves on intercoolers and on the aftercoolers. Provide totally enclosed belt guards, discharge check valves, and pressure switches.

2.1.4 Noise

84 dBA maximum sound level one meter from compressor unit.

2.2 HIGH PRESSURE COMPRESSED AIR DRYER

Include component equipment, inter-connecting piping, wiring and controls, mounted in a cabinet and requiring only the connection to utilities. Degrease dryer cabinet, prime coat, and finish coat with baked enamel. Contractor shall furnish integral components whether specifically required by this specification or not. Air shall leave the dryer at a temperature of [_____] degrees F and a dew point of [_____] degrees F, based on an inlet temperature of 100 degrees F. Pressure drop shall not exceed 3 psi. Provide complete internal tubing, wiring, and piping, such that only connections to air inlet and outlet, to refrigerant compressor contactor, and to condensate drain are necessary.

2.2.1 Construction

Heat sink type dryer consisting of a mechanical refrigeration system equipped with an automatic temperature shutdown switch to prevent freezing, a large aluminum granule heat sink to allow a 4 degrees F automatic temperature control, regenerative air to air exchanger, and main compressed air cooling exchanger. Refrigeration system shall cool thermal mass heat sink which shall, in turn, lower compressed air temperature to dry air. A direct air to refrigerant gas heat exchanger is not acceptable. Dryer shall have no internal traps or filters and shall have large internal air passages to minimize pressure drop.

2.2.2 Air Circuit

Include the following:

a. Regenerative heat exchanger: ASTM A269/A269M, Type 304L seamless stainless steel tube construction, inlet compressed air to outlet compressed air heat exchanger designed to reduce cooling load at design conditions 20 degrees F by inlet air precooling.

b. Main heat exchanger: ASTM A269/A269M, Type 304L seamless stainless steel tube construction, single-pass, designed for minimum air pressure drop with air in the tubes surrounded by aluminum granules.

c. Separator: Fabricated of ASTM A269/A269M, Type 304L seamless stainless steel in accordance with ASME B31.1. Code stamp is not required. Provide moisture separator, low velocity type, incorporating change of air flow direction to prevent moisture carryover.

d. Dryer operating pressure: 5,000 psig working pressure.

e. Drain line: Provide drain line to exterior of dryer with condensate trap or automatic drain valve.

f. Exterior piping connections: Provide with square ends.

2.2.3 Refrigeration System

Include the following:

a. Compressor: ANSI/AHRI 520. Hermetic reciprocating compressor equipped with automatic start-stop control, inherent motor protection, crankcase oil strainer, and suction screen. Refrigerant shall be R-22.

b. Dryer controls: Capable of automatic 0 to 100 percent capacity control with an automatic control expansion valve with sensing bulb to control capacity, with automatic shutdown switch sensor located at point of lowest temperature to prevent freezing.

c. Air cooled condenser.

2.2.4 Instrumentation and Controls

Provide control panel in dryer cabinet containing:

a. Indicators:

(1) Inlet air pressure gage

(2) Discharge air pressure gage

(3) Inlet air temperature gage

(4) Main exchanger temperature gage

(5) Refrigeration compressor suction pressure gage

(6) Refrigeration compressor discharge pressure gage

(7) Power interruption light

(8) High temperature light

(9) Power on light

b. Electrical relays: Locate in an enclosed portion of panel, accessible for easy servicing.

c. Controls and interlocks:

(1) Condenser fan

(2) Compressor across the line contactor

(3) Thermostatic control switch

2.3 HIGH PRESSURE AIR RECEIVERS AND SEPARATORS

ASME BPVC SEC VIII D1, constructed and stamped, seamless, forged, 5,000 psig design working pressure, minimum safety factor of 4, corrosion allowance of 1/16 inch, straight thread, 0-ring sealed, forged steel inlet, outlet, and drain plugs, straight or angle connection as indicated or required. Capacities as indicated. After heat treatment, examine exterior of vessel by liquid penetrant or magnetic particle test; no defects are permitted. Furnish certified (non-destructive examination) NDE report for high pressure air receiver. After hydrostatic testing at the factory, clean the flask to oil-free condition. Abrasive blast interior and exterior to near white condition in accordance with SSPC SP 10/NACE No. 2. Vacuum clean surfaces to remove dust and debris. Check surfaces with black light to ensure there is no oil. Apply 2 or 3 coats of epoxy coating 8 mils minimum dry film thickness, with white finish coat for the interior and gray finish coat for the exterior. Provide certification of factory tests. Securely support receiver and equip with pressure gage, drain valve, and ASME BPVC SEC VIII D1 and ASME BPVC SEC IX code stamped pressure relief valve set as indicated and piped to discharge in a safe manner. Piping shall conform to 5,000 psig standards. Provide each receiver with internal or external blowdown and drain line with manual valve in accessible location, or with extension stem, discharging through a visible open sight drain. Do not manifold cylinder drain piping together. Attachment welds to receiver and separator shall not be permitted.

Register vessel with NBBI and mark registration number on vessel.

2.4 MEDIUM PRESSURE AIR COMPRESSOR

126 to 399 psig system. Multi-stage or Two-stage , air or water cooled reciprocating, belt or direct driven type, suitable for supplying compressed air at pressures indicated. Provide compressor with ball or roller type bearing, pressure lubricated, thermal overload protection as required by NEMA, pressure switch, inlet filter-mufflers, vibration isolators, intercoolers, aftercooler, and flexible connectors. Provide safety control for shutdown and alarm on high discharge air temperature or low oil pressure. Capacity and operating pressure as indicated on drawings. Mount compressor and motor on a base plate and set on the receiver. Design receiver for additional load of compressor and motor.

2.4.1 Receiver

Build receiver (tank) of welded steel, in accordance with ASME BPVC SEC VIII D1, Unfired Pressure Vessels, for 399 psig working pressure at 450 degrees F, complete with pressure gage, ASME BPVC SEC VIII D1 and ASME BPVC SEC IX code stamped safety valve, check valve, shut-off valve on tank outlet, and automatic tank drain on tank. Provide tank with steel supports and bolt to a concrete foundation. Capacity as indicated.

2.4.2 Motor and Starter

Provide motor and starter 72 degrees F ambient temperature rise, continuous duty, drip-proof type motor, ball bearings, for operation with current of voltage, phase, and cycle indicated on the electrical drawings. Motor of such capacity that brake horsepower required by driven equipment at normal rated capacity will not exceed nameplate rating of motor. Provide each motor with automatic, fully enclosed, magnetic starter. Conform to NEMA MG 1 for motor and NEMA ICS 2and NEMA ICS 6 for starter and controls.

2.4.3 Controls

Provide start-and-stop control. Motor shall stop automatically when discharge pressure reaches maximum pressure setting and start automatically when discharge pressure falls to minimum setting. Cylinders shall unload automatically during periods of motor shutdown.

Regulate compressor by dual control. Dual system shall consist of a combination of constant speed control and an automatic start-and-stop control by automatic or manual selector switch.

2.4.3.1 Start-and-Stop Control

When set for start-and-stop control, motor shall stop automatically when discharge pressure reaches maximum pressure setting and start automatically when discharge pressure falls to minimum setting. Cylinders shall unload during periods of motor shutdown.

2.4.3.2 Constant Speed Control

Compressor shall operate continuously at constant speed. Provide means to automatically load and unload compressor at preset minimum and maximum pressure settings, respectively. Provide means for automatic release of pressure within cylinders when the unit is operating without load. Also provide means for manual or automatic unloading of cylinders during starting of unit. Equip compressor with a timed control to stop compressor after a 10-minute unloaded period if air is not used.

2.4.4 Intercoolers and Aftercoolers

Provide intercoolers between all intermediate stages of multi-stage compressors and provide aftercoolers with compressors. Intercoolers for air-cooled compressors shall be the tube-and-fin type. Intercoolers for water-cooled compressors shall be the shell-and-tube type, except that tube-and-fin type may be used when the intercooler is supported by the compressor frame or attached to the compressor. Air or water cooled intercoolers may be the integral cast type when compressor is 25 hp or less. Aftercoolers shall be of the water-cooled shell-and-tube type or air-cooled tube-and-fin type. Water-cooled aftercoolers and intercoolers shall be of sufficient capacity to cool the compressed air to within 15 degrees F and 20 degrees F, respectively, of the temperature of the water entering the coolers. Air-cooled intercoolers and aftercoolers shall have sufficient capacity to cool the compressed air to within 20 degrees F of the ambient temperature under the atmospheric conditions indicated. Provide water-cooled intercoolers and aftercoolers with sight-flow indicator to visually observe the flow of water to the cooler. The pressure drop of compressed air through the cooler shall not exceed one psi. Provide intercoolers and aftercoolers with a moisture separator and drain trap to remove the condensed moisture and oil from the air leaving the cooler.

2.4.4.1 Shell-and-Tube

Floating-head type consisting of a removable and cleanable nest of corrosion-resistant tubes within a steel shell. Air may pass either through the tubes or the shell.

2.4.4.2 Tube-and-Fin

Copper, aluminum, copper-aluminum, or copper-alloy construction. Fins shall be securely bonded to the tubing. Provide tube-and-fin coolers with a fan for circulation of the cooling air. The fan shall be adequately guarded for safety and be driven either from the compressor crankshaft or by an independent electric motor.

2.4.5 Noise

84 dBA maximum sound level one meter from compressor unit.

2.5 MEDIUM PRESSURE Air receivers and separators

ASME BPVC SEC VIII D1, labeled and rated for 275 psig, equipped with required valves and trimmings, including gage and automatic drain valve and ASME BPVC SEC VIII D1 and ASME BPVC SEC IX pressure safety relief valve. Pressure as indicated. Sandblast exterior and interior to SSPC SP 10/NACE No. 2, near-white. Lining shall be a factory applied 8 mil minimum epoxy coating. Exterior finish shall be standard factory finish two coats of rust inhibitor primer and one coat epoxy enamel.

2.6 MEDIUM PRESSURE COMPRESSED AIR DRYERS

Provide medium pressure compressed air dryers of the mechanical refrigeration type, equipped with an automatic temperature shutdown switch to prevent freezing, a regenerative air to air exchanger (in capacity sizes above 10 or 60 scfm as standard with the manufacturer), and a main compressed air cooling exchanger. Refrigeration system shall cool compressed air to dry the air. Dryer shall have no internal traps or filters and shall have pressure drop not greater than 3 psi. Air shall leave the dryer at a temperature of [_____] degrees F and dew point of [_____] degrees F, based on an inlet temperature of 100 degrees F. Provide internal tubing, wiring, and piping complete, such that only connections to air inlet and outlet, to refrigerant compressor contactor, and to condensate drain are necessary.

2.6.1 Air Circuit

a. Regenerative heat exchanger: Inlet compressed air to outlet compressed air heat exchanger (in capacity sizes above 10 or 60 scfm as standard with the manufacturer) designed to reduce cooling load at design conditions 20 degrees F by inlet air precooling.

b. Main heat exchanger: Single-pass, with air in the tubes, heat sink, direct expansion, or flooded cooler type.

c. Separator: Fabricated in accordance with ASME B31.1; code stamp not required; moisture separator low velocity type incorporating change of air flow direction to prevent moisture carryover.

d. Dryer operating pressure: 275 psig working pressure.

e. Drain line: Provide with exterior mounted condensate trap to facilitate servicing.

2.6.2 Refrigeration System

a. Refrigeration compressor: ANSI/AHRI 520. Hermetic, semi-hermetic, or open reciprocating type equipped with automatic start-stop or unloading capacity control; standard components include inherent motor protection, crankcase oil strainer, and suction screen. Refrigerant shall be R-22.

b. Dryer controls: Capable of automatic 0 to 100 percent capacity control. Refrigeration controls shall maintain pressure dew point within the specified range without freezing of condensate. Controls shall include such devices as capillary tube, expansion valve, suction pressure regulator, thermostat, or other approved devices as standard with the manufacturer. Dryer shall have automatic shutdown switch sensor located at point of lowest temperature to prevent freezing.

c. Refrigerant dryer and suction line strainer.

d. Air-cooled condenser, with condenser fan and motor.

2.6.3 Instrumentation and Control

Include control panel in dryer cabinet containing:

a. Indicators for the following services: Inlet air pressure gage, discharge air pressure gage, inlet air temperature gage, main exchanger temperature gage, refrigeration compressor suction pressure gage, refrigeration compressor discharge pressure gage, green "Power On" light, power interruption light, and high temperature light.

b. Electrical relays: Locate in an enclosed portion of the panel, accessible for ease of servicing.

c. Controls and interlocks: To maintain required compressed air dew point and to cycle air-cooled condenser with refrigeration compressor while maintaining head pressure control with low ambient temperature.

2.7 MEDIUM PRESSURE COMPRESSED AIR DRYER (CHILLED WATER TYPE)

Provide medium pressure compressed air dryer of the mechanical refrigerator type, with closed chilled water system, regenerative air to air exchanger, and main compressed air to water heat exchanger. Refrigeration system shall produce chilled water which, in turn, circulates through air-water exchanger to dry the air. Provide internal tubing, wiring and piping complete, such that only connections to air inlet and outlet, to pump contactor, to refrigerant compressor contactor, to condensate drain, and to air cooled condenser need be provided. Dryer shall be suitable for a compressed air operating pressure of 275 psig, with air leaving temperature of [_____] degrees F and dew point of [_____] degrees F at rated pressure.

2.7.1 Air Circuit

a. Regenerative heat exchanger: Air to air exchanger, with inlet air passing through tubes and outlet air in shell, designed to reduce cooling load at design conditions by precooling inlet air 20 degrees F.

b. Main heat exchanger: Shell and tube construction, single-pass, with air in tubes and water in shell, designed for minimum air pressure drop, flanged connections, tubes rolled into tube sheets, and ASME BPVC SEC VIII D1 and ASME BPVC SEC IX Code stamped.

c. Separator: Fabricated of carbon steel to ASME BPVC SEC VIII D1and ASME BPVC SEC IX Code and stamped.

d. Drain: With condensate trap.

2.7.2 Chilled Water Circuit

a. Circulating pump: Single stage, mechanical seals, electric motor driven with line shut-off valves.

b. Liquid cooler: Direct expansion, refrigerant in tubes, water in shell, designed for 300 psig working pressure, removable tube bundle, ASME BPVC SEC VIII D1 and ASME BPVC SEC IX Code stamped and insulated with foam type insulation.

c. Expansion tank: With sight glass, vent, and fill cock.

d. Flow switch: To shut down refrigeration compressor on loss of chilled water flow.

2.7.3 Refrigeration System

a. Refrigeration compressor: ANSI/AHRI 520. Hermetic or semihermetic reciprocating type, with 1750 rpm motor, integral capacity control, oil pressure pump, oil scavenger pump, full-flow oil filter, oil sight glass, inherent motor protection, crankcase heater, suction and discharge service valve, crankcase oil strainer, Monel suction screen, and hot gas bypass capacity control below last step of unloading. Refrigerant shall be R-22.

b. Accessories: Include a discharge line muffler, sight glass, refrigerant dryer, solenoid valve, thermostatic expansion valve, and suction line strainer.

c. Air-cooled condenser: As indicated. Complete air-cooled condenser factory-fabricated and assembled unit consisting of coils, fans, and electric-motor drive. Base capacity at design conditions on 20 degrees F temperature differential between entering air and condensing refrigerant. Saturated refrigerant condensing temperature not over 105 degrees F. Base entering dry bulb outside air temperature on 90 degrees F. Do not take subcooling into account in determining compressor and condenser capacities. Air-cooled condenser may be used for refrigerant storage in lieu of a separate receiver, provided that condenser storage capacity is 20 percent in excess of fully charged system. Provide head pressure control during low ambient temperature.

2.7.4 Instrumentation and Control

Provide a control panel on the dryer containing:

a. Pressure gages (4 1/2 inches diameter) for the following services:

(1) Inlet air

(2) Condenser water inlet

(3) Refrigeration compressor suction

(4) Refrigeration compressor oil pressure

(5) Outlet air

(6) Condenser water outlet

(7) Refrigeration compressor discharge

b. Electrical relays: Locate in an enclosed portion of the panel, accessible from front of panel.

c. Start-stop buttons and green running indicating light.

d. Controls and interlocks.

(1) 115-volt control transformer

(2) Circulating pump across the line contactor

(3) Compressor across the line contactor

(4) Condenser water pressure safety switch

(5) Freeze protection safety switch

(6) Pump-out relay with normally open and normally closed contacts

(7) Oil safety switch

(8) Four stage thermostatic control

(9) Refrigerant dual pressure switch

2.7.5 Temperature Indicators

a. Air inlet

b. Air outlet

c. Chilled water in

d. Chilled water out

e. Dew point

2.8 DESICCANT AIR DRYERS

Chamber of welded steel, [_____] psig working pressure, ASME labeled conforming to ASME BPVC SEC VIII D1, with flanged or threaded fittings, and automatic drain valve. Manufacturer's recommended desiccant in tablet form which will not nest or cake. Contractor shall provide a supply of desiccant for initial operations in unbroken shipping containers equal to not less than four charges of desiccant for the dryer.

2.9 HIGH PRESSURE (HP) AIR PIPING AND ACCESSORIES

2.9.1 HP Air Piping and Tubing

HP air piping and tubing for 5000 psig at 100 degrees F system shall conform to the following:

a. Stainless steel pipe: ASTM A312/A312M, seamless stainless steel, annealed Type 304L or 316L, Schedule 160 up to one inch IPS, double extra strong (XXS) for 1 1/4 to 2 1/2 inches IPS ,larger sizes shall be special as indicated. Wall thickness "schedule" and "weight" designations shall conform to ASME B36.10M. Fittings for pipe 1 1/2 inches IPS and smaller: ASTM A403/A403M, ASME B16.11, forged stainless steel, Type 304L or 316L, socket welding, Class 6000 for 1/4 to one inch IPS, Class 9000 for 1 1/4 and 1 1/2 inches IPS. Fittings for pipe 2 to 2 1/2 inches IPS: ASTM A403/A403M, ASME B16.9, butt welding, seamless wrought stainless steel Type 304L or 316L, double extra strong (XXS).

b. Nickel-copper pipe: ASTM B165, seamless, annealed, Schedule 160 up to one inch IPS, double extra strong (XXS) for 1 1/4 to 3 inches IPS, ,larger sizes shall be special as indicated. Wall thickness "schedule" and "weight" designations shall conform to ASME B36.10M. Fittings 1 1/2 inches IPS and smaller: ASME B16.11, forged nickel-copper ASTM B564, socket welding, Class 6000 for 1/4 to one inch IPS, Class 9000 for 1 1/4 and 1 1/2 inches IPS. Fittings for pipe 2 inches IPS and larger: ASME B16.9, butt welding, seamless wrought 70-30 nickel-copper, double extra strong (XXS), 2 to 3 inches IPS.

c. Stainless steel tubing: ASTM A269/A269M, stainless steel, Type 304, 304L, or 316, seamless, annealed, with wall thicknesses as specified below. Fittings for tubing: stainless steel, Type 304, 304L or 316, conforming to SAE AS4841, SAE AS4842,SAE AS4842/1,SAE AS4843,

SAE AS4843/1,SAE AS4843/2,SAE AS4875SAE AS4875/1,SAE AS4875/2,SAE J514, flared type, suitable for 5000 psi service. Fittings shall have a minimum burst strength of 20,000 psig; furnish laboratory burst test reports. Do not use flareless fittings or bite type fittings. Do not weld tubing.

MINIMUM WALL THICKNESS FOR STAINLESS STEEL TUBING	
Size (Inches O.D.)	Thickness (Inches)
3/8	.058
1/2	.083
5/8	.095
3/4	.120

d. Copper-nickel tube: MIL-T-16420, Composition 70-30, temper-annealed, Type I - seamless Class 6000 (6000 psig working pressure), Grade 2 (material with heat identification), IPS outside diameter sizes. Fittings 1 1/2 inches IPS and smaller: ASME B16.11, MIL-C-15726, forged copper-nickel, socket welding, except that body wall thickness shall not be less than the minimum wall thickness for the size listed in MIL-T-16420 for Class 6000, and the average socket wall thickness shall be 1.25 times, and the minimum socket wall 1.09 times the minimum wall thickness for that size listed in MIL-T-16420 for Class 6000. Fittings 2 to 3 inches IPS: ASME B16.9, butt welding, seamless wrought 70-30 copper-nickel, with minimum wall thickness as listed for that size in MIL-T-16420 for Class 6000.

2.9.2 High Pressure Air Piping

High pressure air piping for 3000 psig at 100 degrees F system shall conform to the following:

a. Stainless steel pipe: ASTM A312/A312M, seamless stainless steel, annealed Type 304L or 316L, Schedule 80 up to one inch IPS, Schedule 160 1 1/4 to 6 inches IPS. Wall thickness "schedule" and "weight" designations shall conform to ASME B36.10M. Fittings for pipe 1 1/2 inches IPS and smaller: ASTM A403/A403M, ASME B16.11, forged stainless steel, Type 304L or 316L, socket welding, Class 3000 for 1/4 to one inch IPS, Class 6000 for 1 1/4 and 1 1/2 inchesIPS. Fittings for pipe 2 inches to 6 inchesIPS: ASTM A403/A403M, ASME B16.9, butt welding, seamless wrought stainless steel Type 304L or 316L, Schedule 160.

b. Stainless steel tubing: ASTM A269/A269M, stainless steel, Type 304, 304L or 316, seamless, annealed, with minimum wall thicknesses as specified below. Fittings for tubing: stainless steel, Type 304, 304L or 316, conforming to SAE AS4841, SAE AS4842,SAE AS4842/1,SAE AS4843, SAE AS4843/1,SAE AS4843/2,SAE AS4875,SAE AS4875/1,SAE AS4875/2, SAE J514, flared type, suitable for 3000 psi service. Fittings shall have a minimum burst strength of 20,000 psig; furnish laboratory burst test reports. Do not use flareless fittings or bite type fittings. Do not weld tubing. Brazed 3000 psi tubing fittings may be used where flared fitting connections are not required for equipment. Use FS QQ-B-654, Grade V, brazing alloy where tubing or fitting or both tubing and fitting are stainless steel.

MINIMUM WALL THICKNESS FOR STAINLESS STEEL TUBING	
Size (Inches O.D.)	Thickness (Inches)
3/8	.058
1/2	.083
5/8	.095
3/4	.120

c. Copper-nickel tube: MIL-T-16420, Composition 70-30, temper-annealed, Type I - seamless, Class 3300 (3300 psig working pressure), Grade 2 (material with heat identification). Fittings, Brazing: bronze or copper-nickel, silver brazed ends, rated for not less than 3000 psi working pressure. Limit brazed joints to required connections to existing piping. Use welded joints for new and existing piping to the maximum extent practical. Fittings, welding, 1 1/2 inches IPS and smaller: ASME B16.11, MIL-C-15726, forged copper-nickel, socket welding, except that body wall thickness shall not be less than the minimum wall thickness for the size listed in MIL-T-16420 for Class 3300, and the average socket wall thickness shall be 1.25 times, and the minimum socket wall 1.09 times the minimum wall thickness for that size listed in MIL-T-16420 for Class 3300; however, for 1/4 inch IPS, ASME B16.11, Class 3000 dimensions may be used when approved by the Contracting Officer. Fittings, welding, 2 to 3 inches IPS: ASME B16.9, butt welding, seamless wrought 70-30 copper-nickel, with minimum wall thickness as listed for that size in MIL-T-16420 for Class 3300.

2.9.3 Globe and Angle Valves

QPL-24109, bronze body.

2.9.4 Needle Valves

QPL-24109, bronze body, except provide needle valve cartridges in lieu of shutoff valve cartridges.

2.9.5 Safety Valves

ASME BPVC SEC VIII D1 and ASME BPVC SEC IX Code stamped safety valve, Type 304L or 316L stainless steel, 70-30 copper-nickel, 70-30 nickel-copper, bronze, carbon steel, with 0-ring seal union thread piece ends as provided for QPL-24109 valves; factory set and sealed.

2.9.6 Pressure Reducing Valves

ANSI/NFLPA T3.12.3, nominal pressure rating of 6000 psig, body of stainless steel, bronze, aluminum bronze, naval brass, outlet pressure and capacity as indicated, shock and vibration test not required, allowance lists not required.

2.9.7 Adapters

Provide suitable tailpiece adapters for installation of valves conforming to QPL-24109 and for other components with similar union end connections. Tailpieces shall match pipe material: Type 304L or 316L stainless steel, 70-30 nickel-copper, 70-30 copper-nickel, socket welding type for 1 1/2 inches IPS and smaller. Tailpieces for tubing: brazed O.D. type suitable for 3000 psi. Provide thread piece adapters for O-ring union installation of components made of material different from pipe or where welded joint installation is not suitable.

2.9.8 Pressure Gages (High Pressure)

Pressure gages for high pressure systems shall conform to ASME B40.100, for air, with a scale approximately twice the system working pressure, nonshatterable safety glass, and pressure blowout back to prevent glass from flying out in case of an explosion. Gages: 4 1/2 inches in diameter with a steel case and tubing and an accuracy of one percent full scale in middle half section of scale and 1 1/2 percent of full scale value in first and last 1/4 sections of scale. Do not fasten bourdon tube pressure-sensitive elements with low-melting-point solder. Print on gage faces in red letters "USE NO OIL." Provide pressure snubbers or equalizer in pressure gage installations on inflow side of a gage valve. Mount gage branches vertically on top of an air line to avoid branch flow of condensate and dirt. Connect a gage to an air line or component through an equalizer, gage valve (slow-opening needle type), and branch with provision for bleed-off.

2.9.9 Snubbers (or Equalizers)

Type 304L or Type 316L stainless steel 70-30 copper-nickel 70-30 nickel-copper body with a rated working pressure not less than system design pressure. Snubber element: sintered stainless steel or other approved type.

2.9.10 Timed Solenoid Drain

Packaged solenoid drain with 1/4 inch, 5000 psig, direct acting, normally closed solenoid valve, solid state timer, drain cycle adjustable from zero to 50 minutes, valve open duration adjustable from one to 14 seconds, power on light, valve open light, operation on 115 or 230 VAC, and housed in NEMA 1 enclosure.

2.9.11 Compressed Air Filters

Provide high pressure compressed air filter, single cartridge type, designed for operating pressures not less than the system design pressure. Filter housing of Type 304L or 316L stainless steel 70-30 copper-nickel 70-30 nickel-copper construction. Provide a cellulose cartridge filter of graded density construction capable of removing liquids and solids of 5 microns and larger. Provide filter with a bottom drain and timed solenoid drain.

2.9.12 Strainers

Y-pattern type with cast stainless steel body, ASTM A351/A351M CF8M (Type 316), CF8 (Type 304), CF3 (Type 304L) or CF3M (Type 316L, 70-30 copper-nickel, 70-30 nickel-copper, forged alloy steel body ASTM A182/A182M, Grade F-22, rated for the system design working pressure, with 20-mesh Monel or stainless steel screen. Net strainer area not less then 2.5 times the inlet connection area.

2.9.13 Unions

O-ring seal type compatible with union ends of QPL-24109 valves, material and end preparation compatible with pipe and fittings.

2.9.14 O-Ring Gaskets

SAE AMS7276.

2.9.15 Hangers and Supports

Provide pipe hangers and supports conforming to MSS SP-58, MSS SP-69, and ASME B31.1, except as specified or indicated otherwise. Hangers for high pressure air lines shall be rigid or braced and sufficiently strong to prevent "whipping" of a pipe if a break occurs while the line is under pressure. Furnish zinc plated pipe hangers and supports except for copper plated inserts for copper piping. Provide tubing supports of U-shaped steel bolts and nuts firmly secured to adequately support structures such as walls, columns, floors, or brackets. Clips shall fit closely around piping but shall have sufficient clearance to permit longitudinal movement of piping during normal expansion and contraction. Provide supports at valves, fittings, branch lines, outlets, changes in direction, equipment, and accessories.

2.10 MEDIUM PRESSURE COMPRESSED AIR PIPING AND ACCESSORIES

Medium pressure compressed air piping and accessories 126 to 399 psig at 150 degrees F shall conform to the following:

2.10.1 Pipe

ASTM A53/A53M or ASTM A106/A106M, seamless carbon steel, Schedule 40, black.

2.10.2 Fittings, Size 2 Inches and Larger

ASME B16.9, carbon steel, butt welding, Schedule 40, or ASME B46.1, carbon steel welding neck flanges, Class 300, ASME B46.1, flanged fittings, carbon steel, Class 300, gaskets ASME B16.20, spiral wound metallic, Class 300, bolts ASTM A193/A193M, Grade B7, and nuts, ASTM A194/A194M, Grade 7. Butt welded joints shall be full penetration consumable insert or backing ring type.

2.10.3 Fittings, Size 1 1/2 Inches and Smaller

ASME B16.11, forged carbon steel, Class 3000 socket welding or Class 2000 threaded. Seal weld threaded joints not required to disassemble piping for maintenance. Joints may also be butt welded or flanged, as specified for sizes 2 inches and larger.

2.10.4 Flat-faced Steel Flanges

Where connections are made to Class 250 cast iron flanges with steel flanges, use only flat-faced Class 300 steel flanges.

2.10.5 Unions

ASME B16.39, Class 2 (500 psig WOG, cold, non-shock).

2.10.6 Valves

2.10.6.1 Globe and Angle Valves

Sizes 2 inches and smaller, bronze, MSS SP-80, Type 3 (Metallic Disc, Renewable Seat), Class 300, threaded ends, or carbon steel, ASME B16.34, Class 300, threaded ends. Sizes larger than 2 inches, ASME B16.34, carbon steel, tapered disk, Class 300, flanged ends.

2.10.6.2 Check Valves

ASME B16.34 or MSS SP-71, Class 300, steel, lift or swing type.

2.10.6.3 Pressure Reducing Valves

ANSI/NFLPA T3.12.3, with nominal pressure rating of not less than inlet system pressure indicated. Provide pressure reducing valves capable of being adjusted to specified flow and pressure, and suitable for intended service. Provide pilot valve for dome loaded type if required for proper operation.

2.10.6.4 Safety Valves

ASME BPVC SEC VIII D1 and ASME BPVC SEC IX, Code stamped safety valve, bronze body with bronze trim, for unfired pressure vessels, threaded or flanged connection; factory set and sealed.

2.10.7 Pressure Gages

ASME B40.100, Accuracy Grade A, for air, with steel or brass case, and nonshatterable safety glass, and a pressure blowout back to prevent glass from flying out in case of an explosion. Gages shall have a 3 1/2 inch minimum diameter dial and a dial range of approximately twice working pressure.

2.10.8 Pipe Hangers and Supports

MSS SP-58, MSS SP-69, and ASME B31.1, except as specified or indicated otherwise. Provide zinc plated pipe hangers and supports. Provide tubing supports of U-shaped steel bolts and nuts firmly secured to adequately support structures such as walls, columns, floors, or brackets. Clips shall fit closely around piping but shall have sufficient clearance to permit longitudinal movement of piping during normal expansion and contraction. Provide supports at valves, fittings, branch lines, outlets, changes in direction, equipment, and accessories.

2.10.9 Strainers

FS WW-S-2739, Class 250, Style Y, simplex type, with 20-mesh Monel or stainless steel screen.

2.10.10 Traps

CID A-A-60001, to drain water and other liquids from system. Type of traps, as indicated, and rated working pressure not less than system operating pressure.

2.10.11 Flexible Connections

Vibration isolation, wire braid reinforced corrugated metal hose type, line-sized, with bronze end connections, suitable for pressure indicated. Length as recommended by manufacturer but not less than 18 inches.

2.10.12 Tetrafluoroethylene Tape

CID A-A-58092 for screw-jointed pipe.

2.11 SLEEVES

2.11.1 Floor Slabs, Roof Slabs, and Outside Walls Above and Below Grade

Galvanized-steel pipe having an inside diameter at least 1/2 inch larger than the outside diameter of the pipe passing through it. Provide sufficient sleeve length to extend completely through floors, roofs, and walls, so that sleeve ends are flush with finished surfaces except that ends of sleeves for floor slabs shall extend 1/2 inch above finished floor surface. Sleeves located in waterproofed construction shall include flange and clamping ring.

2.11.2 Partitions

Galvanized sheet steel, 26 gage or heavier, of sufficient length to completely extend through partition thickness with sleeve ends flush with partition finished surface.

2.12 VALVE BOX

Provide rectangular concrete design with words "Compressed Air" cast or otherwise marked on the cover. Size shall be large enough for removal of valve without removing box. Provide valve box for areas as follows:

a. Roads and traffic areas: Heavy Duty, cast iron cover

b. Other areas: Standard duty, heavy steel plate or concrete cover

2.13 IDENTIFICATION LABELS FOR PIPING

Labels for pipes 3/4 inch O.D. and larger shall bear printed legends to identify contents of pipes and arrows to show direction of flow. Except that of pipes smaller than 3/4 inch O.D., labels shall have color coded backgrounds to signify levels of hazard in accordance with PFI ES 22. Legends and type and size or characters shall also conform to PFI ES 22. Labels shall be made of plastic sheet in conformance with CID A-A-1689 with pressure-sensitive adhesive suitable for the intended applications or they may be premolded of plastic to fit over specific pipe outside diameters 3/4 inch and larger. For pipes smaller than 3/4 inch O.D., furnish brass identification tags 1 1/2 inches in diameter with legends in depressed black-filled characters.

2.14 BURIED UTILITY WARNING AND IDENTIFICATION TAPE

Polyethylene plastic tape manufactured specifically for warning and identification of buried utility lines. Tape shall be of the type provided in rolls, 6 inches minimum width, color codes for compressed air (gray) with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED COMPRESSED AIR LINE BELOW" or similar wording. Code and letter coloring shall be permanent, unaffected by moisture and other substances contained in trench backfill material.

2.15 FRESH WATER

Fresh water for cleaning, flushing, and testing shall be clean and potable.

2.16 BASIC PIPING AND COMPONENT MATERIALS

Conform to the following where material is specified by generic type and no specification is listed.

2.16.1 Stainless Steel

Austenitic type, annealed, ASTM A182/A182M.

2.16.2 Nickel-Copper

70-30 nickel-copper, annealed, ASTM B164, alloy N04400, ASTM B127.

2.16.3 Copper-Nickel

70-30 copper-nickel, soft temper, MIL-C-15726.

2.16.4 Other Materials

For materials where no specification is listed above, conform to material specifications listed in ASME B31.1 or ASME BPVC SEC VIII D1.

2.17 SOURCE QUALITY CONTROL

Test air compressors and compressed air dryers at the factory to assure proper operation. Certify satisfactory accomplishment of tests.

PART 3 EXECUTION

3.1 INSTALLATION

Install materials and equipment as indicated and in accordance with manufacturer's recommendations.

3.1.1 Excavation and Backfilling

Section 31 00 00 EARTHWORK.

3.1.2 Corrosion Protection

Provide corrosion protection for buried steel and corrosion resistant steel piping in accordance with Section 09 97 13.28 PROTECTION OF BURIED STEEL PIPING AND STEEL BULKHEAD TIE RODS.

3.1.3 Piping

Provide Non-Destructive Examination (NDE) report for welding of piping. Unless specifically stated to the contrary, fabrication, assembly, welding, and brazing shall conform to ASME B31.1 for all piping of the air system. Piping shall follow the general arrangement shown. Cut piping accurately to measurements established for the work. Work piping into place without springing or forcing, except where cold-springing is specified. Piping and equipment within buildings shall be entirely out of the way of lighting fixtures and doors, windows, and other openings. Locate overhead piping in buildings in the most inconspicuous positions. Do not bury or conceal piping until it has been inspected, tested, and approved. Where pipe passes through building structure, pipe joints shall not be concealed, but shall be located where they may be readily inspected and building structure shall not be weakened. Avoid interference with other piping, conduit, or equipment. Except where specifically shown otherwise, vertical piping shall run plumb and straight and parallel to walls. Piping connected to equipment shall be installed to provide flexibility for vibration. Adequately support and anchor piping so that strain from weight of piping is not imposed on the equipment.

3.1.3.1 Fittings

Use long radius ells where appropriate to reduce pressure drops. Pipe bends in lieu of fittings may be used for piping where space permits. Pipe bends shall have a uniform radius of at least five times the pipe diameter and must be free from any appreciable flattening, wrinkling, or thinning of the pipe. Mitering of pipe to form elbows, notching straight runs to form full sized tees, or any similar construction shall not be used. Make branch connections with welding tees, except factory made forged welding branch outlets or nozzles having integral reinforcements conforming to ASME B31.1 may be used.

Bending of High Pressure Pipe: Prior to bending pipe for high pressure systems, the Contractor shall submit for approval written fabrication and inspection procedures and calculations showing the required minimum wall thickness of pipe after bending. Only cold bending shall be permitted. The fabrication procedure shall indicate the required pipe wall thickness prior to bending, equipment to be used, set up and bending procedures, and inspection and acceptance criteria. Inspection shall include verification of minimum wall thickness by ultrasonic or other methods if deemed necessary by the Contracting Officer. No wrinkles or other contour irregularities will be permitted in the bent pipe. Check flattening in accordance with ASME B31.1. Include required dimensional checks in inspection procedures and acceptable values tabulated for each pipe size to be bent. Qualified personnel shall perform nondestructive examinations required in accordance with qualified procedures.

3.1.3.2 Clearances for Welding

Provide clearances from walls, ceilings, and floors to permit the installation of joints. The clearances shall be at least 6 inches for pipe sizes 4 inches and less, 10 inches for pipe sizes over 4 inches, and sufficient in corners. However, the specified clearances shall not waive requirements for welders to be qualified for the positions to be welded.

3.1.3.3 Cleaning

Before jointing and erection of piping or tubing, thoroughly clean interiors of pipe sections, tube, and components. In steel pipe, loosen scale and other foreign matter by rapping sharply and expel by wire brush and swab. Blow out both steel pipe and copper tube and components with compressed air at 100 psig or more. Maintain cleanliness by closure of pipe/tube openings with caps or plugs. Before making final terminal connections, blow out complete system with compressed air at 100 psig or more. Cleaning and cleanness of medium pressure systems over 250 psig and high pressure systems shall conform to the paragraph entitled "Cleaning and Cleanness Requirements."

3.1.3.4 Changes in Pipe Size

Use reducing fittings for changes in pipe size. The use of bushings will not be permitted. In horizontal lines, 2 1/2 inches and larger, reducing fittings shall be of the eccentric type to maintain the bottom of the lines in the same plane.

3.1.3.5 Drainage and Flexibility

Compressed air piping shall be free of unnecessary pockets and pitched approximately 3 inches per 100 feet in the direction of flow to low points. Where pipes must be sloped so that condensate flows in opposite direction to air flow, slope 6 inches per 100 feet or greater. Provide flexibility by use of fittings, loops, and offsets in piping. Install branches at top of a main to prevent carryover of condensate and foreign matter.

3.1.4 Threaded Joints

Where possible use pipe with factory cut threads, otherwise cut pipe ends square, remove fins and burrs, and cut taper pipe threads in accordance with ASME B1.20.1. Threads shall be smooth, clean, and full cut. Apply thread tape to male threads only. Work piping into place without springing or springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed.

3.1.5 Flanged Joints in High Pressure System

Install using calibrated torque wrenches or feeler gage methods to assure proper gasket compression. Calibrate torque wrench immediately prior to use.

3.1.6 Welding and Brazing

Perform welding and brazing in accordance with qualified procedures using qualified welders and welding operators and brazers. Do not perform welding and brazing when the quality of the completed weld or braze could be impaired by the prevailing working or weather conditions. The Contracting Officer will determine when weather or working conditions are unsuitable for welding. Welding of hangers, supports, and plates to structural members shall be in accordance with AWS D1.1/D1.1M. Mark welding and brazing detail drawings to identify the welder or brazer making the joint.

3.1.6.1 Cleaning for Welding and Brazing

Surfaces to be welded or brazed shall be free from loose scale, slag, rust, paint, oil, and other foreign material. Joint surfaces shall be smooth and free from defects which might affect proper welding. Clean each layer of weld metal thoroughly by wire brushing, grinding, or chipping prior to inspection or deposition of additional weld metal. Conform to paragraph entitled "Cleaning and Cleanness Requirements" for medium pressure systems over 250 psig and for high pressure systems.

3.1.6.2 Stress Cracking During Brazing

For austenitic stainless steel and other material susceptible to stress corrosion cracking from molten brazing filler metal, avoid applying stress during brazing.

3.1.6.3 Welding or Brazing of Valves

Welding or Brazing of Valves: Disassemble valves subject to damage from heat during welding or brazing and reassemble after installation. Open valves two or three turns off the seat when not subject to heat damage during welding or brazing; do not backseat valve.

3.1.7 Valves

Install valves in conformance with ASME B31.1 at the locations indicated and elsewhere as required for the proper functioning of the system.

3.1.7.1 Globe Valves

Install globe valves so that the pressure will be below the disk. Install globe valves with the stems vertical.

3.1.7.2 Pressure-Reducing Valves

Provide compressed air entering each pressure-reducing valve with a strainer. Provide each pressure-reducing valve unit with two block valves and with a globe or angle bypass valve and bypass pipe. Provide a bypass around a reducing valve of reduced size to restrict its capacity to approximately that of the reducing valve. Provide each pressure reducing valve unit with an indicating gage to show the reduced pressure, and a safety valve on the lower pressure side. These requirements do not apply to small pressure regulating valves used to adjust pressure for pneumatic equipment.

3.1.8 Hangers and Supports

Selection, fabrication and installation of piping hangers and supports shall conform to MSS SP-58, MSS SP-69 except that spacing of the hangers and supports shall be as per Table I. Provide seismic restraints for piping in accordance with SMACNA 1981.

TABLE I. MAXIMUM SPAN FOR PIPE

DIAMETER INCHES	STD. WT. STEEL PIPE SCHEDULE 40	EX. STRONG STEEL PIPE SCHEDULE 80
1/2	5'-0"	5'-0"
3/4	5'-9"	5'-9"
1	6'-6"	6'-6"
1-1/2	7'-6"	7'-9"
2	8'-6"	8'-6"
2-1/2	9'-3"	9'-6"
3	10'-3"	10'-6"
3-1/2	11'-0"	11'-0"

4	11'-6"	11'-9"
5	12'-9"	13'-0"
6	13'-9"	14'-0"
8	15'-6"	16'-0"
10	17'-0"	17'-6"
12	18'-3"	19'-0"

3.1.9 Pressure Gages

Provide pressure gauges with a shut-off valve or petcock installed between the gage and the line.

3.1.10 Strainers

Provide strainers with meshes suitable for the services where indicated, or where dirt might interfere with the proper operation of valve parts, orifices, or moving parts of equipment.

3.1.11 Equipment Foundations

Provide equipment foundations of sufficient size and weight and of proper design to preclude shifting of equipment under operating conditions or under any abnormal conditions which could be imposed upon the equipment. Provide foundations which meet the requirements of the equipment manufacturer, and when required by the Contracting Officer, obtain from the equipment manufacturer approval of the foundation design and construction for the equipment involved. Equipment vibration shall be maintained within acceptable limits, and shall be suitably dampened and isolated.

3.1.12 Equipment Installation

Install equipment strictly in accordance with these specifications, and the manufacturers' installation instructions. Grout equipment mounted on concrete foundations before piping is installed. Install piping in a manner that does not place a strain on any of the equipment. Do not bolt flanged joints tight unless they match properly. Extend expansion bends adequately before installation. Grade, anchor, guide and support piping without low pockets.

3.1.13 Cleaning of System

Clean the various system components before final closing as the installations are completed. Remove foreign matter from equipment and surrounding areas. Cleaning and cleanliness shall conform to paragraph entitled "Cleaning and Cleanliness Requirements" for pressures over 250 psig. Preliminary or final tests will not be permitted until the cleaning is approved by the Contracting Officer.

3.1.14 Pipe Sleeves

Provide pipe sleeves where pipes and tubing pass through masonry or concrete walls, floors, roofs, and partitions. Hold sleeves securely in proper position and location before and during construction. All sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Extend sleeves in floor slabs 2 inches above the finished floor. Pack space between the pipe or tubing and the sleeve firmly with oakum and caulk both ends of the sleeve with elastic cement.

3.1.15 Floor, Wall, and Ceiling Plates

Provide chromium-plated steel or nickel-plated cast iron plates on pipes passing through floors and partitions of finished rooms. Provide painted cast-iron, malleable iron, or steel for other areas.

3.1.16 Flashing for Buildings

Provide flashing in accordance with Section 07 60 00 FLASHING AND SHEET METAL where pipes pass through building roofs and outside walls.

3.1.17 Unions and Flanges

Provide unions and flanges where necessary to permit easy disconnection of piping and apparatus, and as indicated. Provide a union for each connection having a screwed-end valve. Provide unions or flanges not farther apart than 100 feet. Provide unions or flanges as indicated. Provide unions on piping under 2 inches in diameter, and provide flanges on piping 2 inches and over in diameter. Install dielectric unions or flanges between ferrous and non-ferrous piping, equipment, and fittings; except that bronze valves and fittings may be used without dielectric couplings for ferrous-to-ferrous or non-ferrous to non-ferrous connections.

3.1.18 Painting of Piping and Equipment

Paint piping and equipment in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.1.19 Identification of Piping

Identify piping in accordance with PFI ES 22. Use commercially manufactured piping identification labels. Space identification marking on runs not farther apart than 50 feet. Provide two copies of the piping identification code framed under glass and install where directed.

3.1.20 Warning and Identification Tape

Coordinate installation of utility warning and identification tape with backfill operation. Provide tape above buried lines at a depth of 8 to 12 inches below finish grade.

3.2 CLEANING AND CLEANNESS REQUIREMENTS

Cleaning and cleanness requirements shall conform to ASTM A380/A380M and the following.

3.2.1 Substitution

The word "shall" shall be substituted for "should" in ASTM A380/A380M.

3.2.2 Prohibited Methods and Processes

The following methods and processes shall not be used.

a. Chemical descaling (acid pickling).

b. Abrasive blasting and vapor blasting.

c. Alkaline cleaning.

d. Emulsion cleaning.

e. Chelate cleaning.

f. Acid cleaning.

g. Passivation.

h. Corrosion inhibitors shall not be used.

3.2.3 Approval of Methods and Procedures

Prepare and submit written cleaning procedures for approval. Perform production cleaning in accordance with approved procedures.

3.2.4 Tools Used on Corrosion-Resistant Alloys

Tools used on corrosion-resistant alloys such as grinding, polishing, filing, deburring, and brushing tools shall be visually clean and shall not have been used on carbon or low alloy steels, aluminum, lead or materials containing lead or lead components, or other low melting point materials. Wire brushes shall be 300 series stainless steel. Unless otherwise approved, each tool shall be used on only one type of corrosion-resistant metal.

3.2.5 Cleaning Before Installation

Clean piping, components, and equipment before installation.

3.2.6 Cleaning Requirements

Clean surfaces containing no crevices or inaccessible areas by any of the procedures described herein. Clean surfaces containing crevices by immersion in unused or redistilled acetone, ethanol, or isopropanol only.

3.2.6.1 Vapor Degreasing

Vapor degreasing may be used on surfaces containing no crevices or inaccessible areas and shall be accomplished by the following procedures:

a. Dry all parts entering degreaser.

b. Load parts onto racks in the condensing zone so that they do not touch each other, and in such a manner to insure complete draining of solvents.

c. Use perchloroethylene bath. Maintain bath at 250 to 260 degrees F. The bath shall contain a neutral inhibitor to prevent acid formation due to hydrolysis. Other types of inhibitors are not permitted.

d. Change solvent when boiling point of perchloroethylene exceeds 260 degrees F. Dump solvent earlier if cleanliness standards are not attained.

e. Lower or raise parts in the degreaser at a rate not to exceed 12 inches per minute and immerse in vapor phase. Spray with clean solvent during immersion time. Keep the spray nozzle at least one foot below the vapor line during spraying. Allow part to remain in vapor until condensation ceases (3 to 5 minutes). Dry parts completely before removing from degreaser.

3.2.6.2 Degreasing by Immersion or Wiping

Degreasing of parts having no inaccessible areas or crevices may be performed by immersion in solvent or by wiping with a clean lintless wiping cloth saturated with the solvent perchloroethylene, unused or redistilled acetone, ethanol, or isopropanol, or Stoddard solvent for preliminary degreasing. Dry in accordance with paragraph entitled "Drying Requirements."

3.2.6.3 Trisodium-Phosphate Detergent Cleaning (Degreasing)

Trisodium-phosphate detergent cleaning may be used on surfaces containing no crevices or inaccessible areas and shall be accomplished as follows:

a. Remove heavy dirt by either scrubbing with a non-shedding bristle brush using a solution of up to one fluid ounce of nonionic detergent per gallon of tap water or immersing the parts in a hot (approximately 160 - 190 degrees F) solution consisting of 7 to 10 ounces of trisodium phosphate and up to one fluid ounce of the nonionic detergent per gallon of tap water for about 20 minutes. Agitate and use brush as necessary.

b. Rinse parts thoroughly in hot water at a minimum of 120 degree F.

c. Dry the parts in accordance with paragraph entitled "Drying Requirements."

3.2.6.4 Ultrasonic Cleaning

Cleaning methods using ultrasonic equipment may be used.

3.2.7 Drying Requirements

Accomplish drying by still or forced clean air or inert gas, drying oven, or by evacuation. When using evacuation, exercise care to prevent evacuating-pump lubricant from entering the equipment. Check compressed air used for drying to ensure cleanliness by blowing through a clean, white, cotton filter cloth for about 5 minutes at full drying velocity.

3.2.8 Inspection and Acceptance Criteria for Cleanliness

Conform to ASTM A380/A380M and the following:

3.2.8.1 Cleanness Criteria

All surfaces of piping material, equipment, instruments, and other components which will come in contact with compressed air shall be clean to the extent that no contamination is visible to a person with normal visual acuity (natural or corrected) under a lighting level of at least 100 footcandles on the surface being inspected. Cleanness of surface which cannot be visually inspected due to inaccessibility or geometry shall be determined by an interpretation of the discoloration or dirt obtained by wiping with a clean, white, wet or dry cloth. Free of contamination shall mean free of oil, dirt, metallic flakes, preservatives, paint, and any other substances which may present a safety hazard or impair the quality of the compressed air.

3.2.8.2 Critical Surfaces

No rust shall be allowed on valve seats, orifice plates or other critical surfaces. Thin films of rust are acceptable on other corrosion-resistant material surfaces provided there is no visible thickness or evidence of pitting and the total area involved does not exceed one percent of the total surface area of the component in contact with compressed air.

3.2.8.3 Carbon and Low Alloy Steels

A uniform light rust that can be removed by brushing or wiping is acceptable.

3.2.9 Maintaining Cleanness During Installation

Maintain cleanness of piping, components, and equipment during installation. Dirt and debris producing operations shall be performed so that dirt and debris fall away from system openings; otherwise, provide covers over openings to preclude contamination. Cap, plug, cover, or bag openings and pipe ends and secure with tape when they are not required to be open for the performance of work. Metal caps, plugs, and covers shall be austenitic stainless steel. Plastic items and tape shall be free of substances that can have a harmful effect on stainless steel and other corrosion-resistant metals in the system.

3.2.10 Cleanness Verification Flushes

After installation, check the systems for cleanness by flushing with water. Perform flushing so that the minimum velocity through any part of the system is not less than 3.6 feet per second. Pass flush water through a filter for cleanness evaluation. Filter element shall be corrosion-resistant wire cloth with mesh size conforming to ASTM E11, No. 20 (850 micrometers), No. 25 (710 micrometers), or No. 30 (600 micrometers). Filter area shall be sufficient to limit pressure drop so that required flushing velocity can be attained.

3.2.10.1 Flush Acceptance Criteria

The system shall be flushed until there is no more than slight speckling 0.5 cubic centimeters of particulates on the filter screen. There shall be no particles larger than 1/32 by 1/16 inch long. The flush water shall show no visual evidence of contamination such as oil particles, discoloration, or iridescent surface film characteristic of oil.

3.2.10.2 Recleaning of Systems

Systems which fail to meet acceptance flush criteria after flushing for more than 4 hours shall be recleaned by the Contractor at no additional cost to the Government. Prepare recleaning procedures and submit to the Contracting Officer for approval. Remove instruments, components, and any other items that may be damaged by recleaning. Perform recleaning by flushing with hot water at not less than 140 degrees F.

3.3 CLEANING SILVERBRAZED PIPING

Clean silverbrazed piping to remove residual flux remaining in the system after fabrication. Use one of the procedures below. The hot flush and hot recirculating flush are preferred. Minimum flow rate through any part of the system in gallons per minute shall be 1.5 times the inside diameter of the pipe in inches. For any flushing method used, the system shall be full of water so that joints are completely submerged at all times.

3.3.1 Hot Flushing Method

Hot flush the system for one hour using heated fresh water. No part of the system shall go below 110 degrees F.

3.3.2 Hot Recirculating Flush Method

Perform hot recirculating flush for one hour. Heat water during flushing so that no part of the system falls below 110 degrees F. After completing the hot recirculating flush, flush the system with cold fresh water for 15 minutes.

3.3.3 Cold Soak Method

Cold soak the system using fresh water at not less than 60 degrees F for 12 hours. Following the 12 hour soak, flush the system with fresh water at not less than 60 degrees F for 4 hours.

3.4 FIELD QUALITY CONTROL

3.4.1 Examinations

3.4.1.1 Welding Examinations

The Contractor shall perform visual and nondestructive examinations to detect surface and internal discontinuities in completed welds, and submit a Non-Destructive Examination (NDE) report meeting the requirements specified in ASME B31.1. The Contractor shall obtain the services of a qualified commercial inspection or testing laboratory or technical consultant, approved by the Contracting Officer. Visually examine welds. Perform radiographic, liquid penetrant, or magnetic particle examination as specified in Table II of this section. For systems operating at 1000 psig or higher, all welds shall be examined. For high pressure systems operating less than 1000 psig, perform random NDE. When examination and testing indicate defects in a weld joint, the weld shall be repaired by a qualified welder. Remove and replace defects as specified in ASME B31.1, unless otherwise specified. Repair defects discovered between weld passes before additional weld material is deposited. Whenever a defect is removed, and repair by welding is not required, blend the affected area into the surrounding surface, eliminating sharp notches, crevices, or corners. After defect removal is complete and before rewelding, examine the area by the same test methods which first revealed the defect to ensure that the defect has been eliminated. After rewelding, reexamine the repaired area by the same test methods originally used for that area. Any indication of a defect shall be regarded as a defect unless reevaluation by surface conditioning and NDE shows that no unacceptable defects are present. The use of any foreign material to mask, fill in, seal, or disguise welding defects will not be permitted.

3.4.1.2 Brazing Examinations

The Contractor shall perform brazing examinations.

a. Visual Examinations

Visually examine all compressed air systems as follows:

(1) Check brazed joint fit-up. Diametrical clearances shall conform to brazing procedure requirements.

(2) Check base material of pipe and fitting for conformance to the applicable drawing or specification.

(3) Check grade of brazing alloy for conformance to the brazing procedure before fit-up or brazing.

(4) Check completed brazed joint for a complete ring of brazing alloy between the outside surface of the pipe and the face of the fitting, and for a visible fillet.

(5) Check stainless steel and other susceptible material for evidence of stress cracks. Check inside of joint if possible with borescope or other aids.

b. Nondestructive Examination

For high pressure compressed air systems, any fitting, copper-nickel pipe, or stainless steel tubing which is reused after unsweating a brazed joint shall be liquid penetrant examined for cracks. Any crack detected shall be cause for rejection of the fitting or pipe. Liquid penetrant examination shall be performed by qualified personnel.

c. Repair of Brazed Joints

Defective joints may be repaired. However, no more than two attempts to repair by reheating and additional face feeding of brazing filler metal will be permitted, after which the defective joint shall be unsweated, reprepared as a new joint, examined for defects on pipe and fittings, and rebrazed. Perform required NDE.

3.4.2 Testing

3.4.2.1 General Requirements, Testing

Perform testing after cleaning and acceptance of cleanness. Contractor shall provide everything required for tests. Tests shall be subject to the approval of the Contracting Officer. Calibrate the test pressure gage with a dead weight tester within 15 days before use and certify by initial and date on a sticker applied to dial face. Pressurize each piping system individually and check to assure that there are no cross-connections between different systems prior to hydrostatic and operational tests.

Supervision of Testing

For high and medium pressure system, an experienced registered professional engineer responsible for safety and employed by the Contractor shall be present during testing.

3.4.2.2 Hydrostatic and Leak Tightness Tests

a. Preliminary Preparation

Remove or isolate from the system the compressor, air dryer, filters, instruments, and equipment which would be damaged by water during hydrostatic tests and reinstall after successful completion of tests.

b. Performance of Hydrostatic Tests

Hydrostatically test piping systems in accordance with ASME B31.1. Vent or flush air from the piping system. Pressurize system for 10 minutes with water at one and one-half times design working pressure, then reduce to design working pressure and check for leaks and weeps.

c. Compressed Air Leak Tightness Test

After satisfactory completion of hydrostatic pressure test, blow systems dry with clean, oil-free compressed air, and test with clean, dry air at design working pressure. Brush joints with soapy water solution to check for leaks. Install a calibrated test pressure gage in piping system to observe any loss in pressure. Maintain required test pressure for a sufficient length of time to enable an inspection of joints and connections.

d. Compressed Air Pressure Test For High Pressure Systems

For high pressure systems, compressed air at system design pressure shall then stand in a system to equalize temperature. Pressure drop, corrected for temperature change, shall not be more than one percent in 24 hours for a test pressure 1000 psig and above, and not over 5 percent in 6 hours for test pressures from 400 to 1000 psig. Use formula below to correct pressure for temperature change.

PF + 14.7 = (PI + 14.7)(TF + 460)/(TI + 460)
Where PF = Final Pressure, (psig)
Where PI = Initial Pressure, (psig)
Where TF = Final Temperature, (degrees F)
Where TI = Initial Temperature (degrees F)

3.4.2.3 Operational Tests

Test equipment as in service to determine compliance with contract requirements and warranty. During the tests, test equipment under every condition of operation. Test safety controls to demonstrate performance of their required function. Completely test system for compliance with specifications.

3.5 INSTRUCTION TO GOVERNMENT PERSONNEL

Provide 2 man-days of instruction to 2 Government personnel in accordance with Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS for each type of compressor and compressed air dryer in the project.

TABLE II						
HP Piping (400 psig and Higher) Inspection Requirements 1/						
Required Nondestructive Examination						
Welded Joint type and pipe size, inches	VISUAL EXAMINATION		T/PT TEST		RADIOGRAPHY	
	Root Layer	Completed Weld	Root Layer	Completed Weld	Completed Weld	Extent Of
Butt 4 and greater	X2/	X	X2/	X3/	X	360 degrees
Butt 2-1/2 to 3-1/2 incl.	X2/	X	X2/	X3/	X4/5/	At least 60 degrees
Butt less than 2-1/2	X2/	X	X2/	X3/	X4/5/6/	At least 60 degrees
All socket and fillets	X2/	X	X2/	X	--	--

Legend: X - Indicates that test is required.
MT Magnetic Particle Inspection
PT Liquid Penetrant Inspection
RT Radiographic Examination
NOTES:
1/ Where new welds in piping intersects existing or older welds, the latter welds shall be inspected for a distance of 6 inches or a distance equal to 50 percent of the pipe size diameter, whichever is less, as measured from points of intersection. The existing or older weld and adjacent base material shall be free from cracks. Where non-intersecting adjacent existing welds are inadvertently radiographed, only cracks shall be cause for rejection.
2/ MT/PT inspect the first or root pass of welds and when accessible, the reverse or back-chipped ground, gouged or machined side prior to depositing metal on the reverse side. Visual examination at 5X magnification may be substituted for MT/PT inspection. Linear discontinuities shall be unacceptable. Use 5X inspection where crevices cannot be cleaned thoroughly.

___3/ MT/PT test shall be performed only when post-weld heat treatment is required and when specified on drawing. The test shall be conducted after heat treatment and shall include 360 degrees of circumferential weld surface and adjacent base material. Where 360 degrees RT is performed after heat treatment, MT/PT is not required, except where specified on drawing.
___4/ RT of welds on piping in the horizontal fixed position shall represent a sector which was welded in the vertical or overhead position.
___5/ In lieu of 60 degree RT, PT or MT may be performed on the inside of a joint where weld is within 2 1/2 nominal pipe diameters from the open end is back welded, has backing ring removed or used consumable insert.
___6/ RT is required where the working pressure exceeds 575 psig. For working pressure 575 psig and below, inspection may be performed in lieu of RT.

-- End of Section --

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SECTION 22 16 19.26 20

LARGE CENTRIFUGAL AIR COMPRESSORS (OVER 200 HP)
11/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 2011	(2014B) Cylindrical Wormgearing Tolerance and Inspection Methods
ANSI/AGMA 2009	(2001B; R 2008) Bevel Gear Classification, Tolerances, and Inspection Methods

AMERICAN PETROLEUM INSTITUTE (API)

API Std 672	(2004; Errata 2007; Errata 2010) Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical, and Gas Industry Services

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 10	(1997; R 2014) Performance Test Code on Compressors and Exhausters

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM B111/B111M	(2018) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B171/B171M	(2012) Standard Specification for

	Copper-Alloy Plate and Sheet for Pressure Vessels, Condensers and Heat Exchangers
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-7.1	(2011) Commodity Specification for Air; 5th Edition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 112	(2017) Standard Test Procedure for Polyphase Induction Motors and Generators

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2151	(2004) Acoustics - Noise Test Code for Compressors and Vacuum Pumps - Engineering Method (Grade 2)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-PRF-17331	(2019; Rev L) Lubricating Oil, Steam Turbine and Gear, Moderate Service
MIL-T-19646	(1990; Rev A; Notice 1 2021) Thermometer, Gas Actuated, Remote Reading

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219	Mechanical Power Transmission Apparatus

1.2 GENERAL REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section except as specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Air Compressor System

Include wiring diagrams of the air compressor with all accessories. The minimum acceptable scale is [1/4 inch to one foot] [_____].

SD-03 Product Data

Air Compressor

Air Intake Devices

Bypass Line Silencer

Air Flow Rate and Pressure Recorder

[Carbon Monoxide Monitor

] Submit manufacturer's catalog data for compressor and auxiliary equipment in the format provided in API Std 672, Appendix A. Submit all applicable information. For air compressor, include aftercooler, intercoolers, oil cooler, lubrication system, and control valves. Submit air compressor and intercooler performance curves at specified summer and winter design conditions.

SD-06 Test Reports

Air compressor performance tests

Balance Tests

Sound Level and Run-In Tests

Obtain approval prior to shipping compressor.

Air Compressor Performance Tests

Instrumentation Test

Sound Level Tests

Air Compressor System Tests

The test supervisor shall certify performance by test to be in compliance with specifications.

SD-07 Certificates

Air Compressor System

Air Compressor System Installation

Work Plan

Factory Test Procedures

Factory Testing Certification

Qualifications of Field Supervisors

Field Test Procedures

Training Material

SD-10 Operation and Maintenance Data

Air Compressor System, Data Package 3

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted Operating Instructions for Air Compressor

Submit text.

1.4 QUALITY ASSURANCE

1.4.1 Work Plan

Submit a written schedule of dates of installation, start-up, checkout, and test of equipment.

1.4.2 Factory Testing Certification

Submit a statement that the air compressor factory is equipped to perform all required factory tests. Submit in accordance with paragraph entitled "Manufacturer's Certifications."

1.4.3 Qualifications of Field Supervisors

Submit the name and certified written resume of the engineer or technician, listing education, factory training and installation, start-up, and testing supervision experience for at least two projects involving compressors similar to those in this contract.

1.4.4 Training Material

Submit a detailed training program syllabus for training of government personnel, including instructional materials at least three weeks prior to start of tests.

1.4.5 System Installation

Submit certification of air compressor system performance conforming to ASME PTC 10 and ASME BPVC SEC VIII D1. Submit certification of proper system installation in accordance with paragraph entitled "Supervision."

1.4.6 Air Compressor System

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Data shall contain information required for maintenance and repair and shall contain no evidence that proprietary maintenance arrangements with the manufacturer will be necessary. Compressors which will require proprietary maintenance arrangement with the manufacturer require Government review and approval. The compressors may be disapproved if circumstances do not justify approval of compressors with limited availability of maintenance.

1.5 SAFETY

Construct all components of the unit in accordance with the requirements of OSHA 29 CFR 1910.219. Requirements include shaft coupling guards as specified in Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, thermal insulation and jacketing with manufacturer standard covering or aluminum sheet of all surfaces at 125 degrees F and higher within a height of 7 feet from floor level, and use of electrical safety devices. Thermal insulation, furnished by equipment manufacturer, shall conform to ASTM C553, Type I (flexible resilient), Class B-5 (up to 400 degrees F), 2 pcf nominal. Cement insulation to surface with MIL-A-3316, Class 2, adhesive and fasten with 16 gage wire bands at maximum 16 inches on center spacing. Cover insulation with ASTM B209 sheet aluminum jacket. The thermal insulation is required for unit with separate intercooler and aftercooler units.

1.6 EQUIPMENT ARRANGEMENT

Arrangement selected shall maintain 3 foot clearance for access passage and 4 foot clearance for personnel to operate equipment. There are substantial physical and connection point differences among the several air compressors which comply with this specification. The Contractor shall be responsible for selecting equipment and submitting arrangement drawings covering required changes for approval by the Contracting Officer. Changes from the equipment arrangement shown on the contract drawings shall be performed by the Contractor at no additional cost to the Government.

1.7 ELECTRICAL REQUIREMENTS

Comply with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, [and [_____]].

1.8 SUPERVISION

The Contractor shall obtain the services of a qualified engineer or technician from the compressor manufacturer to supervise installation, start-up, and testing of the compressor. After satisfactory installation of the equipment, the engineer or technician shall provide a signed certification that the equipment is installed in accordance with the manufacturer's recommendations.

1.9 DEFINITIONS

Conform to API Std 672 and the following:

Compressor power is shaft power at shaft coupling, including all aerodynamic and mechanical losses.

1.10 INSULATION

Thermal and acoustical insulation shall have flame spread rating not higher than 75, and smoke developed rating not higher than 150 when tested in accordance with ASTM E84.

1.11 POSTED OPERATING INSTRUCTIONS

Provide for air compressor. Include start-up and shutdown sequence instructions.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment complete with accessories shall be selected by the Contractor for performance compatibility.

2.2 AIR COMPRESSOR

The air compressors shall be the packaged, integrally geared, centrifugal type. Include the electric motor driver, integral gears and cases, staged compressors, intercoolers and moisture separators, aftercoolers and moisture separators, instruments, controls, pressure lubrication system with prelubrication pump and shaft-driven lubrication pump, steel base and accessories. The aftercoolers may be mounted separately to meet the performance requirements.

2.2.1 Manufacturer's Certifications

The manufacturer shall certify that the air compressors proposed are of the same design, construction, and frame size, and of equal or not more than 10 percent smaller in capacity as compressors which have been in satisfactory continuous service for at least 2 years at not less than two locations. Furnish the name of the owner, the address of the installation, and the name of a person at the installation who can be contacted for verification. The manufacturer shall also certify that the factory is equipped to perform all required factory tests.

2.2.2 Guaranteed Performance

a. Net Compressed Air Output (All seal losses shall be considered internal and not included in the net output) (Minus zero plus 4 percent): [_____] SCFM

b. Output Pressure Immediately Downstream of Aftercooler (Minus zero plus 4 percent): 125 psig

c. Output Air Maximum Temperature Downstream of Aftercooler: 100 degrees F

d. Inlet Air Pressure at First Stage: [_____] psig

e. Inlet Air Temperature at First Stage: [_____] degrees F

f. Inlet Air Filtration Efficiency: 99.9 percent of 0.5 micrometer size

g. Barometric Pressure: [_____] psig

h. Relative Humidity: [_____] percent

i. Cooling Water Inlet Temperature: [_____] degrees F

j. Total Cooling Water Flow Rate: [_____] gpm

k. Maximum Cooling Water Pressure Drop Through the Compressor and Any Intercooler, Aftercooler, or Oil Cooler: [_____] [8 psi]

l. Maximum Compressor Power Required. (Plus or minus 4 percent): [_____] hp

m. Unloaded Compressor Power and Compressor Interconnections: [_____] hp

n. Maximum sound levels one meter horizontal from compressor and 5 feet above floor as measured per ISO 2151 Test Code for the Measurement of Sound from Pneumatic Equipment: 84 dBA, 90 dB for any octave band.

2.2.3 Additional Performance Requirements

2.2.3.1 Air Quality

Air at compressor intake will be considered breathing air quality conforming to CGA G-7.1, Type I, Grade D or better. Air compressors shall introduce no material, gases, or particles, or chemically alter any materials that will adversely affect or reduce the quality of the air passing through the unit.

2.2.3.2 Surge Output Pressure

API Std 672, paragraph 2.1.12.

2.2.3.3 Unloading

The compressor shall be designed to unload prior to surge limit. The surge limit shall not occur at a capacity greater than 70 percent of the guarantee point capacity. Unloaded compressor power shall not exceed 20 percent of full load power.

2.2.3.4 Ambient and Inlet Conditions Operating Ranges

Allowing for rational engineering performance adjustments due to variations in ambient and inlet conditions, the compressor shall be designed, equipped, and furnished to be fully operational without abnormal wear throughout the entire range between and including the limits of the winter and summer design conditions specified.

a. Summer Design Conditions:

Inlet Air: [_____] degrees F dry bulb and [_____] degrees F wet bulb temperatures, [_____] percent relative humidity

Inlet Cooling Water: [_____] degrees F

Ambient Compressor Room Temperature: [_____] degrees F

Barometric Pressure: [_____] psig

b. Winter (Low Ambient) Design Conditions:

Inlet Air: [_____] degrees F dry bulb and [_____] degrees F wet bulb temperatures, [_____] percent relative humidity

Inlet Cooling Water: [_____] degrees F

Ambient Compressor Room Temperature: [_____] degrees F

Barometric Pressure: [_____] psig.

2.2.3.5 Critical Speeds

Conform to API Std 672, paragraph entitled "Critical Speed."

2.2.3.6 Vibration and Balance

Conform to API Std 672, paragraphs entitled "Vibration and Balance."

2.2.4 Electrical Service Conditions

2.2.4.1 Air Compressor Drive Motor

[_____] volts, 3 phase, 3 wire, 60 hertz electrical service.

2.2.4.2 Accessory electrical Service

See Table I.

TABLE I - COMPRESSOR ACCESSORY ELECTRICAL SERVICE SCHEDULE

Item	Voltage	Phase	Frequency
Control Power and Motors under 1/2	120	1	60 Hz
Accessory Power	460	3	60 Hz

2.2.5 Compressor Controls

Provide complete pneumatic load range control system with each compressor with a manually selectable capability for two modes of load range control as specified. Provide additional electrical, electro-pneumatic, or solid state electronic controls for other specified control and monitor functions. All controls shall conform to NEMA ICS 2 as selected by the compressor manufacturer. Control system enclosure shall conform to NEMA ICS 6. Controls shall be suitable for individual operation of the compressor or parallel operation with one or more other compressors.

2.2.5.1 Two-Step Control Mode

The two-step control mode shall actuate the compressor suction inlet control valve to either a full open position or to a full closed position in accordance with specified, adjustable pressure settings. The pressure settings shall be an adjustable band width plus and minus percentage of an adjustable output gage pressure set point. The compressed air output gage set point shall be adjustable in the range of 105 to 125 psig, and the gage pressure sensor measurement for this set point shall be made downstream of the aftercooler. The adjustable band width about the set point shall be from plus or minus 2 1/2 percent to plus or minus 5 percent. Controls shall close the compressor inlet valve at the high pressure limit of the band width and simultaneously open a bypass vent valve which shall also be provided. Controls shall open the compressor inlet valve at the low pressure limit of the band width and simultaneously close the bypass vent valve.

2.2.5.2 Dual Control Mode

A pressure regulation control mode shall be furnished to control compressor output pressure to within plus or minus one percent of an adjustable output pressure set point. Provide an adjustment range of 105 to 125 psig. When the compressor operates at capacities above surge limit unload setting and below maximum flow stonewall conditions, the control system shall throttle flow at the compressor suction inlet control valve in response to increasing discharge pressure due to decreased demand for compressed air. At lower demand, prior to reaching surge limit at a flow capacity not more than 70 percent of guarantee point capacity, the compressor shall unload by closing the compressor inlet suction control valve and simultaneously opening the bypass vent valve. Use of the bypass vent valve alone to achieve pressure control by a modulation technique of spilling excess air is prohibited. At the low discharge pressure limit, the inlet valve shall open and the bypass vent valve shall close to load the compressor.

2.2.5.3 Unloaded Compressor Start-Up

Each of the two pneumatic control mode systems shall have provision for start-up of the compressor in the unloaded control setting with the compressor inlet valve closed and the bypass valve open.

2.2.5.4 Electrical Start-Up Interlocks

The manual starting circuit of each compressor shall have interlocks to prevent starting until pre-lubrication pump oil pressure and cooling water pump water flow have been established to the required values for safe operation as determined by the compressor manufacturer.

2.2.5.5 Monitor and Safety Controls

Provide supplementary electric, electro-pneumatic, or solid state electronic controls to provide alarm and shut down requirements, plus interlocks with accessories. Requirements are as follows:

a. Shutdown requirements shall cause the controlled compressor to shut down, energize alarms, and light labeled red lights.

b. Alarm only requirements shall not cause the controlled compressor to shut down, but shall sound the same alarms and light labeled amber lights.

c. Light only requirements shall not cause the controlled compressor to shut down, but shall light labeled amber lights.

d. The individual monitor and safety controls shall be as shown on Table 2.

TABLE 2 - MONITOR AND SAFETY CONTROL SCHEDULE

Item	Light and Shutdown	Indicating Alarm	Light Only
1. High Discharge Air Temperature 275 degrees F	Yes	Yes	-
2. High Intercooler Discharge Water Temperature, Each Intercooler	No	Yes	-
3. High Aftercooler Discharge Water Temperature	No	Yes	-
4. High Cooling Water Supply Temperature	No	Yes	-
5. High Lube Oil Temperature	Yes	Yes	-
6. Low Lube Oil Pressure	Yes	Yes	-
7. Low Cooling Water Flow	No	Yes	-
8. Low Oil Reservoir Level	No	Yes	-
9. High Condensate Level Intercooler (wired to one light)	Yes	Yes	-
10. Vibration Monitors Each Pinion	Yes	Yes	-
11. Surge Limit Approach	Yes	Yes	-
12. High Motor Stator Temperature	Yes	Yes	-
13. High Condensate Level Aftercooler	No	No	Yes
14. High Inlet Pressure Drop Across Inlet Air Filters (combined, 3 stage)	No	Yes	-
15. High CO Level	Yes	Yes	-

2.2.5.6 Monitoring Instruments

Provide the following monitoring instruments in addition to the monitor and safety controls. Pressure gages shall conform to ASME B40.100, 4 1/2 inch, red marking pointer, single bourdon tube, brass case, black enamel finish. Provide pressure gages with a pressure snubber and a stainless steel barstock needle isolation valve. Thermometers shall be extended stainless steel sheathed bimetallic stem, 3 1/2 inch dial, and separable 4 inch stainless steel wells. Temperature measurements at inaccessible locations shall be made with remote reading thermometers conforming to MIL-T-19646, Class C separable well of Type 304 stainless steel. Select pressure and temperature gage ranges to give a normal operating reading near the midpoint of the scale range.

a. Oil cooler outlet temperature gages for oil.

b. Oil cooler inlet and outlet temperature gages for water.

c. Lubrication oil pump discharge pressure gage.

d. Compressor seal air pressure gage, if applicable.

e. Inlet air filter differential pressure gage with 8, zero, 8 inch water gage. Provide selector valve, tubing, and tap to measure static gage pressure downstream of each filter stage.

f. Pinion shaft vibration monitor readout with stage selection switch.

g. Total running time readout.

h. Cooling water supply to compressor pressure gage.

i. Cooling water return from compressor pressure gage.

j. Interstage air pressure gages for each interstage.

k. Compressed air pressure downstream of aftercooler pressure gage.

l. Compressed air temperature downstream of aftercooler temperature gage.

m. Interstage air temperature after intercooler of each stage temperature gages.

n. Compressed air temperature at discharge of each stage of compression before cooling temperature gages.

o. Compressor inlet air temperature gage.

p. Cooling water to compressor temperature gage.

q. Cooling water outlet temperature at outlet of each intercooler and aftercooler temperature gages.

2.2.5.7 [Gages on Schematics

Certain pressure and temperature gages are designed on schematic flow diagrams in the drawings. Where a monitor gage satisfies the required location on a schematic, no additional gage needs to be furnished.]

[2.2.5.8 Control Schematics

The drawings show a generalized overall control system for compressor, auxiliaries, remote panel transmitting and receiving, and remote panel. The system is shown using relay symbology. Contractor and equipment suppliers may use standard panel features to accomplish the total requirements using other methods of signal, solid state devices, or revised lamping. All wiring diagrams and required devices shall be approved by the Contracting Officer prior to installation.

]2.2.6 Control Air Supply

[Extend existing][Provide new] control air system of dry and purified air for the compressor controls. Sizing shall be based on not less than [_____] [15 SCFM]. Filtration shall be to 5 micrometers minimum and the air from the dryer shall have a maximum system pressure dew point [40] [0] degrees F.[

The Contractor shall obtain system air for the controls by piping from the existing system.]

2.2.7 Compressor Design Features

Compressor shall be multistage centrifugal, with a minimum of 2 centrifugal compression stages, designed for optimum flow and speed requirements to produce highest space efficiencies at lowest compression ratio and temperature and lowest external noise level. Special attention shall be given to energy saving features in design and arrangement such as radial damper intake valve, long radius interstage piping, and low air velocities. Equipment shall be designed for economical and rapid maintenance. Casing components bearing housings and other major parts shall be shouldered, dowelled, or designed with other provisions to facilitate accurate alignment or reassembly. Shaft seals and bearings shall be accessible for inspection or replacement with a minimum of disassembly.

2.2.7.1 Casings

Casing shall be cast iron, ductile iron, or cast steel. Casing stresses shall be within the limits allowed by ASME BPVC SEC VIII D1. Casings, supports, and baseplates shall be designed and fabricated to preclude excessive and injurious distortion from temperatures, pressures, and forces encountered in service conditions, including surge. Provide jackscrews, lifting lugs, eyebolts, guide dowels, and casing alignment dowels to facilitate disassembly and reassembly. When using jackscrews for parting contacting faces, relieve one of the faces by counterboring or recessing to prevent marring the face, which result in leaking or improper fit. Provide lifting lugs or eyebolts for removable portions of the casings. Flanged casing connections shall conform to ASME B16.1 or ASME B16.5. Threaded connections shall conform to ASME B1.20.1. Casing shall be split in a manner permitting direct access to impellers, shafts, and bearings. Compressors shall be axial flow inlet. Gear cases shall be enclosed, accessible, force lubricated and designed with seals and slingers to keep oil out of air system.

2.2.7.2 Shafts

Shafts shall be of forged or rolled alloy steel and shall have a machined finish throughout their entire length. All rotating components shall be positively secured to shafts by approved mechanical means or interference shrink fits.

2.2.7.3 Impellers

Impellers shall be of 400 series or 17-4 PH stainless steel, open or closed design, with backward leaning vanes, and of welded, milled, or cast construction.

2.2.7.4 Gears

Gears shall be of alloy steel, ANSI/AGMA 2009 and AGMA 2011 Quality Number 12 or better for both bull and pinion gears. Gears shall be hardened to 275 Brinell for bull gear and 320 Brinell for pinion, unless otherwise approved. Gears shall be ground to the required contours, checked for proper contact during assembly at the factory, and shall not require a break-in period in the field for proper operation. All gears shall be pressure lubricated.

2.2.7.5 Seals

Separate air and oil shaft seals shall be provided to confine air in the casing and prevent contamination of the air stream by lubricating oil. Shafts seals shall be labyrinth type, carbon ring type, or a combination of the two types. Provide an air space vented to the atmosphere between the air and oil seals. Seals shall be suitable for all operating conditions including suction throttling, start-up, shutdown, and momentary surge.

2.2.7.6 Thrust Bearings

Axial impeller thrusts shall be absorbed by thrust bearings on the pinion or transferred to the bull gear shaft by conical rider-ring thrust collars. Pinion thrust bearings shall be hydrodynamic (fluid film), multiple-segment type, entitled pad type, or other approved type, and shall be adequate to accommodate all operating conditions, including surging or stonewall operation. Bull gear thrust bearings shall be sized for equal thrust in both directions and shall be adequate for any axial loads transmitted through the driver coupling.

2.2.7.7 Radial Bearings

Radial bearings shall be hydrodynamic (fluid film), precision bored sleeve or pad type, designed for easy replacement by a split design or axially removable arrangement. High speed pinion bearings shall be anti-oil whip, tilting pad, tilted pad, or other approved type. Bearing design shall provide low vibration and sufficient damping at rated speed and all operating modes, including rated capacity and unloading down to 15 to 20 percent of unloaded power.

2.2.7.8 Intercooler, Aftercoolers, and Oil Coolers

Intercoolers, aftercooler, and oil cooler shall include admiralty brass [or copper] tubes conforming to ASTM B111/B111M in admiralty tube sheets conforming toASTM B171/B171M with plate fins and baffles for optimum cooling and fouling resistance using [fresh] [_____] water. Provide an intercooler between stages of compression factory assembled on unit base with piping. The aftercooler may be mounted separately. Intercoolers, aftercooler, and oil cooler shall be factory tested at 1.5 times operating pressure. External intercoolers and aftercooler shall be constructed in accordance with ASME BPVC SEC VIII D1, requirements and be ASME code stamped for 175 psig working pressure. Intercoolers and aftercooler shall be capable of one piece bundle removal. Each intercooler shall be equipped with an integral or direct connected moisture separator with condensate trap or automatic drainer valve assembly. Piping to drainer and drainer assemble shall be Class 300 stainless steel. Design intercoolers and aftercooler for 20 and 15 degrees F approach, respectively, and a fouling factor of 0.001 for both sides of exchanger; however, the approach temperature used to size the coolers shall be reduced if required to meet aftercooler maximum air outlet temperature specified. Nonstandard coolers shall be provided if required to meet the aftercooler maximum air outlet temperature requirement. All coolers shall be of counter-flow design.

2.2.7.9 Lubrication System

Include reservoir, shaft driven positive displacement pump, twin oil coolers, twin filter/strainer (readily replaceable cartridges while operating) and parallel piping and valving provisions to accommodate a separately driven prelube lubrication oil pump for start-up and standby.

System shall be factory assembled and tested. The oil reservoir shall retain a minimum 3-minute oil supply. Lubricating oil shall conform to MIL-PRF-17331, Lubricant No. 2190-TEP or as recommended by compressor manufacturer. Oil cooler shall be designed for a fouling factor of 0.001 for both sides of exchanger. Pressure lubricate hydrodynamic bearings. Provide the oil sump with level indicator and drain and fill connections.

a. Prelubrication pump shall be sized by air compressor manufacturer for the requirements of the system, but shall meet the following requirements. Pump shall be positive displacement gear pump separately mounted with motor on a common base plate with drip lip and drain.

   (1) Performance: Pump shall have separate safety valve bypass set at [_____] [25 psi] above peak expected pressure.

   (2) Materials shall be hardened steel gears and shaft, cast iron case, bronze bearings, mechanical seal.

   (3) Flexible coupling with shaft guard shall be provided, except that these items are not required for a close-coupled pump.

   (4) Motor shall be NEMA MG 1, Design A, Class B insulation, of open drip-proof type. Furnish combination type starter for motor.

b. Lube Oil Heater: Provide thermostatically controlled electric heater in lubrication oil sump of sufficient capacity to heat up and maintain manufacturer's recommended oil temperature when unit is cold at [_____] [32 degrees F] ambient. Provide low oil level indicator with light for protection of heater.

2.2.8 Electric Motors

Efficiency and losses shall be determined in accordance with IEEE 112. Unless otherwise specified horizontal polyphase squirrel cage motors rated one to 125 horsepower shall be tested by dynamometer Method B as described in Section 6.4 of IEEE 112. Motor efficiency shall be calculated using Form B of IEEE 112 calculation procedure.

Polyphase motors larger that 125 horsepower shall be tested in accordance with IEEE 112 with stray load loss determined by direct measurement or indirect measurement (test loss minus conventional loss).

The efficiency shall be identified on the motor nameplate by the caption NEMA Nominal efficiency or NEMA Nom eff.

2.2.8.1 Main Electric Drive Motor

The main drive motor for each compressor shall be an induction motor, [_____] horsepower, with a continuous service factor of 1.0. Size the motor so that the nameplate horsepower rating is not exceeded under the entire range of operating conditions specified. Motor shall be high efficiency type, rated not less than 95 percent based on IEEE 112 testing and labeling. Electrical service will be as specified. Motor shall be designed for reduced voltage starting [at [50] [65] [80] percent of full voltage], allowing for characteristics of the connected load, and shall start without undervoltage tripping. Provide resistance temperature detectors (RTD) attached to or imbedded in motor winding for control system. The motor shall meet the requirements of NEMA MG 1 with Class F insulation. Motor design shall include acoustical covering and reduced noise air intake housing and be rated for 84 dBA or less at 3 feet under full load. Provide space heaters for protection of windings during motor shutdowns.

2.2.8.2 Accessory and Related Equipment Motors

Motors less than 1/2 horsepower shall be single-phase induction motors and shall conform to NEMA MG 1. Motors 1/2 through 5 horsepower shall be three-phase induction motors and shall conform to NEMA MG 1. Single-phase and three-phase motors shall have bimetallic disk thermostats attached to or imbedded in the motor winding. Motors shall have NEMA MG 1 Class B insulation.

2.2.9 Control Panel

Control unit panel conforming to NEMA ICS 6, package or frame mounted, factory designed, assembled, and mounted shall be provided complete with connections made to sensing points. The panel shall be fabricated of formed stretcher leveled sheet steel, reinforced, and assembled into a rigid unit. Gasketed access doors shall be provided as required. Panel shall be factory finish painted. The panel shall meet NEMA 12 requirements.

a. Panel shall contain electric and safety control work required, including either alarm annunciator or individual labeled pilot lights arranged in a group. Panel shall contain alarm device with light and silencing. Generalized arrangement in accordance with drawings.

b. Panel shall contain start and stop buttons (the latter with lockout feature), vibration monitor subpanel, discharge air pressure gage, control test switch and lights, reset button, green unit running light, and control selector switch.

c. Oil pressure gages shall be mounted separately from panel.

2.2.10 Accessories

Required accessories include:

2.2.10.1 Control Valves

Pneumatically controlled valves on suction inlet of compressor and on blowoff bypass line. Mount suction inlet control valve on unit.

2.2.10.2 Air Intake Devices

Compressor air inlet shall be piped to the outside of the building and consist of the following:

a. Intake weather hood with rain hood and bird screen. Material shall be galvanized steel or aluminum alloy, minimum 20 gage.

b. Intake pipe, ASTM A36/A36M steel galvanized, 12 gage or Schedule 5 minimum, from intake weather hood to filter housing flange, welded construction.

c. Filter housing by filter manufacturer to include filter frames, access door(s). Material for housing shall be 0.065 inch thickness, Class 5000 aluminum alloy. Unit shall be rigid and free from distress with all seams sealed.

d. Intake Pipe from Filter Enclosure to Compressor: Aluminum alloy ASTM B209, Alclad alloy 5052-H32 or equivalent, minimum 10 gage, flanged, welded with 5XXX welding rod using TIG method and including expansion bellows.

2.2.10.3 Compressor Air Outlet Connections

Compressor air outlet flexible connection of stainless steel bellows with braided steel cover jacket, with stainless steel liner sleeve, 18 inch nominal length bellows, flanged ends, Class 150. If air bypass connects separately to the compressor from the outlet line, provide a second flexible connection of stainless steel bellows with braided jacket for the bypass.

2.2.11 Inlet Air Filters

Provide a three-stage filter system, complete with mounting racks (horizontal flow), interstage seals, and replaceable filters. Filter unit shall be provided complete including enclosure or housing, and frames. Enclosure shall be Class 5000 aluminum alloy with inlet and outlet flanges. Construction shall be welded or, where welding is not practical, close riveted and caulked, weathertight, with access doors for filter replacement and cleaning. Access doors shall be reinforced, fully gasketed with continuous flexible neoprene gaskets, corrosion-resistant continuous hinges and quarter-turn latches to ensure tightness. All internal ferrous surfaces, including galvanized, shall receive a factory-applied epoxy prime and finish coat for corrosion resistance. Filters shall consist of three separate stages and sized to fit the available space.

2.2.11.1 First-Stage

First-stage filter shall be flat, 2 inch thickness, replaceable media, and rated for the required air quantity at 500 FPM nominal face velocity, friction clean 0.25 inch water gage, efficiency 98 percent of 0.60 microinches and 90 percent of 0.20 microinches.

2.2.11.2 Second-Stage

Second-stage filter shall be deep pleated type, 9 inchesnominal depth and rated for the required air quantity at 350 FPM nominal face velocity, friction clean 0.20 inch watergage, efficiency 98 percent to 0.20 microinches and 90 percent to 0.12 microinches.

2.2.11.3 Third-Stage

Third-stage filter shall be deep pleated type 12 inchesminimum depth and rated for the required air quantity at 350 FPM nominal face velocity, friction clean 0.30 inch watergage, efficiency 99.9 percent to 0.02 microinches.

2.2.11.4 Filter Media

Filter media shall be rated and listed UL Class 2. Filter efficiencies shall be based on National Bureau of Stands (NBS) type discoloration gravimetric test method using atmospheric dust.

2.2.12 Bypass Line Silencer

Provide a bypass line silencer with each compressor as selected by compressor manufacturer for sufficient noise attenuation to meet sound level criteria not greater than 84 dBA measured at an elevation of 5 feet, and 10 feet horizontally from silencer.

2.2.13 Isolating Pad

If specifically recommended by the compressor manufacturer, each compressor steel frame shall be mounted on a neoprene waffle or rib type isolator pad which extends uniformly and continuously along the base mounting surface. The neoprene material shall be of bridge bearing pad quality neoprene and shall be formulated for 40 durometer hardness. The maximum bearing pressure on the isolating pad shall be 50 psi. The pads shall be composed of two layers or 5/16 inch neoprene bonded to and sandwiching 16 gage galvanized steel. Compressor bolt down through the pad shall be accomplished using 1/4 inch thick neoprene impregnated duck washers. Neoprene bushings are not acceptable.

2.3 AIR FLOW RATE AND PRESSURE RECORDER AND MEASUREMENT

Provide a complete flow and pressure measurement and recording package. Provide orifice flanges with pressure taps, square edged stainless steel paddle orifice plate. The orifice plate shall be concentric type, of 0.125 inch thickness and shall meet ASME Standards. Orifice shall be sized for 40 inch water column differential at a full scale flow rate of [_____] SCFM at compressor based on 120 psig upstream pressure. Static gage pressure measurement device of the recorder shall have a range of zero to 200 psig. Provide copper interconnecting tubing between the pressure taps and the recorder as part of this measurement and recording package. Provide a two-pen recorder for the measurement station. Pens shall record pressure (0 to 200 psig range) and air flow (0 to [_____] SCFM). Recorder shall be electric drive and housed in dust-tight steel cabinet. Charts shall be 12 inch diameter with evenly divided graduations. Drive shall be 7 day circle. Provide continuous flow integration of a 7 digit counter type. Pens shall be supplied with long-life cartridges and capillary supply. Chart case shall be internally illuminated. Access to charts shall be through front access window door. Calibrated overall accuracy of the recorded measurements shall be within plus or minus 1.0 percent of full scale. Furnish a supply of 400 charts with the recorder.

2.4 CARBON MONOXIDE MONITOR

The carbon monoxide (CO) monitor unit shall be of the pressure type with attached sampling system. The unit shall be solid state type operation, 2 to 50 ppm range, CO indicating, with provisions for milliamp signal to remote recorder, adjustable set point, and normally open/normally closed contacts for remote signal. Power shall be 120 volt, single phase, 60 hertz with power cord and plug. Response time normally 2 minutes per sample/purge. Unit shall be mounted in a gasketed enclosure with face gage indication CO readings.

2.4.1 Sampling System

Sampling system shall include shutoff valve filter/regulator, pressure gage, manual drainer, and line humidifier set at 50 percent. Draw sample from compressor discharge.

2.4.2 Test System

Test system shall include calibration gas (20 ppm CO) cylinder test gas (200 ppm CO) cylinder, and calibration connectors with quick disconnect.

2.5 SOURCE QUALITY CONTROL

2.5.1 Factory Test Procedures

The completely assembled air compressor package, including the actual contract drive motor, intercoolers, lubrication system, and control panel shall be subjected to performance tests, balance tests, and sound level and run-in tests. Unit shall comply with guarantee requirements applying engineering adjustments to guarantee conditions. Test shall be certified by the manufacturer. Test shall be run on the manufacturer's test stand using driver for this contract. Tests shall be in accordance with ASME PTC 10 format. Full-range performance tests shall indicate performance at maximum rated flow, rating point, and blowoff conditions. All accessory performance conditions shall be reported, including intercoolers, aftercoolers, and lubrication and control systems. The complete unit shall be factory tested with sound meters in accordance with ISO 2151. Location shall be one horizontal meter from unit at 1.5 meters above the floor. Test shall include readings at each octave band midpoint and the "A" scale, and shall be 84 dBA or less and 90 decibels at any octave band. Results of test shall be included in the factory test report on the ISO 2151 format. Factory test data may be corrected to the levels of an equivalent background noise level of 60 dBA showing calculations for reference use.

2.5.2 Supervision of Testing

System and components testing shall be conducted or supervised by either a designated authorized and factory trained representative of the compressor manufacturer supplying the unit or a registered Mechanical Engineer experienced in such work.

2.5.3 System Test

Testing of system shall conform to requirements outlined and shall be witnessed by the Contracting Officer.

2.5.4 Approval of Testing Procedure

Proposed testing procedure shall be approved by the Contracting Officer and the individual in charge of testing prior to conducting tests.

2.5.5 Certification of Performance Tests

The test supervisor shall certify performance by test to be in compliance with specifications.

PART 3 EXECUTION

3.1 INSTALLATION

The Contractor shall install the air compressors and accessories in accordance with manufacturer's recommendations and as indicated on the drawings. All equipment shall be installed plumb and level and anchored to structure, matching holes provided.

3.1.1 Manufacturer's Supervision

Install the compressors under the direct supervision of an authorized representative of the manufacturer.

3.2 GENERAL REQUIREMENTS FOR INSTALLING AIR COMPRESSORS

Air compressors with contract motor and accessories shall be factory assembled, run in, and tested complete before shipment to job site. [The Contractor is advised that there are limitations to door opening sizes and available crane lifting capacity. Crane unit is specified to permit single lifts of complete compressor under special approval only.] Should the unit require disassembly for installation, reassembly shall be under the direct supervision of the compressor manufacturer's authorized representative. Complete unit shall be mounted on a rigid single or equivalent mechanically joined steel or iron base. Submit installation sequence plans to the Contracting Officer for approval prior to installation. [Any building materials removed to accomplish installation shall be reinstalled if undamaged by removal procedures; or if damaged, shall be replaced with new materials to match original configuration.]

3.2.1 Prompt Installation

The Contractor is advised that any compressor received shall be installed and placed in operation promptly to prevent time deterioration when not installed. Should the Contractor sustain a delay exceeding 90 days prior to actual installation, the Contracting Officer shall have the option of requiring breakdown and reassembly to inspect and clean prior to placing in operation. This work shall be at no additional cost to the Government.

3.2.2 Start-Up Services

The Contractor shall furnish the services of a compressor manufacturer's authorized representative to supervise prestart checkout, initial start-up, performance testing, and operator instruction. Time available shall be as required to properly start up but not less than 3 consecutive days for the compressor.

3.3 FIELD QUALITY CONTROL

3.3.1 Field Test Procedures

Complete field performance testing of the total system shall be performed by the Contractor and witnessed by the Contracting Officer. Air compressor system tests shall be conducted by either a compressor manufacturer's factory trained and authorized representative approved by the Contracting Officer or a qualified registered Mechanical Engineer. Tests may be run on individual components or on the system as a whole at Contractor option. Field tests require use of the actual compressor drive motor. Test shall include operation at rated capacity for not less than 4 hours.

3.3.1.1 Air Compressor Performance Tests

Complete performance test shall be run at maximum load, rated load, at point of unload but prior to unload, and unloaded condition. Data shall be recorded listing:

a. Air flow, inlet pressure and temperature, humidity; discharge pressure and temperature.

b. Intercooler water flows, temperatures, and pressures.

c. Aftercooler water flow, temperatures, and pressures.

d. Lube oil cooling water flow, temperatures, and pressures.

e. Lube oil flow, pressures, and temperature.

f. Cooling water pump flow, pressures, and motor amperage.

g. [Cooling tower] [Closed circuit cooler] air flow, water and air temperatures, water pressure, and motor amperage.

h. Electrical load in volts and amperes for compressor motor, prelube oil pump motor, and compressor auxiliaries.

i. Intake filter pressure differential (clean).

j. Start-up sequence, alarm signals and automatic system shutdown.

k. Control sequence, either modulating or two step [in phase with the other air compressors and existing plant air].

l. Test compressor intake and discharge for conformance to CGA G-7.1. Compressor discharge shall show no increase in contaminants.

3.3.1.2 Instrumentation Test

The Contractor may use instrumentation provided in the contract and instrumentation provided by the Contractor to conduct the test. The testing procedure and instrumentation shall be submitted to the Contracting Officer for approval prior to conducting tests. The format of ASME PTC 10 is required. It is intended that a full field test be performed.However, in lieu of precise instrumentation, the Contractor may use certified cooling water pump curves [and [cooling tower] [closed circuit cooler] fan curves]. Shutdown signals shall be caused by throttling selected fluids. Test data, such as air intake temperature and humidity, shall be mathematically corrected to performance test requirement levels.

3.3.1.3 Sound Level Tests

Sound level tests shall be conducted concurrently. Broad Band "A" scale readings and Octave Band readings shall be taken and recorded at the same positions as on the factory testing. Maximum permissible level shall be 84 decibels one horizontal meter from the compressor and 1.5 meters above the floor, with unit in operation and all other significant equipment not required for test within the same building bay shutdown at the same location previously described. A background noise correction to 60 decibels is permissible.

3.3.1.4 Deficiencies Discovered in Testing

Any operational deficiencies noted in the tests shall be promptly corrected and affected portions of the test rerun.

3.3.1.5 Testing Tolerances

A tolerance of plus 2 percent minus zero on flow, plus or minus 4 percent on power, or plus or minus 5 percent on any other variable for each item of equipment or fluid with all others conforming is permissible on field test results when compared to factory test data and to guarantee performance data except that compressor air flow, discharge pressure, and motor power shall be met.

3.3.2 Approval of Testing Procedure

Proposed testing procedure shall be approved by the Contracting Officer and the individual in charge of testing prior to conducting tests.

3.4 TRAINING OF GOVERNMENT PERSONNEL

During start-up and field testing, train Government station personnel in the operation and maintenance of compressor, [cooling tower,] [closed circuit cooler,] associated equipment, and all control and safety devices. Training shall not commence until equipment is operational and station personnel are in attendance. At least one day of classroom training and one day of field training shall be furnished for each designated Government personnel. When factory training is required by the compressor manufacturer for proper maintenance and overhaul of the compressors, such training shall be furnished by the compressor manufacturer at no additional cost to the Government. The Government will bear the cost of travel and living expenses for Government personnel as necessary for the factory training.

-- End of Section --

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SECTION 22 31 00

WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE)
02/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C700	(2020) Cold-Water Meters - Displacement Type, Metal Alloy Main Case
AWWA C701	(2019) Cold-Water Meters - Turbine Type for Customer Service
AWWA D102	(2021) Coating Steel Water-Storage Tanks

ASTM INTERNATIONAL (ASTM)

ASTM A6/A6M	(2021) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A666	(2015) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B43	(2020) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D3299	(2010) Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
ASTM E100	(2017) Standard Specification for ASTM Hydrometers
ASTM E126	(2013a) Inspection and Verification of Hydrometers
ASTM F593	(2017) Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NSF INTERNATIONAL (NSF)

NSF/ANSI 61	(2020) Drinking Water System Components - Health Effects

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation

SD-03 Product Data

Softening Equipment

Spare Parts

Field Instructions

SD-06 Test Reports

Softening Equipment

Piping

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G

1.3 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.4 EXTRA MATERIALS

a. Submit spare parts data for each different item of material and equipment, after approval of the detail drawings and not later than 1 months prior to the date of beneficial occupancy. Include a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 year(s) of service.

b. Provide, for each type of equipment furnished, special tools necessary for adjustment, operation, maintenance, and disassembly; a grease gun or other lubricating device for each type of grease required; and one or more steel cases mounted on the wall complete with flat key locks, two keys, and clips or hooks to hold each tool in a convenient location. Provide tools consisting of high-grade, smooth, forged, alloy, tool steel. Provide lever type greas guns. Deliver tools at the same time as the equipment and hand over on completion of the work.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

a. Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Furnish equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

b. Pumps and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.2 SOFTENING EQUIPMENT

Provide softener battery consisting of water-softener units. Performance specified must refer to each unit and not to the battery as a whole. Submit a complete list of equipment and material, including manufacturer's descriptive and technical literature; performance charts and curves; catalog cuts; and installation instructions.

2.2.1 Equipment Capacity

Provide a fully automatic downflow pressure-type water softener, having a capacity to soften gallons of water with a maximum influent total hardness of milligrams per liter (mg/L) during the interval between successive regenerations, to a maximum effluent total hardness of mg/L. Intervals between successive generations must be hours.

2.2.2 Softener Tank

Provide softener tank that is a minimum of [_____] inches in diameter by [_____] inches straight shell (tangent line to tangent line). Construct tank of buttwelded steel conforming to the ASME BPVC SEC VIII D1. Design shell for a working pressure of [_____] psi. Line tank and both sides of false bottom with nontoxic epoxy or rubber conforming to AWWA D102 . Furnish coatings for potable water tanks conforming to NSF/ANSI 61. Provide the upper head of each tank with an access opening 4 inches by 6 inches or larger. Provide lower side shell of each tank with an access opening 4 by 6 inches or larger. Tank must have angle leg supports of cast-iron or steel.

2.2.3 Underdrain System

Provide a system within the softener tank for collecting softened water and distributing backwash water. Provide header-lateral-distributor head deflector-plate or false bottom type system. Provide underdrain system that distributes the backwash water uniformly over the entire filter area, and at such velocities that prevents the channeling of the filter bed.

2.2.3.1 Header-Lateral-Distributor Head Type

Provide header-lateral-distributor head type consisting of a central manifold or header, connected to laterals provided with strainer heads or strainers with openings placed radially so as to discharge horizontally or downward. Support system by a steel plate or steel angles conforming to ASTM A666 with rubber or nontoxic epoxy linings or by concrete fill or gravel bed or directly on the bottom of the tank. Where the system will permit the loss of the exchange material during the filtering cycle, provide a gravel bed with the system. Provide stainless steel bolts and attaching hardware conforming with ASTM F593. Provide headers and laterals consisting of all red brass, conforming to ASTM B43 or polyvinyl chloride, conforming to ASTM D1785 or ASTM D2241. Provide strainer heads and strainers manufactured of materials compatible with the header-lateral system, and brass or stainless steel. Laterals and strainer heads, after being placed, must not protrude into the header or laterals.

2.2.3.2 Deflector-Plate Type

Provide deflector-plate type consisting of cast-iron or steel, and rubber or nontoxic epoxy lined, fastened to the bottom of the tank, and arranged for discharge through radial slots. Provide pipe connection for softened water outlet or backwash inlet on the underside between the deflector and the tank bottom. Provide deflector-plate type collector system with a gravel bed.

2.2.3.3 False Bottom Type

Furnish false bottom type consisting of a false bottom with attached strainers. Provide strainers and fasteners that are brass or stainless steel. Design system to eliminate the need for a supporting gravel bed.

2.2.4 Gravel Bed

Place supporting bed above the underdrain systems. Provide gravel that is free from clay, loam, dirt, and calcareous or other foreign materials and free of flat or elongated particles. Properly graduate gravel bed to distribute the backwash water, to prevent loss of exchange materials, and to prevent migration of the material in the gravel bed during operation and backwashing. Gravel bed less than 9 inches in depth is not permitted. Where the void size of the top layer of gravel is greater than the smallest particle size of the exchange material, add a 3 inch layer of ilmenite or garnet sand to the gravel bed.

2.2.5 Exchange Material

Component	Concentration (mg/L)
Total Solids	[_____]
Total Dissolved Solids	[_____]
Calcium	[_____]
Sodium and Potassium	[_____]
Total Iron	[_____]
Ferric Iron	[_____]

Component	Concentration (mg/L)
Ferrous Iron	[_____]
Manganese	[_____]
Copper	[_____]
Silica	[_____]
Sulphate	[_____]
Chlorides	[_____]
Nitrates	[_____]
Alkalinity	[_____]
Methyl Orange as Calcium Carbonate	[_____]
Phenolphthalein as Calcium Carbonate	[_____]
Total Hardness as Calcium Carbonate	[_____]
Carbonate Hardness as Calcium Carbonate	[_____]
Noncarbonate Hardness as Calcium Carbonate	[_____]
Free Carbon Dioxide Calcium Carbonate	[_____]
Turbidity in Nethlometric Turbidity units	[_____]
Color by Platinum Standard Comparison	[_____]
Residual Chlorine	[_____]
Dissolved Oxygen	[_____]
Conductivity pH	[_____]

Provide styrene-resinous exchange material that is washed, processed, graded, and suitable for water softening purposes. Provide clean and hard granules, and provide material that is free from defects that affect the serviceability and appearance of the finished product. Do not dose or add any chemical mixture or solution to the water to be or to the water used for backwashing or regeneration other than sodium chloride, except for a cleaner additive recommended by the Exchange Material Manufacturer. Provide material conforming to the following:

a. Working exchange capacity not less than [_____] grains pcf.

b. Approximate shipping weight of [_____] pcf, backwashed and drained volume.

c. Effective size not less than [_____] millimeters.

d. Uniformity coefficient not greater than 2.0.

e. Not more than 1 percent by weight to pass 50-mesh US standard screen.

Bed depth less than 30 inches is not permitted. Do not exceed an application rate of 2 gpm per cubic foot of exchange material. Minimum freeboard above exchanger bed less than 50 percent of bed depth is not acceptable.

2.3 BRINE APPLICATION SYSTEM

Provide a brine application system, comprising one or two tanks, for each installation. Where two tanks are furnished, one tank must serve as a salt saturator tank, and the other as a brine tank. Single tank units must serve as a combined salt saturator and brine tank. Provide sufficient salt storage for three regeneration cycles or 24-hour operation, whichever is greater.

2.3.1 Tanks

Fabricate each saturator, brine or combined-purpose tank from steel conforming to ASTM A6/A6M not less than 3/16 inch thick, lined with enamel, or of fiber glass filament-wound reinforced plastic construction, conforming to ASTM D3299. Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING. Equip each tank with an underdrain system manufactured from polyvinyl chloride conforming to ASTM D1785 or ASTM D2241 or red brass conforming to ASTM B43 and provided with a layer of graded gravel or screens for filtering the brine. Furnish screens manufactured from polyvinyl chloride, brass, or stainless steel. Equip saturator tank or combined-purpose tank with a water inlet valve float-operated or solenoid-operated. Activate solenoid-operated valve by a probe or a float-operated switch or a timer together with a float switch to automatically shut off the incoming supply in the event of failure of the timing mechanism. Mount water inlet valves and switches externally. Floats and probes may be mounted internally or externally, in such a manner that the stored salt does not interfere with their operation. Fabricate all devices in contact with or subject to splashing of brine solution from red brass bronze or polyvinyl chloride.

2.3.2 Hydraulic System

Provide a hydraulic ejector or motor-driven centrifugal pump of all bronze construction with valves, piping, and connections for lifting brine from the brine or combined tank. Provide ejector and motor-driven pump with sufficient capacity to permit a 2 to 1 variation in the concentrated brine rate of flow. Equip hydraulic ejector system with a manual rate-set valve and a check valve on the suction side of the ejector. Where the brine tank or combination tank is emptied during each regeneration period, provide the suction side of the ejector system with a device to prevent the entrance of air into the system. Provide hydraulic ejector system capable of automatically flushing out the dilute brine piping system or completion of the brine cycle. Equip hydraulic pumping system with a manual rate-set valve, a check valve, and a brine measuring meter on the discharge of the pump. Provide brine measuring meter that is electrically interlocked with the pump starter so that after the discharge of a set quantity of brine, the pump motor shuts down. Set point must be infinitely adjustable over a 2 to 1 range. Use a mixing tee to mix dilution water with the concentrated brine. Control water inflow to the mixing tee by means of a manual rate-set valve. Automatically flush out the dilute brine piping system on completion of the brine regeneration cycle. Protect the dilution water supply from inflow of brine by means of back flow prevention device.

2.4 CONTROLS

2.4.1 Valves

Transfer water and brine solution to and from the water softener by a single-unit multiple-port valve or by a package-type valve nest for automatic operation. Design the valve mechanisms such that gradually increasing flows will be attained as ports are opened and initial surges and sudden inrushes of water or brine are avoided. Indicate each step of the operation using a dial pointer.

2.4.1.1 Multiple-Port Valve

Provide an assembly of nonsticking, nonleaking, water-lubricated valve ports that connect to the hard-water inlet, soft-water outlet, backwash inlet and outlet, and brine inlet, all enclosed in a single casing. Accomplish the various steps of operation service, backwash, brine flow, and rinse by the rotation of a shaft that drives the mechanism causing the opening and closing of ports in correct sequence.

2.4.1.2 Package-Type Valve

Provide package-type valve nest consisting of a pilot valve connected with fittings as may be required to each one of a nest of valves hydraulically or pneumatically operated. Provide connections to hard-water inlet, soft-water outlet, backwash inlet and outlet, and brine inlet.

2.4.2 Operation

Control of softener regeneration must be fully automatic initiated by a control switch connected to a water meter . Use fully automatic controls that permit regeneration to proceed automatically with no manual assistance other than replenishment of salt storage. Controls must be subject to convenient and accurate manual adjustment and must be designed for manual operation in the event of failure of the electrical equipment. Provide an interlocking system to prevent regeneration of more than one unit at a time.

2.5 ELECTRICAL WORK

Provide electrical motor-driven equipment specified complete with motors motor starters and controls. Provide motor starters complete with properly sized thermal overload protection and other appurtenances necessary for the motor specified. Perform electrical work as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices.

2.6 BOLTS, NUTS, AND FASTENERS

Furnish all bolts, anchor bolts, nuts, washers, plates, bolt sleeves, and all other types of supports necessary for the installation of the equipment with the equipment and galvanize unless otherwise indicated. Provide expansion bolts that have malleable-iron and lead composition elements. Unless otherwise specified, stud, tap, and machine bolts must be of refined bar iron. All threads must conform to ASME B1.1. Bolts, anchor bolts, nuts, and washers specified to be galvanized, must be zinc coated, after being threaded, by the hot-dip process in conformity with ASTM A123/A123M or ASTM A153/A153M. Provide Type 316 stainless steel bolts, anchor bolts, nuts, and washers specified to be stainless steel. Where indicated, specified, or required, provide anchor bolts with square plates at least 4 by 4 by 3/8 inch or with square heads and washers and be set in the concrete forms with suitable pipe sleeves.

2.7 AUXILIARY EQUIPMENT

2.7.1 Water Meter

Provide each softener with a displacement or turbine-type water meter reading in U.S. gallons, and conforming to AWWA C700 or AWWA C701 as appropriate. Equip meter with necessary wiring and electric controls for automatic regeneration when the softener has delivered [_____] gallons of water. Equip meter with necessary wiring and an alarm device to give notice when the unit has delivered [_____] gallons of water. Install meter in the soft-water line from the softener unit, and locate as to be readily accessible for reading and setting. Meter contacts must be infinitely adjustable over the range of the meter to permit setting to suit actual hardness of the water being treated.

2.7.2 Automatic Hardness Tester

Install a hardness tester for automatically testing the hardness of the water in the soft-water line leading from each softener unit. Provide wall mounted automatic hardness tester that is capable of carrying out intermittent tests on the softened water and of giving visual warning that the residual hardness present exceeds a predetermined limit. Equip tester with necessary wiring and [electrical controls for automatic regeneration] [an alarm device to give notice] when the hardness of the water delivered by the softener unit exceeds [_____] mg/1.

2.7.3 Electric Motors

Furnish motors that are single-phase, suitable for operation on 115-volt, single-phase, 60 cycle, alternating current conforming to NEMA MG 1. Design each motor for operation in a 40-degree C ambient temperature. Provide motor controls conforming to NEMA ICS 1.

2.7.4 Piping

Pipe Fabricate pipesmaller than 4 inches in diameter, excluding the underdrain and brine collection systems, from galvanized steel conforming to ASTM A53/A53M with malleable-iron fittings conforming to ASME B16.3. Pipe 4 inches in diameter and larger must be flanged ductile-iron conforming to AWWA C115/A21.15 with ductile-iron fittings conforming to AWWA C110/A21.10 and AWWA C111/A21.11. Use pipe hangers and supports conforming to MSS SP-58 on all 1-1/2 inch diameter or smaller pipe with runs longer than 7 feet, and on all 2 inch diameter or larger pipe with runs longer than 9 feet. Fabricate pipe hanger and supports from steel and space no more than 7 to 9 feet as applicable.

2.7.5 Valves and Unions

Provide bronze gate valves smaller than 4 inches with screwed ends, conforming to MSS SP-80 and valves 4 inches or larger consisting of iron body with flanged ends, conforming to MSS SP-70. Valves must open counterclockwise, and the operating wheel must have an arrow, cast in the metal, indicating the direction of opening. Provide unions conforming to ASME B16.39.

2.7.6 Gauges and Cocks

Furnish pressure gauges and sampling cocks on each softener unit connected to the hard-water inlet and soft-water outlet to indicate the pressure loss through the softener and its pipe, valve, and fitting assembly, and to sample the hard and soft water. Provide a sampling cock on the brine system which will permit sampling of the dilute brine solution. Gauges must be precision type with bronze Bourdon tube and phenolic case and an accuracy of plus or minus 1/2 percent conforming to ASME B40.100. Sampling cocks must be of brass, ground key, lever handle, faucet type.

2.7.7 Water and Brine Testing Equipment

Provide a complete water-testing set recommended by the manufacturer with the softener. Include complete instructions for conducting tests for hardness in accordance with AWWA 10084. Provide two Baume hydrometers conforming to ASTM E100 and ASTM E126, and calibrated for the range necessary for testing saturated brine solution and three glass cylinders of heat-resistant glass to hold sufficient brine for testing.

2.8 FACTORY PAINTING

Provide factory painting conforming to manufacturer's standard factory finish for the intended service.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Submit drawings showing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Sshow proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

3.2.1 Softener and Brine Tanks

Anchor softener and brine tanks to a concrete mat. Provide anchor brackets, anchor rods or straps to hold the tank to the anchors in the mat. Where concrete or gravel fill is provided for support of the header-lateral-distributor head, protect strainer heads and strainers while concrete or gravel fill is being placed.

3.2.2 Valves

Install valves as nearly as possible in the position indicated consistent with convenience of operating the hand wheel. Carefully erect and support all valves in their respective position free from all distortion and strain on appurtenances during handling and installation. Carefully inspect all material for defects in workmanship and material, and debris and foreign material cleaned out of valve openings and seats, all operating mechanisms operated to check their proper functioning, and all nuts and bolts checked for tightness. Repair or replace valves and other equipment which do not operate easily or are otherwise defective.

3.2.3 Pumps

Mount pump and motor on a common monoblock. Anchor the monoblock to a concrete mat. Provide anchor brackets, anchor rods, or straps to hold the monoblock to the anchors in the mat.

3.2.4 Piping

Install piping to accurate lines and grades and, where possible, parallel to building walls. Where temporary supports are used, they must be sufficiently rigid to prevent shifting or distortion of the pipe. Make provision for expansion where necessary. All piping must pitch toward low points, and make provision for draining these low points. Use a sufficient number of unions or flanges to allow for the dismantling of all water pipe, valves, and equipment. Peerform installation of piping including cleaning, cutting, threading and jointing, in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.3 MANUFACTURER'S SERVICES

3.3.1 Manufacturer's Representative

Provide services by a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. Supervise the installing, adjusting, and testing of equipment.

3.3.2 Field Training

Conduct training course for operating staff as designated by the Contracting Officer. The training period, for a total of 8 hours of normal working time, must start after the system is functionally completed but prior to final acceptance tests. Submit proposed diagrams, field instructions, and other sheets, prior to posting. Post framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, where directed. Prepare condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system in typed form, frame as specified above for the wiring and control diagrams and post beside the diagrams. Post the framed instructions before acceptance testing of the systems. Cover all of the items contained in the Operating and Maintenance Instructions. Submit 6 complete copies of operating instructions outlining the step-by-step procedures required for system startup, operation and shutdown. Include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operation features. Submit 6 complete copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include simplified wiring, layout, and control diagrams of the system as installed.

3.4 TESTING AND PERFORMANCE

After installation of the water softener, perform operating tests to assure that the water softener system operates properly. If any deficiencies are revealed during any tests, correct such deficiencies and reconduct the tests.

3.4.1 Softeners

Run each softener to exhaustion and regenerate it to full capacity in accordance with manufacturer's instructions before test is started. Put softener through a complete cycle of operation at a constant flow rate. During capacity test, the softened water must be wasted to the sewer if necessary to maintain the required flow rate. Determine the total grains of equivalent calcium carbonate removed by testing the hard water at such intervals that will give a representative calcium carbonate content.

a. After each run, regenerate the unit using salt brine delivered from the measuring tank in the amount called for by operating instructions. Near the end of the brine rinse and beginning of production of zero soft-water, take samples of the water every 2.5 minutes, read the meter, and record the reading. Titrate samples for chlorides, and consider zero soft-water production to begin when chlorides, as chloride radicals, are not in excess of 20 milligrams per liter above the chloride content of the hard-water. When the required number of gallons of hard water of specified hardness have been run through the softener, take a quart sample of the softened water and test.

b. Use the test results in determining the capacity and performance of the softener. Take a sample of hard-water and test in a similar manner. Make a complete log of each test run, giving the following data: date, time or readings, total water softened, and pounds of salt used per regeneration. Collect all samples in clean, glass-stoppered bottles. Thoroughly rinse bottles with water being sampled, and plainly mark all samples for identification.

c. Supply the salt required for regeneration of the exchange material after each of the above test runs. Under actual operating conditions the exchange material must not be washed out of the apparatus, the turbidity and color of the soft water must not exceed the turbidity and color of the hard water, and during any softening run, slugs of dirty or turbid water must not be delivered regardless of the change of demand rate up to the maximum on the apparatus. During the specified test of the softener, the soft-water sampling cock must remain open and a stream of softened water must be run through a rubber hose, discharging at the bottom of a wide mouth, 1 gallon glass jar or bottle set against a white background so that the color and turbidity may be under observation at all times. Amount of salt used for regeneration exceeding [_____] pounds per 1,000 grains hardness of equivalent calcium carbonate removed is not permitted.

3.4.2 Piping

After installation, test all pipelines for watertightness. For these tests furnish testing plugs or caps, all necessary pressure pumps, pipe connections, gauges, other equipment, and all labor required. Indicate test pressures in the process pipe schedule shown. Test joints of air lines using a soapy water solution to detect leaks. The obtaining of water, electric power and other utility items as well as the disposal of water drainage are also the responsibilities of Contractor. Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report must indicate the final position of controls.

3.5 FIELD PAINTING

Paint equipment which did not receive a factory finish as specified in Section 09 90 00 PAINTS AND COATINGS. Thoroughly clean factory painted items requiring touching up in the field of all foreign material and prime and top-coat with the manufacturer's standard factory finish.

-- End of Section --

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SECTION 23 01 30.41

HVAC SYSTEM CLEANING
05/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 62.1	(2019) Ventilation for Acceptable Indoor Air Quality

INSTITUTE OF INSPECTION, CLEANING, AND RESTORATION CERTIFICATION (IICRC)

ANSI/IICRC S520	(2015) Standard and Reference Guide for Professional Mold Remediation

NATIONAL AIR DUCT CLEANERS ASSOCIATION (NADCA)

NADCA	(2005) Introduction to HVAC System Cleaning Services
NADCA ACR	(2013) Standard for Assessment, Cleaning, and Restoration of HVAC Systems
NADCA ASCS	(2013) Air Systems Cleaning Specialist to the NADCA Standard ACR
NADCA HVAC Inspection Manual	(2021) Procedures for Assessing the Cleanliness of Commercial HVAC Systems

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)

NAIMA AH112	(1993) Cleaning Fibrous Glass or Lined Sheet Metal Ducts
NAIMA AH122	(2006) Cleaning Fibrous Insulated Duct Systems - Recommended Practices
NAIMA AH127	(1999) Facts About the Impact of Duct Cleaning on Internal Duct Insulation

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1966	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 402-C-01-001	(2001) IAQ Building Education and Assessment Tool (I-BEAM)
EPA 402-F-91-102	(1991) Building Air Quality: A Guide for Building Owners and Facility Managers

UNDERWRITERS LABORATORIES (UL)

UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 181A	(2013; Reprint Dec 2021) Standard for Safety Closure Systems for Use with Rigid Air Ducts
UL 181B	(2013; Reprint Dec 2021) UL Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors

1.2 DEFINITIONS

1.2.1 NADCA Standards

Perform the services specified here in accordance with the current published standards of the National Air Duct Cleaners Association (NADCA, NADCA ASCS,NADCA ACR and NADCA HVAC Inspection Manual).

a. All terms in this specification are defined as stated in the NADCA Standards.

b. Follow NADCA Standards without modification or deviation.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Record of Existing Conditions; G

Coordination Plan; G

NADCA Firm; G

NADCA Team Assistants; G

NADCA Air System Cleaning Specialist (ASCS); G

NADCA Supervisor Qualifications; G

Records of Experience in the Field of HVAC System Cleaning; G

NADCA Work Execution Schedule; G

SD-03 Product Data

Safety Data Sheets (SDS); G

SD-06 Test Reports

Testing Procedures Summary; G

Gravimetric Analysis; G

Post-Project Report; G

1.4 QUALITY CONTROL

1.4.1 NADCA Firm

Submit information certifying that the NADCA firm is a first tier subcontractor who is not affiliated with any other company participating in work on this contract, including furnishing equipment. Further, submit the following, for the firm, to Contracting Officer for approval:

a. Independent NADCA firm:

NADCA Firm: NADCA registration number and expiration date of current certification;

NADCA Supervisor Qualifications: Name and copy of NADCA supervisor certificate and expiration date of current certification.

NADCA Air System Cleaning Specialist (ASCS): Name and documented evidence that the team field leader has satisfactorily performed full-time supervision of HVAC cleaning work in the field for not less than 3 years immediately preceding this contract's bid opening date.

NADCA Team Assistants: Names and documented evidence that each field technician has satisfactorily assisted a NADCA team field leader in performance of HVAC cleaning work in the field for not less than one year immediately preceding this contract's bid opening date.

Current Certificates: Ensure registrations and certifications are current, and valid for the duration of this contract. Renew Certifications which expire prior to completion of the HVAC cleaning work, in a timely manner so that there is no lapse in registration or certification. NADCA agency or NADCA team personnel without a current registration or current certification are not to perform HVAC cleaning work on this contract.

b. TAB Team Members: NADCA team approved to accomplish work on this contract are full-time employees of the NADCA firm. No other personnel is allowed to do HVAC cleaning work on this contract.

c. Replacement of NADCA Team Members: Replacement of members may occur if each new member complies with the applicable personnel qualifications and each is approved by the Contracting Officer.

1.4.2 Experience

Submit records of experience in the field of HVAC system cleaning. Bids will only be considered from firms which are regularly engaged in HVAC system maintenance with an emphasis on HVAC system cleaning and decontamination.

1.4.3 Equipment, Materials and Labor

Possess and furnish all necessary equipment, materials and labor to adequately perform the specified services and comply with the applicable provisions of NADCA General Specifications for the Cleaning of Commercial HVAC Systems and ASHRAE 62.1.

a. Assure that all employees have received safety equipment training, medical surveillance programs, individual health protection measures, and manufacturer's product and Safety Data Sheets (SDS) as required for the work by the U.S. Occupational Safety and Health Administration, and as described by this specification. For work performed in countries outside of the U.S.A., comply with applicable national safety codes and standards.

b. Maintain a copy of all current SDS documentation and safety certifications at the site at all times, as well as comply with all other site documentation requirements of applicable OSHA programs and this specification.

c. Submit all Safety Data Sheets (SDS) for all chemical products proposed used in the cleaning process, including all VOC ratings.

1.4.4 Licensing

Provide proof of maintaining the proper license(s), if any, as required to do work in the state of Georgia. Comply with all Federal, State and local rules, regulations, and licensing requirements.

1.4.5 Health And Safety

1.4.5.1 Safety Standards

Comply with all applicable Federal, State, and local requirements for protecting the safety of the contractors' employees, building occupants, and the environment. In particular, follow all applicable standards of the Occupational Safety and Health Administration (OSHA) when working in accordance with this specification, and EM 385-1-1.

1.4.5.2 Occupant Safety

Employ no processes or materials in such a manner that introduce additional hazards into occupied spaces.

1.4.5.3 Disposal of Debris

Dispose of all debris removed from the HVAC System in accordance with applicable Federal, State and local requirements.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Mechanical Drawings

Obtain one copy of the following documents:

a. Project drawings and specifications

b. Approved construction revisions pertaining to the HVAC system

c. Any existing indoor air quality (IAQ) assessments or environmental reports prepared for the facility.

Submit a NADCA Work Execution Schedule to the Contracting Officer within 10 working days of the contract award.

1.5.2 Site Conditions

The HVAC system includes any interior surface of the facility's air distribution system for conditioned spaces and/or occupied zones. This includes the entire heating, air-conditioning and ventilation system from the points where the air enters the system to the points where the air is discharged from the system. The return air grilles, return air ducts (except ceiling plenums and mechanical room) to the air handling unit (AHU), the interior surfaces of the AHU, mixing box, coil compartment, condensate drain pans, humidifiers and dehumidifiers, supply air ducts, fans, fan housing, fan blades, air wash systems, spray eliminators, turning vanes, filters, filter housings, reheat coils, and supply diffusers are all considered part of the HVAC system. The HVAC system may also include other components such as dedicated exhaust and ventilation components and make-up air systems.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Perform the services specified here in accordance with the current published standards of the National Air Duct Cleaners Association (NADCA, NADCA ASCS,NADCA ACR and NADCA HVAC Inspection Manual).

a. All terms in this specification have their meaning defined as stated in the NADCA Standards.

b. Follow NADCA Standards with no modifications or deviations being allowed. Remove visible surface contaminants and deposits from within the HVAC system in strict accordance with these specifications.

3.1 PREPARATION

3.1.1 HVAC System Inspections And Site Preparations

3.1.1.1 HVAC System Evaluation

Prior to the commencement of any cleaning work, perform a visual inspection of the HVAC system in the presence of the Contracting Officer to determine appropriate methods, tools, and equipment required to satisfactorily complete this project. Cleanliness inspection should include air handling units and representative areas of HVAC system components and ductwork. In HVAC systems that include multiple air handling units, a representative sample of units should be inspected. Notify the Contracting Officer 10 days prior to the planned inspection. As part of evaluation, record photographs and videos of each inspection location to document the "as found" condition prior to cleaning.

Document damaged system components found during the inspection and submit to the Contracting Officer, clearly labeled "Record of Existing Conditions."

3.1.1.2 Site Evaluation and Preparations

HVAC System Evaluation shall be conducted without negatively impacting indoor environment through excessive disruption of settled dust, microbial amplification or other debris. In cases where contamination is suspected, and/or in sensitive environments where even small amounts of contaminant may be of concern, implement environmental engineering control measures.

Conduct a site evaluation, and establish a specific, coordination plan which details how each area of the building is protected during the various phases of the project.

3.2 APPLICATION

3.2.1 General HVAC System Cleaning Requirements

3.2.1.1 Containment

Collect debris removed during cleaning and take precautions to ensure that debris is not otherwise dispersed outside the HVAC system during the cleaning process.

3.2.1.2 Particulate Collection

Where the Particulate Collection Equipment (PCE) is exhausting inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or greater). When the PCE is exhausting outside the building, undertake mechanical cleaning operations only with PCE, including adequate filtration to contain debris removed from the HVAC system. When the PCE is exhausting outside the building, take precautions to locate the equipment down wind and away from all air intakes and other points of entry into the building.

3.2.1.3 Controlling Odors

Take all reasonable measures to control offensive odors and/or mist vapors during the cleaning process.

3.2.1.4 Component Cleaning

Employ cleaning methods such that all HVAC system components are Visibly Clean as defined in applicable standards. Upon completion, return all components to those settings recorded just prior to cleaning operations.

3.2.1.5 Air-Volume Control Devices

Mark the position of dampers and any air-directional mechanical devices inside the HVAC system prior to cleaning and, upon completion, restore to their marked position.

3.2.1.6 Service Openings

Utilize service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry, and inspection. Utilize the existing service openings already installed in the HVAC system where possible.

Create other openings where needed, created and resealed in conformance with NADCA Standard 05. Place closures so they do not significantly hinder, restrict, alter the air-flow within the system, or compromise the structural integrity of the system. Properly insulate closures to prevent heat loss/gain or condensation on surfaces within the system. Conform construction techniques used in the creation of openings to requirements of applicable building and fire codes, and applicable NFPA, SMACNA and NADCA Standards. Cutting service openings into flexible duct is not permitted. Disconnect flexible duct at the ends as needed for proper cleaning and inspection.

Reseal rigid fiber glass ductboard duct systems in accordance with NAIMA recommended practices; NAIMA AH112, NAIMA AH122, and NAIMA AH127. Only closure techniques which comply with UL 181, UL 181A, or UL 181B are suitable for fiber glass duct system closures.

Provide access doors for openings that need to be re-opened for future inspection or remediation. Refer to Section 23 31 13.00 40 - Metal Ducts for access doors. Clearly mark all service openings, capable of being re-opened for future inspection or remediation, and report their location in project report documents.

3.2.1.7 Ceiling Sections (Tile)

Carefully remove and reinstall ceiling sections to gain access to HVAC systems during the cleaning process. Replace any damaged ceiling sections caused by the removal at no cost to the Government.

3.2.1.8 Air Distribution Devices (Registers, Grilles and Diffusers)

Clean all air distribution devices.

3.2.1.9 Air Handling Units, Terminal Units, Blowers and Exhaust Fans

Ensure that supply, return, and exhaust fans and blowers are thoroughly cleaned. Areas for cleaning include blowers, fan housings, plenums (except ceiling supply and return plenums), scrolls, blades, or vanes, shafts, baffles, dampers and drive assemblies. Remove all visible surface contamination deposits in accordance with NADCA Standards.

a. Clean all air handling unit (AHU) internal surfaces, components and condensate collectors and drains.

b. Assure that a suitable operative drainage system is in place prior to beginning wash down procedures.

c. Clean all coils and related components, including evaporator fins.

3.2.1.10 Duct Systems

a. Create service openings in the system as necessary in order to accommodate cleaning of otherwise inaccessible areas.

b. Mechanically clean all duct systems to remove all visible contaminants, such that the systems are capable of passing NADCA Cleaning Verification Testings Standards.

c. Any exposed edges in internal duct lining within duct, including but not limited to interfaces with externally insulated duct, shall be fully protected, sealed and encapsulated to prevent future erosion.

3.2.2 Mechanical Cleaning Methodology

3.2.2.1 Source Removal Cleaning Methods

Clean the HVAC system using Source Removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and safely remove contaminants from the facility. Select Source Removal methods which will render the HVAC System Visibly Clean and capable of passing NADCA cleaning verification methods Standards and other specified standards and tests, in accordance with all general requirements. Use no cleaning method, or combination of methods, which could potentially damage components of the HVAC system or negatively alter the integrity of the system.

Incorporate the use of vacuum collection devices that are operated continuously during cleaning for all methods used. Connect a vacuum device to the downstream end of the section being cleaned through a predetermined opening. Use a vacuum collection device of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment is assured.

Equip all vacuum devices exhausting air inside the building, including hand-held vacuums and wet-vacuums, with HEPA filters (minimum efficiency).

Equip all vacuum devices exhausting air outside the facility with Particulate Collection including adequate filtration to contain Debris removed from the HVAC system, in a manner that does not allow contaminants to re-enter the facility. Release of debris outdoors which violates any outdoor environmental standards, codes or regulations is not allowed.

All methods require mechanical agitation devices to dislodge debris adhered to interior HVAC system surfaces, such that debris may be safely conveyed to vacuum collection devices. Acceptable methods include those which will not potentially damage the integrity of the ductwork, nor damage porous surface materials such as liners inside the ductwork or system components.

3.2.2.2 Methods of Cleaning Fibrous Glass Insulated Components

Thoroughly clean glass thermal insulation elements present in any equipment or ductwork with HEPA vacuuming equipment. Clean while the HVAC system is under constant negative pressure, and not permitted to get wet in accordance with applicable NADCA and NAIMA standards and recommendations.

Do not use cleaning methods that cause damage to fibrous glass components or renders the system capable of passing Cleaning Verification Tests NADCA Standards.

Provide surface treatment for insulation for sections of internally-lined duct. Select and apply encapsulants, coatings, and insulation repair products to completely restore surface integrity of fibrous glass surfaces in accordance with applicable standards and manufacturer's installation instructions.

3.2.2.3 Damaged Fibrous Glass Material

If there is any evidence of damage, deterioration, delamination, friable material, mold or fungus growth, or moisture such that fibrous glass materials cannot be restored by cleaning or resurfacing with an acceptable insulation repair coating, identify them to the Contracting Officer for replacement.

When requested or specified, remediate exposed damaged insulation in air handlers and/or ductwork requiring replacement.

If insulation is damaged as a result of this work under this specification, notify Contracting Officer and initiate a meeting with same to determine options for repair or replacement of insulation.

3.2.2.4 Replacement Material

If replacement of fiber glass materials is required, conform all materials to applicable industry codes and standards, including those of UL and SMACNA 1966.

Replacement of damaged insulation is **not** covered by this specification. Refer to Section 23 07 00 - Thermal Insulation for Mechanical Systems.

3.2.2.5 Cleaning of Coils

Use any cleaning method which renders the coil visibly clean and capable of passing NADCA Coil Cleaning Verification Standards. Coil drain pans are subject to Non-Porous Surfaces Cleaning Verification. Maintain operability of the drain for the condensate at all times. Do not damage, displace, inhibit heat transfer, or cause erosion of the coil surface or fins, and conform to coil manufacturer recommendations when available. Thoroughly rinse coils with clean water to remove any latent residues.

3.2.2.6 Antimicrobial Agents and Coatings

Perform application of antimicrobial agents used to control the growth of fungal or bacteriological contaminants after the removal of surface deposits and debris. Perform mold remediation in accordance with ANSI/IICRC S520.

Use only antimicrobial agents registered by the U.S. Environmental Protection Agency (EPA 402-F-91-102)(EPA 402-C-01-001) specifically for use within HVAC system.

Apply antimicrobial agents in strict accordance with manufacturer's instructions.

Use only antimicrobial coating products, for both porous and non-porous surfaces, which are EPA registered, water soluble solutions with supporting efficacy data and SDS records.

Apply antimicrobial coatings according to manufacturer's instructions. Spray coatings directly onto interior ductwork surfaces, rather than "fog" downstream onto surfaces. Achieve a continuous film on the surface treated by the coating application, and apply in strict accordance with manufacturer's minimum millage surface application rate standards for effectiveness.

3.3 FIELD QUALITY CONTROL

3.3.1 CLEANLINESS VERIFICATION

3.3.1.1 General

Verification of HVAC System cleanliness is determined after mechanical cleaning and before the application of any treatment or introduction of any treatment-related substance to the HVAC system, including antimicrobial agents and coatings.

3.3.1.2 Visual Inspection

Visually inspect the HVAC system to ensure that no visible contaminants are present.

If no contaminants are evident through visual inspection, consider the HVAC system clean; however, further verification of the system cleanliness through gravimetric or wipe testing analysis testing may be requested at the discretion of the Contracting Officer.

If visible contaminants are evident through visual inspection, re-clean those portions of the system where contaminants are visible, and subject to re-inspection for cleanliness.

As part of inspection, record photographs and videos of inspection locations to document post-cleaning condition.

3.3.1.3 Gravimetric Analysis

At the expense of the **Contractor**, test sections of the HVAC system for cleanliness using the NADCA Vacuum Test (gravimetric analysis) as specified in applicable NADCA Standards. Ensure levels of debris collected are equal to or less than acceptable levels defined in applicable NADCA Standards.

If gravimetric analysis determines that levels of debris are equal to or lower than those levels specified, the system is considered clean and to have passed cleanliness verification.

If gravimetric analysis determines that levels of debris exceed those specified in applicable NADCA standards, the system will not be considered clean, and re-cleaning of those sections of the system which failed cleanliness verification will be required at the expense of the HVAC system cleaning contractor.

Perform cleanliness verification immediately after mechanical cleaning and before the HVAC system is restored to normal operation.

3.3.1.4 Verification of Coil Cleaning

Cleaning is to restore the coil pressure drop to within 10 percent of the pressure drop measured when the coil was first installed. If the original pressure drop is not known, the coil will be considered clean only if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection (see NADCA HVAC Inspection Manual Standards).

3.3.2 Post-Project Report

At the conclusion of the project, provide a Testing Procedures Summary and Post-Project Report indicating the following:

a. Success of the cleaning project, as verified through visual inspection andor gravimetric analysis.

b. Areas of the system found to be damaged and/or in need of repair.

-- End of Section --

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SECTION 23 03 00.00 20

BASIC MECHANICAL MATERIALS AND METHODS
08/10, CHG 3: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

1.2 RELATED REQUIREMENTS

This section applies to all sections of Divisions: 21, FIRE SUPPRESSION; 22, PLUMBING; and 23, HEATING, VENTILATING, AND AIR CONDITIONING of this project specification, unless specified otherwise in the individual section.

1.3 QUALITY ASSURANCE

1.3.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.2 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.3 Service Support

The equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.4 Manufacturer's Nameplate

For each item of equipment, provide a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.3.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions must be considered mandatory, the word "should" is interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" must be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" must be interpreted to mean the "lessor." References to the "permit holder" must be interpreted to mean the "Contractor."

1.3.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 ELECTRICAL REQUIREMENTS

Furnish motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors must conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors shall have a maximum of 120 volt control circuits, and must have auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work must be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment must be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.6 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work.

Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished must be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.7 ACCESSIBILITY

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 PAINTING OF NEW EQUIPMENT

New equipment painting must be factory applied or shop applied, and must be as specified herein, and provided under each individual section.

3.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system must be designed for the temperature service.

3.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F must be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat must be aluminum or light gray.

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F must receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of 1 mil; and two coats of enamel applied to a minimum dry film thickness of 1 mil per coat.

b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F must receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F must receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

-- End of Section --

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC
11/15

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.4 (1983; Amendment 1985; R 2006) Specification for Sound Level Meters (ASA 47)

ASA S1.11 PART 1 (2014) American National Standard Electroacoustics – Octave-Band and Fractional-Octave-Band Filters – Part 1: Specifications

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 203 (1990; R 2011) Field Performance Measurements of Fan Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 62.1 (2019) Ventilation for Acceptable Indoor Air Quality

ASHRAE HVAC APP IP HDBK (2016) HVAC Applications Handbook, I-P Edition

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1 (2002; 6th ed) National Standards for Total System Balance

AABC MN-4 (1996) Test and Balance Procedures

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE (2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB MASV (2006) Procedural Standards for Measurements and Assessment of Sound and Vibration

NEBB PROCEDURAL STANDARDS (2015) Procedural Standards for TAB (Testing, Adjusting and Balancing)

Environmental Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition
SMACNA 1858	(2004) HVAC Sound And Vibration Manual - First Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82	Protection of Stratospheric Ozone

1.2 DEFINITIONS

a. AABC: Associated Air Balance Council

b. COTR: Contracting Officer's Technical Representative

c. DALT: Duct air leakage test

d. DALT'd: Duct air leakage tested

e. HVAC: Heating, ventilating, and air conditioning; or heating, ventilating, and cooling

f. NEBB: National Environmental Balancing Bureau

g. Out-of-tolerance data: Pertains only to field acceptance testing of Final DALT or TAB report. When applied to DALT work, this phase means "a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction and sealant class.""a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by Appendix D REQUIREMENTS FOR DUCT AIR LEAK TESTING." When applied to TAB work this phase means "a measurement taken during TAB field acceptance testing which does not fall within the range of plus 5 to minus 5 percent of the original measurement reported on the TAB Report for a specific parameter."

h. Season of maximum heating load: The time of year when the outdoor temperature at the project site remains within plus or minus 30 degrees Fahrenheit of the project site's winter outdoor design temperature, throughout the period of TAB data recording.

i. Season of maximum cooling load: The time of year when the outdoor temperature at the project site remains within plus or minus 5 degrees Fahrenheit of the project site's summer outdoor design temperature, throughout the period of TAB data recording.

j. Season 1, Season 2: Depending upon when the project HVAC is completed and ready for TAB, Season 1 is defined, thereby defining Season 2. Season 1 could be the season of maximum heating load, or the season of maximum cooling load.

k. Sound measurements terminology: Defined in AABC MN-1, NEBB MASV, or SMACNA 1858 (TABB).

l. TAB: Testing, adjusting, and balancing (of HVAC systems)

m. TAB'd: HVAC Testing/Adjusting/Balancing procedures performed

n. TAB Agency: TAB Firm

o. TAB team field leader: TAB team field leader

p. TAB team supervisor: TAB team engineer

q. TAB team technicians: TAB team assistants

o. TAB team field leader: TAB team field leader

p. TAB team supervisor: TAB team engineer

q. TAB team technicians: TAB team assistants

r. TABB: Testing Adjusting and Balancing Bureau

1.2.1 Similar Terms

In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results.

The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS			
Contract Term	AABC Term	NEBB Term	TABB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems	International Standards for Environmental Systems Balance
TAB Specialist	TAB Engineer	TAB Supervisor	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures	Field Readiness Check & Prelim. Field Procedures

1.3 WORK DESCRIPTION

The work includes duct air leakage testing (DALT) and testing, adjusting, and balancing (TAB) of new and existing heating, ventilating, and cooling (HVAC) air and water distribution systems including equipment and performance data, ducts, and piping which are located within, on, under, between, and adjacent to buildings, including records of existing conditions.

Perform TAB in accordance with the requirements of the TAB procedural standard recommended by the TAB trade association that approved the TAB Firm's qualifications. Comply with requirements of AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 (TABB) as supplemented and modified by this specification section. All recommendations and suggested practices contained in the TAB procedural standards are considered mandatory.

Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct DALT testing in compliance with the requirements specified in SMACNA 1972 CD, except as supplemented and modified by this section. Conduct DALT and TAB work in accordance with the requirements of this section.

1.3.1 Air Distribution Systems

Test, adjust, and balance systems (TAB) in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to exterior of air distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.2 Water Distribution Systems

TAB systems in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to water distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. At Contractor's option and with Contracting Officer's written approval, the piping systems may be insulated before systems are TAB'd.

Terminate piping insulation immediately adjacent to each flow control valve, automatic control valve, or device. Seal the ends of pipe insulation and the space between ends of pipe insulation and piping, with waterproof vapor barrier coating.

After completion of work under this section, insulate the flow control valves and devices as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.3 TAB SCHEMATIC DRAWINGS

Show the following information on TAB Schematic Drawings:

1. A unique number or mark for each piece of equipment or terminal.

2. Air quantities at air terminals.

3. Air quantities and temperatures in air handling unit schedules.

4. Water quantities and temperatures in thermal energy transfer equipment schedules.

5. Water quantities and heads in pump schedules.

6. Water flow measurement fittings and balancing fittings.

7. Ductwork Construction and Leakage Testing Table that defines the DALT test requirements, including each applicable HVAC duct system ID or mark, duct pressure class, duct seal class, and duct leakage test pressure. This table is included in the file for Graphics for Unified Facilities Guide Specifications: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graph

The Testing, Adjusting, and Balancing (TAB) Specialist must review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the effective and accurate TAB of the system, including records of existing conditions, and systems readiness check. The TAB Specialist must provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.The Testing, Adjusting, and Balancing (TAB) Specialist must review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the effective and accurate TAB of the system, including records of existing conditions, and systems readiness check. The TAB Specialist must provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

Submit three copies of the TAB Schematic Drawings and Report Forms to the Contracting Officer, no later than 21 days prior to the start of TAB field measurements.

1.3.4 Related Requirements

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

Specific requirements relating to Reliability Centered Maintenance (RCM) principals and Predictive Testing and Inspection (PTI), by the construction contractor to detect latent manufacturing and installation defects must be followed as part of the Contractor's Quality Control program. Refer to the paragraph SUSTAINABILITY for detailed requirements.
Requirements for price breakdown of HVAC TAB work are specified in Section 01 20 00 PRICE AND PAYMENT PROCEDURES.

Requirements for construction scheduling related to HVAC TAB work are specified in Section 01 32 17.00 20 COST LOADED NETWORK ANALYSIS SCHEDULES (NAS).

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Records of Existing Conditions; G

Independent TAB Agency and Personnel Qualifications; G

TAB Design Review Report; G

TAB Firm; G

Designation of TAB Team Assistants; G

Designation of TAB Team Engineer; G or TAB Specialist; G

Designation of TAB Team Field Leader; G

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms; G

SD-03 Product Data

Equipment and Performance Data; G

TAB Related HVAC Submittals; G

A list of the TAB Related HVAC Submittals, no later than 7 days after the approval of the TAB team engineer and assistant.

TAB Procedures; G

Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.

Calibration; G

Systems Readiness Check; G

TAB Execution; G

TAB Verification; G

SD-06 Test Reports

Completed Pre-Final DALT Report; G

Certified Final DALT Report; G

Prerequisite HVAC Work Checkout List For Proportional Balancing; G

Certified Final TAB Report for Proportional Balancing; G

Prerequisite HVAC Work Checkout List For Season 1; G

Certified Final TAB Report for Season 1; G

Prerequisite HVAC Work Checkout List For Season 2; G

Certified Final TAB Report for Season 2; G
TAB Design Review Report; G

TAB Report for Season 1; G

TAB Report for Season 2; G

SD-07 Certificates

Independent TAB Agency and Personnel Qualifications; G

DALT and TAB Submittal and Work Schedule; G

TAB Pre-Field Engineering Report; G

Instrument Calibration Certificates; G

DALT and TAB Procedures Summary; G

Completed Pre-Final DALT Work Checklist; G

Advance Notice of Pre-Final DALT Field Work; G

Advance Notice of TAB Field Work for Proportional Balancing; G

Advance Notice of TAB Field Work for Season 1; G

Advance Notice of TAB Field Work for Season 2 G

TAB Firm; G

Design Review Report; G

[Pre-field DALT Preliminary Notification; G

] Advanced Notice for TAB Field Work; G

Prerequisite HVAC Work Check Out List ; G

1.5 QUALITY ASSURANCE

1.5.1 Independent TAB Agency and Personnel Qualifications

To secure approval for the proposed agency, submit information certifying that the TAB agency is a first tier subcontractor who is not affiliated with any other company participating in work on this contract, including design, furnishing equipment, or construction. Further, submit the following, for the agency, to Contracting Officer for approval:

a. Independent AABC or NEBB or TABB TAB agency:

TAB agency: AABC registration number and expiration date of current certification; or NEBB certification number and expiration date of current certification; or TABB certification number and expiration date of current certification.

TAB team supervisor: Name and copy of AABC or NEBB or TABB TAB supervisor certificate and expiration date of current certification.

TAB team field leader: Name and documented evidence that the team field leader has satisfactorily performed full-time supervision of TAB work in the field for not less than 3 years immediately preceding this contract's bid opening date.

TAB team field technicians: Names and documented evidence that each field technician has satisfactorily assisted a TAB team field leader in performance of TAB work in the field for not less than one year immediately preceding this contract's bid opening date.

Current certificates: Registrations and certifications are current, and valid for the duration of this contract. Renew Certifications which expire prior to completion of the TAB work, in a timely manner so that there is no lapse in registration or certification. TAB agency or TAB team personnel without a current registration or current certification are not to perform TAB work on this contract.

b. TAB Team Members: TAB team approved to accomplish work on this contract are full-time employees of the TAB agency. No other personnel is allowed to do TAB work on this contract.

c. Replacement of TAB team members: Replacement of members may occur if each new member complies with the applicable personnel qualifications and each is approved by the Contracting Officer.

1.5.1.1 TAB Standard

Perform TAB in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard are considered mandatory. Use the provisions of the TAB Standard, including checklists, report forms, etc., as nearly as practical, to satisfy the Contract requirements. Use the TAB Standard for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, adhere to the manufacturer's recommendations.

All quality assurance provisions of the TAB Standard such as performance guarantees are part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures must be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements are considered mandatory, including the latest requirements of ASHRAE 62.1.

1.5.1.2 Qualifications

a. TAB Firm

The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including building systems commissioning .

Certification must be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor must immediately notify the Contracting Officer and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding

Contract Award is not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm will be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor.

These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm must be a prime subcontractor of the Contractor and be financially and corporately independent of the mechanical subcontractor, reporting directly to and paid by the Contractor.

b. TAB Specialist

The TAB Specialist must be either a member of AABC,an experienced technician of the Firm certified by the NEBB, or a Supervisor certified by the TABB. The certification must be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, immediately notify the Contracting Officer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist will be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

c. TAB Specialist Responsiblities

TAB Specialist responsibilities include all TAB work specified herein and in related sections under his direct guidance. The TAB specialist is required to be onsite on a daily basis to direct TAB efforts. The TAB Specialist must participate in the commissioning process.

1.5.1.3 TAB Related HVAC Submittals

The TAB Specialist must prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. Accompany the submittals identified on this list with a letter of approval signed and dated by the TAB Specialist when submitted to the Government. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

1.5.2 Responsibilities

The Contractor is responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate TAB execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule listed in the paragraph TAB SUBMITTAL AND WORK SCHEDULE.

1.5.2.1 Contractor

a. TAB personnel: Ensure that the DALT work and the TAB work is accomplished by a group meeting the requirements specified in the paragraph TAB PERSONNEL QUALIFICATION REQUIREMENTS.

b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor, and ensure that a representative is present for the sheetmetal contractor, mechanical contractor, electrical contractor, and automatic temperature controls contractor.

c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:

(1) Contract drawings and specifications

(2) Approved submittal data for equipment

(3) Construction work schedule

(4) Up-to-date revisions and change orders for the previously listed items

d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in the paragraph TAB SUBMITTAL AND WORK SCHEDULE is met.

e. Coordination of supporting personnel:

Provide the technical personnel, such as factory representatives or HVAC controls installer required by the TAB field team to support the DALT and the TAB field measurement work.

Provide equipment mechanics to operate HVAC equipment and ductwork mechanics to provide the field designated test ports to enable TAB field team to accomplish the DALT and the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team, and cause no delay in the DALT and the TAB field work.

Conversely, ensure that the HVAC controls installer has required support from the TAB team field leader to complete the controls check out.

f. Deficiencies: Ensure that the TAB Agency supervisor submits all Design/Construction deficiency notifications directly to the Contracting officer within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.

g. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.

h. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all of the following are completed.

(1) HVAC system installations are fully complete.

(2) HVAC prerequisite checkout work lists specified in the paragraph PRE-FIELD TAB ENGINEERING REPORT are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved prerequisite HVAC work checklist.

(3) DALT field checks for all systems are completed.

(4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.

i. Advance notice: Furnish to the Contracting Officer with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.

j. Insulation work: For required DALT work , ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed and sealed.

1.5.2.2 TAB Agency

Provide the services of a TAB team which complies with the requirements of the paragraph INDEPENDENT TAB AGENCY PERSONNEL QUALIFICATIONS. The work to be performed by the TAB agency is limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section.

1.5.2.3 TAB Team Supervisor

a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.

b. Pre-DALT/TAB meeting: Attend meeting with Contractor.

c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.

d. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report, the during the DALT or TAB field work.

e. Pre-field DALT preliminary notification: Monitor the completion of the duct installation of each system and provide the necessary written notification to the Contracting Officer.

f. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.

g. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.

h. Technical assistance for DALT work.

(1) Technical assistance: Provide immediate technical assistance to TAB field team.

(2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report. Conduct the site visit full-time for a minimum of one 8 hour workday duration.

i. Final DALT report: Certify the DALT report. This certification includes the following work:

(1) Review: Review the Pre-final DALT report data. From these field reports, prepare the Certified Final DALT report.

(2) TAB Verification: Verify adherence, by the TAB field team, to the procedures specified in this section.

j. Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.

(1) TAB field visit: Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of one 8 hour workday duration. Review the TAB final report data and certify the TAB final report.

k. Certified TAB report: Certify the TAB report. This certification includes the following work:

(1) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.

(2) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.

l. Design/Construction deficiencies: Within 3 working days after the TAB Agency has encountered any design or construction deficiencies, the TAB Supervisor must submit written notification directly to the Contracting Officer, with a separate copy to the Contractor, of all such deficiencies. Provide in this submittal a complete explanation, including supporting documentation, detailing deficiencies. Where deficiencies are encountered that are believed to adversely impact successful completion of TAB, the TAB Agency must issue notice and request direction in the notification submittal.

m. TAB Field Check: The TAB team supervisor must attend and supervise TAB field check.

1.5.2.4 TAB Team Field Leader

a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.

b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.

c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC Checklist, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

1.5.3 Project/Site Conditions

1.5.3.1 DALT and TAB Services to Obtain Existing Conditions

Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct this DALT and TAB work in accordance with the requirements of this section.

1.5.4 Sequencing and Scheduling

1.5.4.1 Projects with Phased Construction

This specification section is structured as though the HVAC construction, and thereby the TAB work, will be completed in a single phase. When the construction is completed in phases, the DALT work and TAB work must be planned, completed, and accepted for each construction phase.

a. Phasing of Work

This specification section is structured as though the HVAC construction, and thereby the TAB work, is going to be completed in a single phase. All elements of the TAB work are addressed on this premise. When a contract is to be completed in construction phases, including the TAB work, and the DALT work, the TAB work and DALT work must be planned for, completed and approved by the Contracting Officer with each phase. An example of this case would be one contract that requires the rehabilitation of the HVAC in each of several separated buildings. At the completion of the final phase, compile all approved reports and submit as one document.

1.5.4.2 DALT and TAB Submittal and Work Schedule

Comply with additional requirements specified in Appendix C: DALT AND TAB SUBMITTAL AND WORK SCHEDULE included at the end of this section.

Submit this schedule,and TAB Schematic Drawings, adapted for this particular contract, to the Contracting Officer (CO) for review and approval. Include with the submittal the planned calendar dates for each submittal or work item. Resubmit an updated version for CO approval every 90 calendar days. Compliance with the following schedule is the Contractor's responsibility.

a. TAB Design Review Report

Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

b. Pre-Field DALT Preliminary Notification

Notification: On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing within 7 calendar days after completion.

1.5.4.3 TAB Pre-Field Engineering Report

Submit report containing the following information:

a. Step-by-step TAB procedure:

(1) Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete methodology for accomplishing each seasonal TAB field work session.

(2) Air System Diagrams: Use the contract drawings and duct fabrication drawings if available to provide air system diagrams in the report showing the location of all terminal outlet supply, return, exhaust and transfer registers, grilles and diffusers. Use a key numbering system on the diagrams which identifies each outlet contained in the outlet airflow report sheets. Show intended locations of all traverses and static pressure readings.

(3) Procedural steps: Delineate fully the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.

b. Pre-field data: Submit AABC or NEBB or SMACNA 1780 data report forms with the following pre-field information filled in:

(1) Design data obtained from system drawings, specifications, and approved submittals.

(2) Notations detailing additional data to be obtained from the contract site by the TAB field team.

(3) Designate the actual data to be measured in the TAB field work.

(4) Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. Place the instrument key number in the blank space where the measured data would be entered.

c. Prerequisite HVAC work checkout list: Provide a list of inspections and work items which are to be completed by the Contractor. This list must be acted upon and completed by the Contractor and then submitted and approved by the Contracting Officer prior to the TAB team coming to the contract site.

At a minimum, a list of the applicable inspections and work items listed in the NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" must be provided for each separate system to be TAB'd.

1.5.5 Subcontractor Special Requirements

Perform all work in this section in accordance with the paragraph SUBCONTRACTOR SPECIAL REQUIREMENTS in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS, stating that all contract requirements of this section must be accomplished directly by a first tier subcontractor. No work may be performed by a second tier subcontractor.

1.5.6 Instrument Calibration Certificates

It is the responsibility of the TAB firm to provide instrumentation that meets the minimum requirements of the standard under which the TAB Firm's qualifications are approved for use on a project. Instrumentation must be in proper operating condition and must be applied in accordance with the instrumentation's manufacturer recommendations.

All instrumentation must bear a valid NIST traceable calibration certificate during field work and during government acceptance testing. All instrumentation must be calibrated within no later than one year of the date of TAB work or government acceptance testing field work.

1.5.7 TAB Standard

Perform TAB in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard are considered mandatory. Use the provisions of the TAB Standard, including checklists, report forms, etc., as nearly as practical, to satisfy the Contract requirements. Use the TAB Standard for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, adhere to the manufacturer's recommendations.

All quality assurance provisions of the TAB Standard such as performance guarantees are part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures must be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements are considered mandatory, including the latest requirements of ASHRAE 62.1.

1.5.8 Sustainability

Contractor must submit the following as part of the Quality Control Plan for acceptance testing:

a. List all test equipment to be used, including its manufacturer,model number, calibration date, and serial number.

b. Certificates of test personnel qualifications and certifications. Provide certification of compliance with 40 CFR 82.

c. Proof of equivalency if the contractor desires to substitute a test requirement.

Perform the following PTI as an integral part of the TAB process per the most recent edition of the NASA RCBEA GUIDE:

Compressors:
a. Vibration Analysis
b. Balance Test and Measurement
c. Alignment (laser preferred)
d. Lubricating Oil Test
e. Thermodynamic Performance Test
f. Hydraulic Oil Test (optional)

Fans:
a. Vibration Analysis
b. Balance Test and Measurement
c. Alignment (laser preferred)
d. Lubricating Oil Test
e. Thermodynamic Performance Test

Heat Exchangers (General):
a. Hydrostatic Test
b. Airborne Ultrasonic Test
c. Thermodynamic Performance Test
d. Infrared Thermography (optional)

Heat Exchangers (Condenser Air Cooled):
a. Hydrostatic Test
b. Thermodynamic Performance Test
c. Airborne Ultrasonic Test (optional)
d. Pulse Ultrasonic Test (optional)
e. Infrared Thermography (optional)

Heat Exchangers (Condenser Water Cooled):
a. Hydrostatic Test
b. Thermodynamic Performance Test
c. Airborne Ultrasonic Test (optional)
d. Pulse Ultrasonic Test (optional)
e. Infrared Thermography (optional)

Heat Exchange Cooling Tower:
a. Vibration Analysis
b. Balance Test and Measurement
c. Alignment (laser preferred)
d. Lubricating Oil Test
e. Performance Test

HVAC Ducts:
a. Operational Test
b. Ductwork Leak Testing (DALT); Pre-Final DALT report, Final

DALT report

Piping Systems:
a. Vibration Analysis
b. Infrared Thermography

Steam Coils:
a. Warranty Test
b. Vibration Analysis
c. Performance Test
d. Infrared Thermography

Valves:
a. Hydrostatic Test
b. Airborne Ultrasonic Test (optional)
c. Thermodynamic Performance Test (optional)
d. Infrared Thermography (optional)

1.5.9 Qualifications

1.5.9.1 TAB Firm

The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including building systems commissioning .

Certification must be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor must immediately notify the Contracting Officer and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm will be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor.

These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm must be a prime subcontractor of the Contractor and be financially and corporately independent of the mechanical subcontractor, reporting directly to and paid by the Contractor.

1.5.9.2 TAB Specialist

The TAB Specialist must be either a member of AABC,an experienced technician of the Firm certified by the NEBB, or a Supervisor certified by the TABB. The certification must be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, immediately notify the Contracting Officer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist will be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

1.5.9.3 TAB Specialist Responsibilities

TAB Specialist responsibilities include all TAB work specified herein and in related sections under his direct guidance. The TAB specialist is required to be onsite on a daily basis to direct TAB efforts. The TAB Specialist must participate in the commissioning process specified in Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING.

1.5.9.4 TAB Related HVAC Submittals

The TAB Specialist must prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. Accompany the submittals identified on this list with a letter of approval signed and dated by the TAB Specialist when submitted to the Government. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

1.5.10 Responsibilities

The Contractor is responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate TAB execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule listed in the paragraph TAB SUBMITTAL AND WORK SCHEDULE.

1.5.10.1 Contractor

a. TAB personnel: Ensure that the DALT work and the TAB work is accomplished by a group meeting the requirements specified in the paragraph TAB PERSONNEL QUALIFICATION REQUIREMENTS.

b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor, and ensure that a representative is present for the sheetmetal contractor, mechanical contractor, electrical contractor, and automatic temperature controls contractor.

c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:

   (1) Contract drawings and specifications

   (2) Approved submittal data for equipment

   (3) Construction work schedule

   (4) Up-to-date revisions and change orders for the previously listed items

d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in the paragraph TAB SUBMITTAL AND WORK SCHEDULE is met.

e. Coordination of supporting personnel:

   Provide the technical personnel, such as factory representatives or

HVAC controls installer required by the TAB field team to support the DALT and the TAB field measurement work.

Provide equipment mechanics to operate HVAC equipment and ductwork mechanics to provide the field designated test ports to enable TAB field team to accomplish the DALT and the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team, and cause no delay in the DALT and the TAB field work.

Conversely, ensure that the HVAC controls installer has required support from the TAB team field leader to complete the controls check out.

f. Deficiencies: Ensure that the TAB Agency supervisor submits all Design/Construction deficiency notifications directly to the Contracting officer within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.

g. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.

h. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all of the following are completed.

(1) HVAC system installations are fully complete.

(2) HVAC prerequisite checkout work lists specified in the paragraph PRE-FIELD TAB ENGINEERING REPORT are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved prerequisite HVAC work checklist.

(3) DALT field checks for all systems are completed.

(4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.

i. Advance notice: Furnish to the Contracting Officer with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.

j. Insulation work: For required DALT work , ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed and sealed.

1.5.10.2 TAB Agency

Provide the services of a TAB team which complies with the requirements of the paragraph INDEPENDENT TAB AGENCY PERSONNEL QUALIFICATIONS. The work to be performed by the TAB agency is limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section.

1.5.10.3 TAB Team Supervisor

a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.

b. Pre-DALT/TAB meeting: Attend meeting with Contractor.

c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.

d. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report, the during the DALT or TAB field work.

e. Pre-field DALT preliminary notification: Monitor the completion of the duct installation of each system and provide the necessary written notification to the Contracting Officer.

f. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.

g. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.

h. Technical assistance for DALT work.

(1) Technical assistance: Provide immediate technical assistance to TAB field team.

(2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report. Conduct the site visit full-time for a minimum of one 8 hour workday duration.

i. Final DALT report: Certify the DALT report. This certification includes the following work:

(1) Review: Review the Pre-final DALT report data. From these field reports, prepare the Certified Final DALT report.

(2) TAB Verification: Verify adherence, by the TAB field team, to the procedures specified in this section.

j. Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.

(1) TAB field visit: Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of one 8 hour workday duration. Review the TAB final report data and certify the TAB final report.

k. Certified TAB report: Certify the TAB report. This certification includes the following work:

(1) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.

(2) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.

l. Design/Construction deficiencies: Within 3 working days after the TAB Agency has encountered any design or construction deficiencies, the TAB Supervisor must submit written notification directly to the Contracting Officer, with a separate copy to the Contractor, of all such deficiencies. Provide in this submittal a complete explanation, including supporting documentation, detailing deficiencies. Where deficiencies are encountered that are believed to adversely impact successful completion of TAB, the TAB Agency must issue notice and request direction in the notification submittal.

m. TAB Field Check: The TAB team supervisor must attend and supervise TAB field check.

1.5.10.4 TAB Team Field Leader

a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.

b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.

c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC Checklist, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

1.5.11 Test Reports

1.5.11.1 Data from DALT Field Work

Report the data for the Pre-final DALT Report and Certified Final DALT Report in compliance the following requirements:

a. Report format: Submit report data on Air Duct Leakage Test Summary

Report Forms as shown on Page 6-2 of SMACNA 1972 CD. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Include node numbers in the completed report forms to identify each duct section. The TAB supervisor must review and certify the report.

b. The TAB supervisor must include a copy of all calculations prepared in determining the duct surface area of each duct test section. In addition,provide the ductwork air leak testing (DALT) reports with a copy(s) of the calibration curve for each of the DALT test orifices used for testing.

c. Instruments: List the types of instruments actually used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments must have been calibrated within one year of the date of use in the field. Instrument calibration must be traceable to the measuring standards of the National Institute of Standards and Technology.

d. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

1.5.11.2 Certified TAB Reports

Submit: TAB Report for Season 1 and TAB Report for Season 2 in the following manner:

a. Report format: Submit the completed pre-field data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed and certified by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data must be typewritten. Handwritten report forms or report data are not acceptable.

b. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for the rooms, or zones, as designated in the following list:

(1) . Measure and compile data on a continuous basis for the period in which TAB work affecting those rooms is being done.

(2) Measure and record data only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode.

(3) Data may be compiled using direct digital controls trend logging where available. Otherwise, temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls must be fully operational a minimum of 24 hours in advance of commencing data compilation. Include the specified data in the TAB Report .

c. System Diagrams: Provide updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations. Use a key numbering system on the diagram which identifies each outlet contained in the outlet airflow report sheets.

d. Static Pressure Profiles: Report static pressure profiles for air duct systems. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. Include the following in the static pressure report data, in addition to AABC/NEBB/TABB required data:

(1) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.

(2) Report static pressure drop across chilled water coils, DX coils, hot water coils, steam coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.

(3) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and two-position, installed in unit cabinetry.

(4) Report static pressure drop across air filters, acoustic silencers, moisture eliminators, air flow straighteners, air flow measuring stations or other pressure drop producing specialty items installed in unit cabinetry, or in the system ductwork. Examples of these specialty items are smoke detectors, white sound generators, RF shielding, wave guides, security bars, blast valves, small pipes passing through ductwork, and duct mounted humidifiers.

Do not report static pressure drop across duct fittings provided for the sole purpose of conveying air, such as elbows, transitions, offsets, plenums, manual dampers, and branch takes-offs.

(5) Report static pressure drop across outside air and relief/exhaust air louvers.

(6) Report static pressure readings of supply air, return air, exhaust/relief air, and outside air in duct at the point where these ducts connect to each air moving unit.[and also at the following locations:

Main Duct: Take readings at four locations along the full length of the main duct, 25 percent, 50 percent, 75 percent, and 100 percent of the total duct length.

Floor Branch Mains: Take readings at floor branch mains served by a main duct vertical riser.

Branch Main Ducts: Take readings at branch main ducts.

VAV Terminals: Take readings at inlet static pressure at VAV terminal box primary air branch ducts.

VAV Terminals, Fan Powered: Take readings at fan discharge and inlet static pressures for series and parallel fan powered VAV terminal boxes.]

e. Duct Traverses: Report duct traverses for main [and branch main] supply, return, exhaust, relief and outside air ducts. This includes all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows. The TAB Agency must evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pilot traverse plane as defined by AMCA 203, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane."

f. Instruments: List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.

Instrumentation, used for taking wet bulb temperature readings must provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.

g. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

h. Performance Curves: The TAB Supervisor must include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.

i. Calibration Curves: The TAB Supervisor must include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturi's and flow orifices TAB'd on the job.

1.6 PROJECT/SITE CONDITIONS

1.6.1 DALT and TAB Services to Obtain Existing Conditions

Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct this DALT and TAB work in accordance with the requirements of this section.

1.7 SEQUENCING AND SCHEDULING

1.7.1 Projects with Phased Construction

This specification section is structured as though the HVAC construction, and thereby the TAB work, will be completed in a single phase. When the construction is completed in phases, the DALT work and TAB work must be planned, completed, and accepted for each construction phase.

1.7.1.1 Phasing of Work

This specification section is structured as though the HVAC construction, and thereby the TAB work, is going to be completed in a single phase. All elements of the TAB work are addressed on this premise. When a contract is to be completed in construction phases, including the TAB work, and the DALT work, the TAB work and DALT work must be planned for, completed and approved by the Contracting Officer with each phase. An example of this case would be one contract that requires the rehabilitation of the HVAC in each of several separated buildings. At the completion of the final phase, compile all approved reports and submit as one document.

1.7.2 DALT and TAB Submittal and Work Schedule

Comply with additional requirements specified in Appendix C: DALT AND TAB SUBMITTAL AND WORK SCHEDULE included at the end of this section.

Submit this schedule,and TAB Schematic Drawings, adapted for this particular contract, to the Contracting Officer (CO) for review and approval. Include with the submittal the planned calendar dates for each submittal or work item. Resubmit an updated version for CO approval every 90 calendar days. Compliance with the following schedule is the Contractor's responsibility.

Qualify TAB Personnel: Within 45 calendar days after date of contract award, submit TAB agency and personnel qualifications.

Pre-DALT/TAB Meeting: Within 30 calendar days after the date of approval of the TAB agency and personnel, meet with the COTR.

Design Review Report: Within 60 calendar days after the date of the TAB agency personnel qualifications approval, submit design review report.

Pre-Field DALT Preliminary Notification: On completion of the duct installation for each system, notify the Contracting Officer in writing within 5 days after completion.

Ductwork Selected for DALT: Within 7 calendar days of Pre-Field DALT Preliminary Notification, the COTR will select which of the project ductwork must be DALT'd.

DALT Field Work: Within 48 hours of COTR's selection, complete DALT field work on selected.

Submit Pre-final DALT Report: Within one working day after completion of DALT field work, submit Pre-final DALT Report. Separate Pre-final DALT reports may be submitted to allow phased testing from system to system.

DALT Work Field Check: Upon approval of the Pre-final DALT Report, schedule the COTR's DALT field check work with the Contracting Officer.

Submit Final DALT Report: Within 15 calendar days after completion of successful DALT Work Field Check, submit TAB report.

Pre-Field TAB Engineering Report: Within 15 calendar days after approval of the TAB agency Personnel Qualifications, submit the Pre-Field TAB Engineering Report.

Prerequisite HVAC Work Check Out List and Advanced Notice For TAB Field Work.

1.7.2.1 TAB Design Review Report

Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

1.7.2.2 Pre-Field DALT Preliminary Notification

Notification: On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing within 7 calendar days after completion.

1.7.2.3 TAB Pre-Field Engineering Report

Submit report containing the following information:

a. Step-by-step TAB procedure:

   (1) Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete methodology for accomplishing each seasonal TAB field work session.

   (2) Air System Diagrams: Use the contract drawings and duct fabrication drawings if available to provide air system diagrams in the report showing the location of all terminal outlet supply, return, exhaust and transfer registers, grilles and diffusers. Use a key numbering system on the diagrams which identifies each outlet contained in the outlet airflow report sheets. Show intended locations of all traverses and static pressure readings.

   (3) Procedural steps: Delineate fully the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.

b. Pre-field data: Submit AABC or NEBB or SMACNA 1780 data report forms with the following pre-field information filled in:

   (1) Design data obtained from system drawings, specifications, and approved submittals.

   (2) Notations detailing additional data to be obtained from the contract site by the TAB field team.

   (3) Designate the actual data to be measured in the TAB field work.

   (4) Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. Place the instrument key number in the blank space where the measured data would be entered.

c. Prerequisite HVAC work checkout list: Provide a list of inspections and work items which are to be completed by the Contractor. This list must be acted upon and completed by the Contractor and then submitted and approved by the Contracting Officer prior to the TAB team coming to the contract site.

   At a minimum, a list of the applicable inspections and work items listed in the NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" must be provided for each separate system to be TAB'd.

1.8 WARRANTY

Furnish workmanship and performance warranty for the] TAB system work performed for a period not less than 1 years from the date of Government acceptance of the work; issued directly to the Government. Include provisions that if within the warranty period the system shows evidence of major performance deterioration, or is significantly out of tolerance, resulting from defective TAB or DALT workmanship, the corrective repair or replacement of the defective materials and correction of the defective workmanship is the responsibility of the TAB firm. Perform corrective action that becomes necessary because of defective materials and workmanship while system TAB and DALT is under warranty 7 days after notification, unless additional time is approved by the Contracting Officer. Failure to perform repairs within the specified period of time constitutes grounds for having the corrective action and repairs performed by others and the cost billed to the TAB firm. The Contractor must also provide a 1 year contractor installation warranty.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 WORK DESCRIPTIONS OF PARTICIPANTS

Comply with requirements of this section as specified in Appendix A WORK DESCRIPTIONS OF PARTICIPANTS.

3.2 TAB MEETING

Meet with the Contracting Officer's technical representative (COTR) to develop a mutual understanding relative to the details of the DALT work and TAB work requirements. Ensure that the TAB supervisor is present at this meeting. Requirements to be discussed include required submittals, work schedule, and field quality control.

3.3 TAB PROCEDURES

3.3.1 TAB Field Work

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents.

That is, comply with the the requirements of AABC MN-1 or SMACNA 1780 (TABB) and SMACNA 1858 (TABB),except as supplemented and modified by this section.

Provide instruments and consumables required to accomplish the TAB work. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. Conduct TAB work, including measurement accuracy, and sound measurement work in conformance with the AABC MN-1 and AABC MN-4, or NEBB TABES and NEBB MASV, or SMACNA 1780 (used by TABB) and SMACNA 1858 sound measurement procedures, except as supplemented and modified by this section.

3.3.2 Preliminary Procedures

Use the approved pre-field engineering report as instructions and procedures for accomplishing TAB field work. TAB engineer is to locate, in the field, test ports required for testing. It is the responsibility of the sheet metal contractor to provide and install test ports as required by the TAB engineer.

3.3.3 TAB Air Distribution Systems

3.3.3.1 Units With Coils

Report heating and cooling performance capacity tests for hot water, chilled water, DX and steam coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

   Do not determine entering and leaving wet and dry bulb temperatures by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

   Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

   Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.3.3.2 Air Handling Units

Air handling unit systems including fans (air handling unit fans, exhaust fans and winter ventilation fans), coils, ducts, plenums, mixing boxes, terminal units, variable air volume boxes, and air distribution devices for supply air, return air, outside air, mixed air relief air, and makeup air.

3.3.3.3 Rooftop Air Conditioning

Rooftop air conditioning systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.

For refrigeration compressors/condensers/condensing units/evaporators, report data as required by NEBB, AABC, and TABB standard procedures, including refrigeration operational data.

3.3.3.4 Heating and Ventilating Units

Heating and ventilating unit systems including fans, coils, ducts, plenums, roof vents, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.3.3.5 Makeup Air Units

Makeup air unit systems including fans, coils, ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.3.3.6 Return Air Fans

Return air fan system including fan ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.3.3.7 Fan Coils

Fan coil unit systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.

3.3.3.8 Exhaust Fans

Exhaust fan systems including fans, ducts, plenums, grilles, and hoods for exhaust air.

3.3.3.9 Cabinet Heaters

3.3.3.10 Cooling Units

3.3.3.11 Door Heaters

Door heater systems, including fans, coils, and diffusers.

3.3.3.12 Unit Heaters

3.3.4 TAB Water Distribution Systems

3.3.4.1 Chilled Water

Chilled water systems including chillers, condensers, cooling towers, pumps, coils, system balance valves and flow measuring devices.

For water chillers, report data as required by AABC, NEBB and TABB standard procedures, including refrigeration operational data.

3.3.4.2 Heating Hot Water

Heating hot water systems including boilers, hot water converters (e.g., heat exchangers), pumps, coils, system balancing valves and flow measuring devices.

3.3.4.3 Dual Temperature Water

Dual temperature water systems including boilers, converters, chillers, condensers, cooling towers, pumps, coils, and system balancing valves, and flow measuring devices.

3.3.5 Sound Measurement Work

3.3.5.1 Areas To Be Sound Measured

In the following spaces, measure and record the sound power level for each octave band listed in ASHRAE HVAC APP IP HDBK Noise Criteria:

a. All HVAC mechanical rooms, including machinery spaces and other spaces containing HVAC power drivers and power driven equipment.

b. All spaces sharing a common barrier with each mechanical room, including rooms overhead, rooms on the other side of side walls, and rooms beneath the mechanical room floor.

3.3.5.2 Procedure

Measure sound levels in each room, when unoccupied except for the TAB team, with all HVAC systems that would cause sound readings in the room operating in their noisiest mode. Record the sound level in each octave band. Attempt to mitigate the sound level and bring the level to within the specified ASHRAE HVAC APP IP HDBK noise criteria goals, if such mitigation is within the TAB team's control. State in the report the ASHRAE HVAC APP IP HDBK noise criteria goals. If sound level cannot be brought into compliance, provide written notice of the deficiency to the Contractor for resolution or correction.

3.3.5.3 Timing

Measure sound levels at times prescribed by AABC or NEBB or TABB.

3.3.5.4 Meters

Measure sound levels with a sound meter complying with ASA S1.4, Type 1 or 2, and an octave band filter set complying with ASA S1.11 PART 1. Use measurement methods for overall sound levels and for octave band sound levels as prescribed by NEBB.

3.3.5.5 Calibration

Calibrate sound levels as prescribed by AABC or NEBB or TABB, except that calibrators emitting a sound pressure level tone of 94 dB at 1000 hertz (Hz) are also acceptable.

3.3.5.6 Background Noise Correction

Determine background noise component of room sound (noise) levels for each (of eight) octave bands as prescribed by AABC or NEBB or TABB.

3.3.6 TAB Work on Performance Tests Without Seasonal Limitations

3.3.6.1 Performance Tests

In addition to the TAB proportionate balancing work on the air distribution systems and the water distribution systems, accomplish TAB work on the HVAC systems which directly transfer thermal energy. TAB the operational performance of the heating systems and cooling systems.

3.3.6.2 Ambient Temperatures

On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.3.6.3 Sound Measurements

Comply with the paragraph SOUND MEASUREMENT WORK, specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.

3.3.6.4 Water Chillers

For water chillers, report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

3.3.6.5 Refrigeration Units

For refrigeration compressors/condensers/condensing units, report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

3.3.6.6 Coils

Report heating and cooling performance capacity tests for hot water, chilled water, DX and steam coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For Central station air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing".

   Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

   Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

   Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.3.7 TAB Work on Performance Tests With Seasonal Limitations

3.3.7.1 Performance Tests

Accomplish proportional balancing TAB work on the air distribution systems and water distribution systems, in other words, accomplish adjusting and balancing of the air flows and water flows, any time during the duration of this contract, subject to the limitations specified elsewhere in this section. However, accomplish, within the following seasonal limitations, TAB work on HVAC systems which directly transfer thermal energy.Accomplish proportionate balancing TAB work on the air distribution systems and water distribution systems, in other words, accomplish adjusting and balancing of the air flows and water flows, any time during the duration of this contract, subject to the limitations specified elsewhere in this section. However, accomplish, within the following seasonal limitations, TAB work on HVAC systems which directly transfer thermal energy.

3.3.7.2 Season Of Maximum Load

Visit the contract site for at least two TAB work sessions for Season 1 and Season 2 field measures. [Visit the contract site during the season of maximum heating load] [and] [visit the contract site during the season of maximum cooling load], the goal being to TAB the operational performance of the [heating systems] [and] [cooling systems] under their respective maximum outdoor environment-caused loading. During the seasonal limitations, TAB the operational performance of the [heating systems] [and] [cooling systems].Visit the contract site for at least two TAB work sessions for TAB field measurements. [Visit the contract site during the season of maximum heating load] [and] [visit the contract site during the season of maximum cooling load], the goal being to TAB the operational performance of the [heating systems] [and] [cooling systems] under their respective maximum outdoor environment-caused loading. During the seasonal limitations, TAB the operational performance of the [heating systems] [and] [cooling systems].

3.3.7.3 Ambient Temperatures

On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.3.7.4 Sound Measurements

Comply with the paragraph SOUND MEASUREMENT WORK, specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.

[3.3.7.5 Water Chillers

Water chillers: For water chillers,report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

][3.3.7.6 Refrigeration Units

For refrigeration compressors/condensers/condensing units,report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

][3.3.7.7 Coils

Report heating and cooling performance capacity tests for [hot water], [chilled water], [DX] [and steam coils] for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For Central station air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

   Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

   Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

   Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

]3.3.8 Workmanship

Conduct TAB work on the HVAC systems until measured flow rates are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. This TAB work includes adjustment of balancing valves, balancing dampers, and sheaves. Further, this TAB work includes changing out fan sheaves and pump impellers if required to obtain air and water flow rates specified or indicated. If, with these adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, contact the Contracting Officer for direction.

3.3.9 Deficiencies

Strive to meet the intent of this section to maximize the performance of the equipment as designed and installed. However, if deficiencies in equipment design or installation prevent TAB work from being accomplished within the range of design values specified in the paragraph WORKMANSHIP, provide written notice as soon as possible to the Contractor and the Contracting Officer describing the deficiency and recommended correction.

Responsibility for correction of installation deficiencies is the

Contractor's. If a deficiency is in equipment design, call the TAB team supervisor for technical assistance. Responsibility for reporting design deficiencies to Contractor is the TAB team supervisor's.

3.3.10 TAB Reports

Additional requirements for TAB Reports are specified in Appendix B REPORTS - DALT and TAB

[After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and certification, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms is to be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and thereby the TAB report is considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP.
]
[After completion of the TAB work, prepare a pre-final TAB report using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms is to be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and the TAB report is considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP of this section.

Prepare the report neatly and legibly; the pre-final TAB report is the final TAB report minus the TAB supervisor's review and certification. Obtain, at the contract site, the TAB supervisor's review and certification of the TAB report.

Verbally notify the COTR that the field check of the TAB report data can commence; give this verbal notice 48 hours in advance of field check commencement. Do not schedule field check of the TAB report until the specified workmanship requirements have been met or written approval of the deviations from the requirements have been received from the Contracting Officer.
]

3.3.11 Quality Assurance - COTR TAB Field Acceptance Testing

3.3.11.1 TAB Field Acceptance Testing

During the field acceptance testing, verify, in the presence of the COTR, random selections of data (water, air quantities, air motion, [sound level readings]) recorded in the TAB Report. Points and areas for field acceptance testing are to be selected by the COTR. Measurement and test procedures are the same as approved for TAB work for the TAB Report.

Field acceptance testing includes verification of TAB Report data recorded for the following equipment groups:

Group 1: All chillers, boilers, return fans, computer room units, and air handling units (rooftop and central stations).

Group 2: 25 percent of the VAV terminal boxes and associated diffusers and registers.

Group 3: 25 percent of the supply diffusers, registers, grilles associated with constant volume air handling units.

Group 4: 25 percent of the return grilles, return registers, exhaust grilles and exhaust registers.

Group 5: 25 percent of the supply fans, exhaust fans, and pumps.

Further, if any data on the TAB Report for Groups 2 through 5 is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, additional group data verification is required in the presence of the COTR. Verify TAB Report data for one additional piece of equipment in that group. Continue this additional group data verification until out-of-tolerance data ceases to be found.

3.3.11.2 Additional COTR TAB Field Acceptance Testing

If any of the acceptance testing measurements for a given equipment group is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, terminate data verification for all affected data for that group. The affected data for the given group will be disapproved. Make the necessary corrections and prepare a revised TAB Report. Reschedule acceptance testing of the revised report data with the COTR.

Further, if any data on the TAB Report for a given field acceptance test group is out-of-tolerance, then field test data for one additional field test group as specified herein. Continue this increase field test work until out-of-tolerance data ceases to to be found. This additional field testing is up and above the original 25 percent of the of reported data entries to be field tested.

If there are no more similar field test groups from which to choose, additional field testing from another, but different, type of field testing group must be tested.

3.3.11.3 Prerequisite for Approval

Compliance with the field acceptance testing requirements of this section is a prerequisite for the final Contracting Officer approval of the TAB Report submitted.

3.4 MARKING OF SETTINGS

Upon the final TAB work approval, permanently mark the settings of HVAC adjustment devices including valves, gauges, splitters, and dampers so that adjustment can be restored if disturbed at any time. Provide permanent markings clearly indicating the settings on the adjustment devices which result in the data reported on the submitted TAB report.

3.5 MARKING OF TEST PORTS

The TAB team is to permanently and legibly mark and identify the location points of the duct test ports. If the ducts have exterior insulation, make these markings on the exterior side of the duct insulation. Show the location of test ports on the as-built mechanical drawings with dimensions given where the test port is covered by exterior insulation.

3.6 APPENDICES

Appendix A WORK DESCRIPTIONS OF PARTICIPANTS
Appendix B REPORTS - DALT and TAB
Appendix C DALT AND TAB SUBMITTAL AND WORK SCHEDULE

Appendix D REQUIREMENTS FOR DUCT AIR LEAK TESTING

Appendix A

WORK DESCRIPTIONS OF PARTICIPANTS

The Contractor is responsible for ensuring compliance with all requirements of this specification section. However, the following delineation of specific work items is provided to facilitate and co-ordinate execution of the various work efforts by personnel from separate organizations.

1. Contractor

a. HVAC documentation: Provide pertinent contract documentation to the TAB Firm, to include the following: the contract drawings and specifications; copies of the approved submittal data for all HVAC equipment, air distribution devices, and air/water measuring/balancing devices; the construction work schedule; and other applicable documents requested by the TAB Firm. Provide the TAB Firm copies of contract revisions and modifications as they occur.

b. Schedules: Ensure the requirements specified under the paragraph "DALT and TAB Schedule" are met.

c. Pre-DALT and TAB meeting: Arrange and conduct the Pre-DALT and TAB meeting. Ensure that a representative is present for the sheet metal contractor, the mechanical contractor, the electrical contractor, and the automatic temperature controls contractor.

d. Coordinate Support: Provide and coordinate support personnel required by the TAB Firm in order to accomplish the DALT and TAB field work. Support personnel may include factory representatives, HVAC controls installers, HVAC equipment mechanics, sheet metal workers, pipe fitters, and insulators. Ensure support personnel are present at the work site at the times required.

e. Correct Deficiencies: Ensure the notifications of Construction Deficiencies are provided as specified herein. Refer to the paragraph CONSTRUCTION DEFICIENCIES. Correct each deficiency as soon as practical with the Contracting Officer, and submit revised schedules and other required documentation.

f. Pre-TAB Work Checklists: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as pre-TAB work checklist items, the deficiencies pointed out by the TAB team supervisor in the design review report.

Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's DALT and TAB Work Procedures Summary. Do not allow the TAB team to commence TAB field work until all of the following are completed.

g. Give Notice of Testing: Submit advance notice of proportional balancing, Season 1, and Season 2 TAB field work accompanied by completed prerequisite HVAC Work List

h. Insulation work: Ensure that no insulation is shall not be installed on ducts to be DALT'd until DALT work on the subject ducts is complete.

Ensure the duct and piping systems are properly insulated and vapor sealed upon the successful completion and acceptance of the DALT and TAB work.

2. TAB Team Supervisor

a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.

b. Schedule: Ensure the requirements specified under the paragraph "DALT and TAB Schedule" are met.

c. Submittals: Provide the submittals specified herein.

d. Pre-DALT/TAB meeting: Attend meeting with Contractor. Ensure TAB personnel that will be involved in the TAB work under this contract attend the meeting.

e. Design Review Report: Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

f. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the DALT and TAB Procedures Summary, the during the DALT or TAB field work.

Ensure the Contractor is properly notified and aware of all support personnel needed to perform the TAB work. Maintain communication with the Contractor regarding support personnel throughout the duration of the TAB field work, including the TAB field acceptance testing checking.

Ensure all inspections and verifications for the Pre-Final DALT and Pre-TAB Checklists are completely and successfully conducted before DALT and TAB field work is performed.

g. Advance Notice: Monitor the completion of the duct system installations and provide the Advance Notice for Pre-Final DALT field work as specified herein.

h. Technical Assistance: Provide technical assistance to the DALT and TAB field work.

i. Deficiencies Notification: Ensure the notifications of Construction Deficiencies are provided as specified herein. Comply with requirements of the paragraph CONSTRUCTION DEFICIENCIES. Resolve each deficiency as soon as practical and submit revised schedules and other required documentation.

j. Procedures: Develop the required TAB procedures for systems or system components not covered in the TAB Standard.

3. TAB Team Field Leader

a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.

b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.

c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC work list, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

Appendix B

REPORTS - DALT and TAB

All submitted documentation must be typed, neat, and organized. All reports must have a waterproof front and back cover, a title page, a certification page, sequentially numbered pages throughout, and a table of contents. Tables, lists, and diagrams must be titled. Generate and submit for approval the following documentation:

1. DALT and TAB Work Execution Schedule

Submit a detailed schedule indicating the anticipated calendar date for each submittal and each portion of work required under this section. For each work entry, indicate the support personnel (such as controls provider, HVAC mechanic, etc.) that are needed to accomplish the work. Arrange schedule entries chronologically.

2. DALT and TAB Procedures Summary

Submit a detailed narrative describing all aspects of the DALT and TAB field work to be performed. Clearly distinguish between DALT information and TAB information. Include the following:

a. A list of the intended procedural steps for the DALT and TAB field work from start to finish. Indicate how each type of data measurement will be obtained. Include what Contractor support personnel are required for each step, and the tasks they need to perform.

b. A list of the project's submittals that are needed by the TAB Firm in order to meet this Contract's requirements.

c. The schematic drawings to be used in the required reports, which may include building floor plans, mechanical room plans, duct system plans, and equipment elevations. Indicate intended TAB measurement locations, including where test ports need to be provided by the Contractor.

d. The data presentation forms to be used in the report, with the preliminary information and initial design values filled in.

e. A list of DALT and TAB instruments to be used, edited for this project, to include the instrument name and description, manufacturer, model number, scale range, published accuracy, most recent calibration date, and what the instrument will be used for on this project.

f. A thorough checklist of the work items and inspections that need to be accomplished before DALT field work can be performed. The Contractor must complete, submit, and receive approval of the Completed Pre-Final DALT Work Checklist before DALT field work can be accomplished.

g. A thorough checklist of the work items and inspections that need to be accomplished before the [Season 1]TAB field work can be performed. The Contractor must complete, submit, and receive approval of the Completed [Season 1]Pre-TAB Work Checklist before the [Season 1]TAB field work can be accomplished.

[h. A thorough checklist of the work items and inspections that need to be accomplished before the Season 2 TAB field work can be performed. The

Contractor must complete, submit, and receive approval of the Completed Season 2 Pre-TAB Work Checklist before the Season 2 TAB field work can be accomplished.

] i. The checklists specified above shall be individually developed and tailored specifically for the work under this contract. Refer to NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under the paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" for examples of items to include in the checklists.

3. Design Review Report

Submit report containing the following information:

a. Review the contract specifications and drawings to verify that the TAB work can be successfully accomplished in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.

b. Submit a typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the DALT work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. If no deficiencies are evident, state so in the report.

4. Completed Pre-Final DALT Work Checklist

Report the data for the Pre-Final DALT Report meeting the following requirements:

a. Submit a copy of the approved DALT and TAB Procedures Summary: Provide notations describing how actual field procedures differed from the procedures listed.

b. Report format: Submit a comprehensive report for the DALT field work data using data presentation forms equivalent to the "Air Duct Leakage Test Summary Report Forms" located in the SMACNA 1972 CD. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Node numbers shall be included in the completed report forms to identify each duct section.

c. Calculations: Include a copy of all calculations prepared in determining the duct surface area of each duct test section. Include in the DALT reports copy(s) of the calibration curve for each of the DALT test orifices used for testing.

d. Instruments: List the types of instruments actually used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments are to be calibrated within one year of the date of use in the field; instrument calibration is to be traceable to the measuring standards of the National Institute of Standards and Technology.

e. TAB Supervisor Approval: Include on the submitted report the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

5. Final DALT Report

On successful completion of all COTR field checks of the Pre-final DALT Report data for all systems, the TABS Supervisor shall assemble, review, sign and submit the Final DALT Report to the Contracting Officer for approval.

6. TAB Reports: Submit TAB Report for Proportional Balancing, Season 1, and Season 2 in the following manner:

a. Procedure Summary: Submit a copy of the approved DALT and TAB Procedures Summary. When applicable, provide notations describing how actual field procedures differed from the procedures listed.

b. Report format: Submit the completed data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed, approved and signed by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data shall be typewritten. Handwritten report forms or report data are not acceptable.

c. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for the rooms, or zones, as designated in the following list:

[_____]

(1) Data shall be measured and compiled on a continuous basis for the period in which TAB work affecting those rooms is being done.

(2) Data shall be measured/recorded only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode. Provide a detailed explanation wherever a final measurement did not achieve the required value.

(3) Data may be compiled using direct digital controls trend logging where available. Otherwise, the Contractor shall temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls shall have been fully operational a minimum of 24 hours in advance of commencing data compilation. The specified data shall be included in the [Season I TAB Report] [Season I and Season 2 TAB Report].

d. Air System Diagrams: Provided updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations.

e. Air Static Pressure Profiles: Report static pressure profiles for air duct systems including: [AHU-1][RTAC-1][MUA-1][_____]. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. The static pressure report data shall include, in addition to AABC or NEBB or TABB required data, the following:

(1) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.

(2) Report static pressure drop across chilled water coils, DX coils, hot water coils, steam coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.

(3) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and two-position, installed in unit cabinetry.

(4) Report static pressure drop across air filters, acoustic silencers, moisture eliminators, air flow straighteners, air flow measuring stations or other pressure drop producing specialty items installed in unit cabinetry, or in the system ductwork. Examples of these specialty items are smoke detectors, white sound generators, RF shielding, wave guides, security bars, blast valves, small pipes passing through ductwork, and duct mounted humidifiers.

Do not report static pressure drop across duct fittings provided for the sole purpose of conveying air, such as elbows, transitions, offsets, plenums, manual dampers, and branch takes-offs.

(5) Report static pressure drop across outside air and relief/exhaust air louvers.

(6) Report static pressure readings of supply air, return air, exhaust/relief air, and outside air in duct at the point where these ducts connect to each air moving unit.

[f. Duct Transverses: Report duct traverses for main [and branch main] supply, return[, exhaust, relief and outside air] ducts. [This shall include all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows.] The TAB Agency shall evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pitot traverse plane as defined by AMCA 203, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane".

] g. Instruments: List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.

Instrumentation, used for taking wet bulb temperature readings shall provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.

h. Performance Curves: The TAB Supervisor shall include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.

i. Calibration Curves: The TAB Supervisor shall include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturis and flow orifices TAB'd on the job.

j. Data From TAB Field Work: After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and approval signature, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms shall be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and thereby the TAB report shall be considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP.

Appendix C

DALT AND TAB SUBMITTAL AND WORK SCHEDULE

Perform the following items of work in the order listed adhering to the dates schedule specified below. Include the major items listed in this schedule in the project network analysis schedule required by Section 01 32 17.00 20 COST-LOADED NETWORK ANALYSIS SCHEDULES (NAS).

Submit TAB Agency and TAB Personnel Qualifications: Within [42] [_____] calendar days after date of contract award.

Submit the DALT and TAB Work Execution Schedule: within [14] [_____] days after receipt of the TAB agency and TAB personnel qualifications approval. Revise and re-submit this schedule 28 days prior to commencement of DALT work and 28 days prior to the commencement of TAB Season 1 work and TAB Season 2 work.

Submit the DALT and TAB Work Procedures Summary: within [14] [_____] days after receipt of the initial approved DALT and TAB Work Execution Schedule.

Meet with the COTR at the Pre-DALT/TAB Meeting: Within [28] [_____] calendar days after receipt of the approved initial DALT/TAB Execution Schedule.

Submit Design Review Report: Within [56] [_____] calendar days after the receipt of the approved initial DALT and TAB Work Execution Schedule.

[Conduct measurements and submit the Record of Existing Facility Conditions: within [28] [_____] days after receipt of approved DALT and TAB Work Procedures Summary.

] Advance Notice of Pre-Final DALT Field Work: After the completed installation of the HVAC duct system to be DALT'd, submit to the Contracting Officer an Advance Notice of Pre-Final DALT Field Work accompanied by the completed Pre-Final DALT Work Checklist for the subject duct system.

Ductwork Selected for DALT: Within 14 calendar days after receiving an acceptable completed Pre-Final DALT Work Checklist, the Contracting Officer's technical representative (COTR) will select the project ductwork sections to be DALT'd.

DALT Field Work: Within 48 hours of COTR's selection, complete DALT field work on selected project ductwork.

Submit Pre-Final DALT Report: Within two working days after completion of DALT field work, submit Pre-final DALT Report. Separate Pre-final DALT reports may be submitted to allow phased testing from system to system.

Quality Assurance - COTR DALT Field Checks: Upon approval of the Pre-final DALT Report, the COTR's DALT field check work shall be scheduled with the Contracting Officer.

Submit Final DALT Report: Within [14] [_____] calendar days after completion of successful DALT Work Field Check, submit [Season 1]TAB report.

Advance Notice of [Season 1]TAB Field Work: At a minimum of [14][_____] calendar days prior to [Season 1]TAB Field Work, submit advance notice of TAB field work accompanied by completed [Season 1]Pre-TAB Work Checklist.

[Season 1]TAB Field Work: At a minimum of [84][_____] calendar days prior to CCD, [and when the ambient temperature is within Season 1 limits,] accomplish [Season 1]TAB field work.

Submit [Season 1]TAB Report: Within [14] [_____] calendar days after completion of [Season 1]TAB field work, submit initial [Season 1]TAB report.

[Season 1]Quality Assurance - COTR TAB Field Check: [30] [_____] calendar days after initial [Season 1]TAB report is approved by the Contracting Officer, conduct [Season 1]field check.

Complete [Season 1]TAB Work: Prior to CCD, complete all TAB work [except Season 2 TAB work] and submit final.

Receive the approved TAB report: Within 21 calendar days, receive the report from Contracting Officer approved TAB report.

Advance Notice of Season 2 TAB Field Work: At a minimum of [126] [_____]calendar days after CCD, submit advance notice of Season 2 TAB field work accompanied by completed Season 2 Pre-TAB Work Checklist.

[Season 2 TAB Field Work: Within [14] [_____] calendar days after date of advance notice of Season 2 TAB field work and when the ambient temperature is within Season 2 limits, accomplish Season 2 TAB field work.

Submit Season 2 TAB Report: Within [14] [_____] calendar days after completion of Season 2 TAB field work, submit Season 2 TAB report.

Season 2 Quality Assurance - COTR TAB Field Checks: [28] [_____] calendar days after the Season 2 TAB report is approved by the Contracting Officer, conduct Season 2 field check.

Complete Season 2 TAB Work: Within [14] [_____] calendar days after the completion of Season 2 TAB field data check, complete all TAB work.]

Receive the approved TAB report: Within calendar 21 days, receive the report from Contracting Officer.

Appendix D					
REQUIREMENTS FOR DUCT AIR LEAK TESTING					
		SYSTEMS			
		[Package Rooftop w/VAV Unit No. [1] [______]]	[Package Rooftop w/VAV Unit No. [2] [______]]	[Package Rooftop w/CV Unit No. [1] [______]]	[Package Rooftop w/CV Unit No. [2] [______]]
Duct System Static Pressure, in inches W.C.	for Supply	[4] [______]	[4] [______]	[2] [______]	[2] [______]
	for Return	[2] [______]	[2] [______]	[1] [______]	[1] [______]
	for Exhaust	[______]	[______]	[______]	[______]
	for Outside Air	[2] [______]	[2] [______]	[1] [______]	[1] [______]
System Oval/Round Duct and Rectangular Duct SMACNA Seal Class	for Supply	A	A	A	A
	for Return	A	A	A	A
	for Exhaust	A	A	A	A
	for Outside Air	A	A	A	A
System Oval/Round Duct SMACNA Leak Class	for Supply	[3] [______]	[3] [______]	[6] [______]	[6] [______]
	for Return	[6] [______]	[6] [______]	[12] [______]	[12] [______]
	for Exhaust	[______]	[______]	[______]	[______]
	for Outside Air	[6] [______]	[6] [______]	[12] [______]	[12] [______]

Appendix D					
REQUIREMENTS FOR DUCT AIR LEAK TESTING					
		SYSTEMS			
		[Package Rooftop w/VAV Unit No. [1] [______]]	[Package Rooftop w/VAV Unit No. [2] [______]]	[Package Rooftop w/CV Unit No. [1] [______]]	[Package Rooftop w/CV Unit No. [2] [______]]
System Rectangular Duct SMACNA Leak Class	for Supply	[6] [______]	[6] [______]	[12] [______]	[12] [______]
	for Return	[12] [______]	[12] [______]	[24] [______]	[24] [______]
	for Exhaust	[______]	[______]	[______]	[______]
	for Outside Air	[12] [______]	[12] [______]	[24] [______]	[24] [______]
Duct Test Pressure, in inches W.C.	for Supply	[4] [______]	[2] [______]	[50] [______]	[2] [______]
	for Return	[2] [______]	[2] [______]	[1] [______]	[1] [______]
	for Exhaust	[______]	[______]	[______]	[______]
	for Outside Air	[2] [______]	[2] [______]	[1] [______]	[1] [______]

Appendix D					
REQUIREMENTS FOR DUCT AIR LEAK TESTING					
		SYSTEMS			
		[AHU w/ Economizer & CV Unit No. [1] [______]]	[AHU w/ Economizer & CV Unit No. [2] [______]]	[Series VAV Terminal Boxes Unit No. [1] [______]]	[Exhaust Systems Unit No. [1] [______]]
Duct System Static Pressure, in millimeters W.C.	for Supply	[2] [______]	[2] [______]	[0.5] [______]	n/a
	for Return	[1] [______]	[1] [______]	[0.5] [______]	n/a
	for Exhaust	[0.5] [______]	[0.5] [______]	n/a	[1] [______]
	for Outside Air	[1] [______]	[1] [______]	n/a	n/a
System Oval/Round Duct and Rectangular Duct SMACNA Seal Class	for Supply	A	A	A	A
	for Return	A	A	A	A
	for Exhaust	A	A	A	A
	for Outside Air	A	A	A	A
System Oval/Round Duct SMACNA Leak Class	for Supply	[6] [______]	[6] [______]	12	n/a
	for Return	[12] [______]	[12] [______]	12	n/a
	for Exhaust	[12] [______]	[12] [______]	n/a	[12] [______]
	for Outside Air	[12] [______]	[12] [______]	n/a	n/a

Appendix D					
REQUIREMENTS FOR DUCT AIR LEAK TESTING					
		SYSTEMS			
		[AHU w/ Economizer & CV Unit No. [1] [______]]	[AHU w/ Economizer & CV Unit No. [2] [______]]	[Series VAV Terminal Boxes Unit No. [1] [______]]	[Exhaust Systems Unit No. [1] [______]]
System Rectangular Duct SMACNA Leak Class	for Supply	[12] [______]	[12] [______]	24	n/a
	for Return	[24] [______]	[24] [______]	24	n/a
	for Exhaust	[24] [______]	[24] [______]	n/a	[24] [______]
	for Outside Air	[24] [______]	[24] [______]	n/a	n/a
Duct Test Pressure, in inches W.C.	for Supply	[2] [______]	[2] [______]	[0.5] [______]	n/a
	for Return	[1] [______]	[1] [______]	[0.5] [______]	n/a
	for Exhaust	[0.5] [______]	[0.5] [______]	n/a	[1] [______]
	for Outside Air	[1] [______]	[1] [______]	n/a	n/a

-- End of Section --

SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS
02/13, CHG 7: 05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. At the discretion of the Government, the manufacturer of any material supplied will be required to furnish test reports pertaining to any of the tests necessary to assure compliance with the standard or standards referenced in this specification.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - SI (2019; Errata 1-4 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 5-7 2021; Interpretation 1-4 2020; Interpretation 5-8 2021; Addenda AU-BF 2020) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASHRAE 90.2 (2020) Energy-Efficient Design of Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A167 (2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A240/A240M (2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

ASTM A580/A580M (2018) Standard Specification for Stainless Steel Wire

ASTM B209 (2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

ASTM C195 (2007; R 2013) Standard Specification for Mineral Fiber Thermal Insulating Cement

ASTM C450 (2008) Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging

ASTM C533 (2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation

ASTM C534/C534M	(2020a) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2019) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2022) Standard Specification for Cellular Glass Thermal Insulation
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C585	(2010) Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C592	(2022a) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C610	(2015) Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
ASTM C612	(2014; R 2019) Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C755	(2019b) Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation
ASTM C795	(2008; R 2018) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010; R 2015) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM C1126	(2018) Standard Specification for Faced or

	Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM C1136	(2021) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C1710	(2011) Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM D2863	(2019) Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM D5590	(2000; R 2010; E 2012) Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2022) Standard Test Methods for Gravimetric Determination ofWater Vapor Transmission Rate of Materials
ASTM E2231	(2021) Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
ASTM E2336	(2020) Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

GREEN SEAL (GS)

GS-36	(2013) Adhesives for Commercial Use

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Stds	(8th Ed) National Commercial & Industrial Insulation Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2021) Standard for the Installation of Warm Air Heating and Air Conditioning Systems
NFPA 96	(2021) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY (TAPPI)

TAPPI T403 OM	(2015) Bursting Strength of Paper

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-A-24179	(1969; Rev A; Am 2 1980; Notice 1 1987; Notice 2 2020) Adhesive, Flexible Unicellular-Plastic Thermal Insulation
MIL-PRF-19565	(1988; Rev C) Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

UNDERWRITERS LABORATORIES (UL)

UL 94	(2013; Reprint Apr 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials

UL 2818	(2013) GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings

1.2 SYSTEM DESCRIPTION

1.2.1 General

Provide field-applied insulation and accessories on mechanical systems as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated. Insulation of heat distribution systems and chilled water systems outside of buildings shall be as specified in Section 33 61 13 PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM, Section 33 63 13.19 CONCRETE TRENCH HYDRONIC AND STEAM ENERGY DISTRIBUTION, Section 33 60 02 ABOVEGROUND HEAT DISTRIBUTION SYSTEM, and Section 33 61 13.13 PREFABRICATED UNDERGROUND HYDRONIC ENERGY DISTRIBUTION. Field applied insulation materials required for use on Government-furnished items as listed in the SPECIAL CONTRACT REQUIREMENTS shall be furnished and installed by the Contractor.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Submit the three SD types, SD-02 Shop Drawings, SD-03 Product Data, and SD-08 Manufacturer's Instructions at the same time for each system.

SD-02 Shop Drawings

MICA Plates; G

Pipe Insulation Systems and Associated Accessories

Duct Insulation Systems and Associated Accessories

Equipment Insulation Systems and Associated Accessories

Recycled content for insulation materials; S

SD-03 Product Data

Pipe Insulation Systems; G

Duct Insulation Systems; G

Equipment Insulation Systems; G

SD-04 Samples

Thermal Insulation; G

Display Samples; G

SD-07 Certificates

Indoor air quality for adhesives; S

SD-08 Manufacturer's Instructions

Pipe Insulation Systems; G

Duct Insulation Systems; G

Equipment Insulation Systems; G

1.4 CERTIFICATIONS

1.4.1 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.5 QUALITY ASSURANCE

1.5.1 Installer Qualification

Qualified installers shall have successfully completed three or more similar type jobs within the last 5 years.

1.6 DELIVERY, STORAGE, AND HANDLING

Materials shall be delivered in the manufacturer's unopened containers. Materials delivered and placed in storage shall be provided with protection from weather, humidity, dirt, dust and other contaminants. The Contracting Officer may reject insulation material and supplies that become dirty, dusty, wet, or contaminated by some other means. Packages or standard containers of insulation, jacket material, cements, adhesives, and coatings delivered for use, and samples required for approval shall have manufacturer's stamp or label attached giving the name of the manufacturer and brand, and a description of the material, date codes, and approximate shelf life (if applicable). Insulation packages and containers shall be asbestos free.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit a complete list of materials, including manufacturer's descriptive technical literature, performance data, catalog cuts, and installation instructions. The product number, k-value, thickness and furnished accessories including adhesives, sealants and jackets for each mechanical system requiring insulation shall be included. The product data must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. Materials furnished under this section shall be submitted together in a booklet and in conjunction with the MICA plates booklet

(SD-02). Annotate the product data to indicate which MICA plate is applicable.

2.1.1 Insulation System

Provide insulation systems in accordance with the approved MICA National Insulation Standards plates as supplemented by this specification. Provide field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems that are located within, on, under, and adjacent to buildings; and for plumbing systems. Provide CFC and HCFC free insulation.

2.1.2 Surface Burning Characteristics

Unless otherwise specified, insulation must have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flame spread, and smoke developed indexes, shall be determined by ASTM E84 or UL 723. Test insulation in the same density and installed thickness as the material to be used in the actual construction. Prepare and mount test specimens according to ASTM E2231.

2.2 MATERIALS

Provide insulation that meets or exceed the requirements of ASHRAE 90.2. Insulation exterior shall be cleanable, grease resistant, non-flaking and non-peeling. Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state. Materials to be used on stainless steel surfaces shall meet ASTM C795 requirements. Calcium silicate shall not be used on chilled or cold water systems. Materials shall be asbestos free. Provide product recognized under UL 94 (if containing plastic) and listed in FM APP GUIDE.

2.2.1 Adhesives

Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) that meet either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants must meet limit requirements of "Other" category within SCAQMD Rule 1168 sealants table). Provide aerosol adhesives used on the interior of the building that meet either emissions requirements of CDPH SECTION 01350 (use the office or classroom requirements, regardless of space type) or VOC content requirements of GS-36. Provide certification or validation of indoor air quality for adhesives.

2.2.1.1 Acoustical Lining Insulation Adhesive

Adhesive shall be a nonflammable, fire-resistant adhesive conforming to ASTM C916, Type I.

2.2.1.2 Mineral Fiber Insulation Cement

Cement shall be in accordance with ASTM C195.

2.2.1.3 Lagging Adhesive

Lagging is the material used for thermal insulation, especially around a cylindrical object. This may include the insulation as well as the cloth/material covering the insulation. To resist mold/mildew, lagging adhesive shall meet ASTM D5590 with 0 growth rating. Lagging adhesives shall be nonflammable and fire-resistant and shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Adhesive shall be MIL-A-3316, Class 1, pigmented white or red and be suitable for bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bonding glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or Class 2 for attaching fibrous glass insulation to metal surfaces. Lagging adhesives shall be applied in strict accordance with the manufacturer's recommendations for pipe and duct insulation.

2.2.1.4 Contact Adhesive

Adhesives may be any of, but not limited to, the neoprene based, rubber based, or elastomeric type that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. The adhesive shall not adversely affect, initially or in service, the insulation to which it is applied, nor shall it cause any corrosive effect on metal to which it is applied. Any solvent dispersing medium or volatile component of the adhesive shall have no objectionable odor and shall not contain any benzene or carbon tetrachloride. The dried adhesive shall not emit nauseous, irritating, or toxic volatile matters or aerosols when the adhesive is heated to any temperature up to 212 degrees F. The dried adhesive shall be nonflammable and fire resistant. Flexible Elastomeric Adhesive: Comply with MIL-A-24179, Type II, Class I. Provide product listed in FM APP GUIDE.

2.2.2 Caulking

ASTM C920, Type S, Grade NS, Class 25, Use A.

2.2.3 Corner Angles

Nominal 0.016 inch aluminum 1 by 1 inch with factory applied kraft backing. Aluminum shall be ASTM B209, Alloy 3003, 3105, or 5005.

2.2.4 Fittings

Fabricated Fittings are the prefabricated fittings for flexible elastomeric pipe insulation systems in accordance with ASTM C1710. Together with the flexible elastomeric tubes, they provide complete system integrity for retarding heat gain and controlling condensation drip from chilled-water and refrigeration systems. Flexible elastomeric, fabricated fittings provide thermal protection (0.25 k) and condensation resistance (0.05 Water Vapor Transmission factor). For satisfactory performance, properly installed protective vapor retarder/barriers and vapor stops shall be used on high relative humidity and below ambient temperature applications to reduce movement of moisture through or around the insulation to the colder interior surface.

2.2.5 Finishing Cement

ASTM C450: Mineral fiber hydraulic-setting thermal insulating and finishing cement. All cements that may come in contact with Austenitic stainless steel must comply with ASTM C795.

2.2.6 Fibrous Glass Cloth and Glass Tape

Fibrous glass cloth, with 20X20 maximum mesh size, and glass tape shall have maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Tape shall be 4 inch wide rolls. Class 3 tape shall be 4.5 ounces/square yard. Elastomeric Foam Tape: Black vapor-retarder foam tape with acrylic adhesive containing an anti-microbial additive.

2.2.7 Staples

Outward clinching type monel .

2.2.8 Jackets

2.2.8.1 Aluminum Jackets

Aluminum jackets shall be corrugated, embossed or smooth sheet, 0.016 inch nominal thickness; ASTM B209, Temper H14, Temper H16, Alloy 3003, 5005, or 3105. Corrugated aluminum jacket shall not be used outdoors. Aluminum jacket securing bands shall be Type 304 stainless steel, 0.015 inch thick, 1/2 inch wide for pipe under 12 inch diameter and 3/4 inch wide for pipe over 12 inch and larger diameter. Aluminum jacket circumferential seam bands shall be 2 by 0.016 inch aluminum matching jacket material. Bands for insulation below ground shall be 3/4 by 0.020 inch thick stainless steel, or fiberglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated Pittsburgh or "Z" type longitudinal joint. When the "Z" joint is used, the bands at the circumferential joints shall be designed by the manufacturer to seal the joints and hold the jacket in place.

2.2.8.2 Polyvinyl Chloride (PVC) Jackets

Polyvinyl chloride (PVC) jacket and fitting covers shall have high impact strength, ultraviolet (UV) resistant rating or treatment and moderate chemical resistance with minimum thickness 0.030 inch.

2.2.8.3 Vapor Barrier/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive, greater than 3 plies standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive); with 0.0000 permeability when tested in accordance with ASTM E96/E96M, using the water transmission rate test method; heavy duty, white or natural; and UV resistant. Flexible Elastomeric exterior foam with factory applied, UV Jacket made with a cold weather acrylic adhesive. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and excellent Water Vapor Transmission (WVT) rate.

2.2.8.4 Vapor Barrier/Vapor Retarder

Apply the following criteria to determine which system is required.

a. On ducts, piping and equipment operating below 55 degrees F or located outside shall be equipped with a vapor barrier.

b. Ducts, pipes and equipment that are located inside and that always operate above 55 degrees F shall be installed with a vapor retarder where required as stated in paragraph VAPOR RETARDER REQUIRED.

2.2.9 Vapor Retarder Required

ASTM C921, Type I, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where a minimum puncture resistance of 25 Beach units is acceptable. Minimum tensile strength, 35 pounds/inch width. ASTM C921, Type II, minimum puncture resistance 25 Beach units, tensile strength minimum 20 pounds/inch width. Jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing. Based on the application, insulation materials that require manufacturer or fabricator applied pipe insulation jackets are cellular glass, when all joints are sealed with a vapor barrier mastic, and mineral fiber. All non-metallic jackets shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flexible elastomerics require (in addition to vapor barrier skin) vapor retarder jacketing for high relative humidity and below ambient temperature applications.

2.2.9.1 White Vapor Retarder All Service Jacket (ASJ)

ASJ is for use on hot/cold pipes, ducts, or equipment indoors or outdoors if covered by a suitable protective jacket. The product shall meet all physical property and performance requirements of ASTM C1136, Type I, except the burst strength shall be a minimum of 85 psi. ASTM D2863 Limited Oxygen Index (LOI) shall be a minimum of 31.

In addition, neither the outer exposed surface nor the inner-most surface contacting the insulation shall be paper or other moisture-sensitive material. The outer exposed surface shall be white and have an emittance of not less than 0.80. The outer exposed surface shall be paintable.

2.2.9.2 Vapor Retarder/Vapor Barrier Mastic Coatings

2.2.9.2.1 Vapor Barrier

The vapor barrier shall be self adhesive (minimum 2 mils adhesive, 3 mils embossed) greater than 3 plies standard grade, silver, white, black and embossed white jacket for use on hot/cold pipes. Permeability shall be less than 0.02 when tested in accordance with ASTM E96/E96M. Products shall meet UL 723 or ASTM E84 flame and smoke requirements and shall be UV resistant.

2.2.9.2.2 Vapor Retarder

The vapor retarder coating shall be fire and water resistant and appropriately selected for either outdoor or indoor service. Color shall be white. The water vapor permeance of the compound shall be in accordance with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions. The coating shall be nonflammable, fire resistant type. 55 Coating shall meet MIL-PRF-19565 Type II (if selected for indoor service) and be Qualified Products Database listed. All other application and service properties shall be determined pursuant to ASTM C647.

2.2.9.3 Laminated Film Vapor Retarder

ASTM C1136, Type I, maximum moisture vapor transmission 0.02 perms, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork; where Type II, maximum moisture vapor transmission 0.02 perms, a minimum puncture resistance of 25 Beach units is acceptable. Vapor retarder shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flexible Elastomeric exterior foam with factory applied UV Jacket. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and an excellent WVT rate.

2.2.9.4 Polyvinylidene Chloride (PVDC) Film Vapor Retarder

The PVDC film vapor retarder shall have a maximum moisture vapor transmission of 0.02 perms, minimum puncture resistance of 150 Beach units, a minimum tensile strength in any direction of 30 lb/inch when tested in accordance with ASTM D882, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.9.5 Polyvinylidene Chloride Vapor Retarder Adhesive Tape

Requirements must meet the same as specified for Laminated Film Vapor Retarder above.

2.2.9.6 Vapor Barrier/Weather Barrier

The vapor barrier shall be greater than 3 ply self adhesive laminate -white vapor barrier jacket- superior performance (less than 0.0000 permeability when tested in accordance with ASTM E96/E96M). Vapor barrier shall meet UL 723 or ASTM E84 25 flame and 50 smoke requirements; and UV resistant. Minimum burst strength 185 psi in accordance with TAPPI T403 OM . Tensile strength 68 lb/inch width (PSTC-1000). Tape shall be as specified for laminated film vapor barrier above.

2.2.10 Vapor Retarder Not Required

ASTM C921, Type II, Class D, minimum puncture resistance 50 Beach units on all surfaces except ductwork, where Type IV, maximum moisture vapor transmission 0.10, a minimum puncture resistance of 25 Beach units is acceptable. Jacket shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.11 Wire

Soft annealed ASTM A580/A580M Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.2.12 Insulation Bands

Insulation bands shall be 1/2 inch wide; 26 gauge stainless steel.

2.2.13 Sealants

Sealants shall be chosen from the butyl polymer type, the styrene-butadiene rubber type, or the butyl type of sealants. Sealants shall have a maximum permeance of 0.02 perms based on Procedure B for ASTM E96/E96M, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.3 PIPE INSULATION SYSTEMS

Conform insulation materials to Table 1 and minimum insulation thickness as listed in Table 2 and meet or exceed the requirements of ASHRAE 90.1 - SI.

Limit pipe insulation materials to those listed herein and meeting the following requirements:

2.3.1 Recycled Materials

Provide insulation materials containing the following minimum percentage of recycled material content by weight:

Rock Wool: 75 percent slag of weight
Fiberglass: 20 percent glass cullet
Rigid Foam: 9 percent recovered material
Phenolic Rigid Foam: 9 percent recovered material

Provide data identifying percentage of recycled content for insulation materials.

2.3.2 Aboveground Cold Pipeline (-30 to 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications, shall be as follows:

2.3.2.1 Cellular Glass

ASTM C552, Type II, and Type III. Supply the insulation from the fabricator with (paragraph WHITE VAPOR RETARDER ALL SERVICE JACKET (ASJ)) ASJ vapor retarder and installed with all longitudinal overlaps sealed and all circumferential joints ASJ taped or supply the insulation unfaced from the fabricator and install with all longitudinal and circumferential joints sealed with vapor barrier mastic.

2.3.2.2 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II. Type I, Grade 1 for tubular materials. Type II, Grade 1, for sheet materials. Type I and II shall have vapor retarder/vapor barrier skin on one or both sides of the insulation, and require an additional exterior vapor retarder covering for high relative humidity and below ambient temperature applications.

2.3.2.3 Mineral Fiber Insulation with Integral Wicking Material (MFIWM)

ASTM C547. Install in accordance with manufacturer's instructions. Do not use in applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

2.3.2.4 Polyisocyanurate Insulation

ASTM C591, Type I. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

2.3.3 Aboveground Hot Pipeline (Above 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications shall meet the following requirements. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.1 Mineral Fiber

ASTM C547, Types I, II or III, supply the insulation with manufacturer's recommended factory-applied jacket.

2.3.3.2 Calcium Silicate

ASTM C533, Type I indoor only, or outdoors above 250 degrees F pipe temperature. Supply insulation with the manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.3 Cellular Glass

ASTM C552, Type II and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket.

2.3.3.4 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II to 220 degrees F service. Type I for tubular materials. Type II for sheet materials.

2.3.3.5 Phenolic Insulation

ASTM C1126 Type III to 250 degrees F service shall comply with ASTM C795. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.6 Perlite Insulation

ASTM C610

2.3.3.7 Polyisocyanurate Insulation

ASTM C591, Type I. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

2.3.4 Aboveground Dual Temperature Pipeline

Selection of insulation for use over a dual temperature pipeline system (Outdoor, Indoor - Exposed or Concealed) shall be in accordance with the most limiting/restrictive case. Find an allowable material from paragraph PIPE INSULATION MATERIALS and determine the required thickness from the most restrictive case. Use the thickness listed in paragraphs INSULATION THICKNESS for cold & hot pipe applications.

2.3.5 Below-ground Pipeline Insulation

For below-ground pipeline insulation, use cellular glass, ASTM C552, type II.

2.4 DUCT INSULATION SYSTEMS

2.4.1 Factory Applied Insulation

Provide factory-applied ASTM C534/C534M Grade 1, Type II, flexible elastomeric closed cell insulation according to manufacturer's recommendations for insulation with insulation manufacturer's standard reinforced fire-retardant vapor barrier, with identification of installed thermal resistance (R) value and out-of-package R value.

2.4.1.1 Rigid Insulation

Calculate the minimum thickness in accordance with ASHRAE 90.2.

2.4.1.2 Blanket Insulation

Calculate minimum thickness in accordance with ASTM C553.

2.4.2 Kitchen Exhaust Ductwork Insulation

Insulation thickness shall be a minimum of 2 inches, blocks or boards, either mineral fiber conforming to ASTM C612, Class 5, 20 pcf average or calcium silicate conforming to ASTM C533, Type II. Provide vapor barrier for outside air connection to kitchen exhaust hood. The enclosure materials and the grease duct enclosure systems shall meet testing requirements of ASTM E2336 for noncombustibility, fire resistance, durability, internal fire, and fire-engulfment with a through-penetration fire stop.

2.4.3 Acoustical Duct Lining

2.4.3.1 General

For ductwork indicated or specified in Section 23 30 00 HVAC AIR DISTRIBUTION to be acoustically lined, provide external insulation in accordance with this specification section and in addition to the acoustical duct lining. Do not use acoustical lining in place of duct wrap or rigid board insulation (insulation on the exterior of the duct).

2.4.3.2 Duct Liner

Flexible Elastomeric Acoustical and Conformable Duct Liner Materials: Flexible Elastomeric Thermal, Acoustical and Conformable Insulation Compliance with ASTM C534/C534M Grade 1, Type II; and NFPA 90A or NFPA 90B as applicable.

2.4.4 Duct Insulation Jackets

2.4.4.1 All-Purpose Jacket

Provide insulation with insulation manufacturer's standard reinforced fire-retardant jacket with or without integral vapor barrier as required by the service. In exposed locations, provide jacket with a white surface suitable for field painting.

2.4.4.2 Metal Jackets

2.4.4.2.1 Aluminum Jackets

ASTM B209, Temper H14, minimum thickness of 27 gauge (0.016 inch), with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide smooth surface jackets for jacket outside dimension 8 inches and larger. Provide corrugated surface jackets for jacket outside dimension 8 inches and larger. Provide stainless steel bands, minimum width of 1/2 inch.

2.4.4.2.2 Stainless Steel Jackets

ASTM A167 or ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (0.010 inch), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 1/2 inch.

2.4.4.3 Vapor Barrier/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive), heavy duty white or natural).

2.4.5 Weatherproof Duct Insulation

Provide ASTM C552, cellular glass thermal insulation, ASTM C534/C534M Grade 1, Type II, flexible elastomeric cellular insulation, and weatherproofing as specified in manufacturer's instruction. Multi-ply, Polymeric Blend Laminate Jacketing: Construction of laminate designed to provide UV resistance, high puncture, tear resistance and an excellent WVT rate.

2.5 EQUIPMENT INSULATION SYSTEMS

Insulate equipment and accessories as specified in Tables 5 and 6. In outside locations, provide insulation 1/2 inch thicker than specified. Increase the specified insulation thickness for equipment where necessary to equal the thickness of angles or other structural members to make a smooth, exterior surface. Submit a booklet containing manufacturer's published installation instructions for the insulation systems in coordination with the submitted MICA Insulation Stds plates booklet. Annotate their installation instructions to indicate which product data and which MICA plate are applicable. The instructions must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. A booklet is also required by paragraphs titled: Pipe Insulation Systems and Duct Insulation Systems.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

Apply insulation to unheated and uncooled piping and equipment. Do not compress flexible elastomeric cellular insulation at joists, studs, columns, ducts, and hangers. The insulation must not pull apart after a one hour period; replace any insulation found to pull apart after one hour.

3.1.1 Display Samples

Submit and display, after approval of materials, actual sections of installed systems, properly insulated in accordance with the specification requirements. Such actual sections must remain accessible to inspection throughout the job and will be reviewed from time to time for controlling the quality of the work throughout the construction site. Each material used shall be identified, by indicating on an attached sheet the specification requirement for the material and the material by each manufacturer intended to meet the requirement. The Contracting Officer will inspect display sample sections at the jobsite. Approved display sample sections shall remain on display at the jobsite during the construction period. Upon completion of construction, the display sample sections will be closed and sealed.

3.1.1.1 Pipe Insulation Display Sections

Display sample sections shall include as a minimum an elbow or tee, a valve, dielectric waterways and flanges, a hanger with protection shield and insulation insert, or dowel as required, at support point, method of fastening and sealing insulation at longitudinal lap, circumferential lap, butt joints at fittings and on pipe runs, and terminating points for each type of pipe insulation used on the job, and for hot pipelines and cold pipelines, both interior and exterior, even when the same type of insulation is used for these services.

3.1.1.2 Duct Insulation Display Sections

Display sample sections for rigid and flexible duct insulation used on the job. Use a temporary covering to enclose and protect display sections for duct insulation exposed to weather

3.1.2 Installation

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests specified in other sections of this specification are completed. Material such as rust, scale, dirt and moisture shall be removed from surfaces to receive insulation. Insulation shall be kept clean and dry. Insulation shall not be removed from its shipping containers until the day it is ready to use and shall be returned to like containers or equally protected from dirt and moisture at the end of each workday. Insulation that becomes dirty shall be thoroughly cleaned prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, the insulation will be rejected, and shall be immediately removed from the jobsite. Joints shall be staggered on multi layer insulation. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces. Insulation, jacketing and accessories shall be installed in accordance with MICA Insulation Stds plates except where modified herein or on the drawings.

3.1.3 Firestopping

Where pipes and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be sealed with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING. The protection of ducts at point of passage through firewalls must be in accordance with NFPA 90A and/or NFPA 90B. All other penetrations, such as piping, conduit, and wiring, through firewalls must be protected with a material or system of the same hourly rating that is listed by UL, FM, or a NRTL.

3.1.4 Painting and Finishing

Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.5 Installation of Flexible Elastomeric Cellular Insulation

Install flexible elastomeric cellular insulation with seams and joints sealed with rubberized contact adhesive. Flexible elastomeric cellular insulation shall not be used on surfaces greater than 220 degrees F. Stagger seams when applying multiple layers of insulation. Protect insulation exposed to weather and not shown to have vapor barrier weatherproof jacketing with two coats of UV resistant finish or PVC or metal jacketing as recommended by the manufacturer after the adhesive is dry and cured.

3.1.5.1 Adhesive Application

Apply a brush coating of adhesive to both butt ends to be joined and to both slit surfaces to be sealed. Allow the adhesive to set until dry to touch but tacky under slight pressure before joining the surfaces. Insulation seals at seams and joints shall not be capable of being pulled apart one hour after application. Insulation that can be pulled apart one hour after installation shall be replaced.

3.1.5.2 Adhesive Safety Precautions

Use natural cross-ventilation, local (mechanical) pickup, and/or general area (mechanical) ventilation to prevent an accumulation of solvent vapors, keeping in mind the ventilation pattern must remove any heavier-than-air solvent vapors from lower levels of the workspaces. Gloves and spectacle-type safety glasses are recommended in accordance with safe installation practices.

3.1.6 Welding

No welding shall be done on piping, duct or equipment without written approval of the Contracting Officer. The capacitor discharge welding process may be used for securing metal fasteners to duct.

3.1.7 Pipes/Ducts/Equipment That Require Insulation

Insulation is required on all pipes, ducts, or equipment, except for omitted items as specified.

3.2 PIPE INSULATION SYSTEMS INSTALLATION

Install pipe insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

3.2.1 Pipe Insulation

3.2.1.1 General

Pipe insulation shall be installed on aboveground hot and cold pipeline systems as specified below to form a continuous thermal retarder/barrier, including straight runs, fittings and appurtenances unless specified otherwise. Installation shall be with full length units of insulation and using a single cut piece to complete a run. Cut pieces or scraps abutting each other shall not be used. Pipe insulation shall be omitted on the following:

a. Pipe used solely for fire protection.

b. Chromium plated pipe to plumbing fixtures. However, fixtures for use by the physically handicapped shall have the hot water supply and drain, including the trap, insulated where exposed.

c. Sanitary drain lines.

d. Air chambers.

e. Adjacent insulation.

f. ASME stamps.

g. Access plates of fan housings.

h. Cleanouts or handholes.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

Pipe insulation shall be continuous through the sleeve.

Provide an aluminum jacket or vapor barrier/weatherproofing self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 ply standard grade, silver, white, black and embossed with factory applied moisture retarder over the insulation wherever penetrations require sealing.

3.2.1.2.1 Penetrate Interior Walls

The aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 plies standard grade, silver, white, black and embossed shall extend 2 inches beyond either side of the wall and shall be secured on each end with a band.

3.2.1.2.2 Penetrating Floors

Extend the aluminum jacket from a point below the backup material to a point 10 inches above the floor with one band at the floor and one not more than 1 inch from the end of the aluminum jacket.

3.2.1.2.3 Penetrating Waterproofed Floors

Extend the aluminum jacket rom below the backup material to a point 2 inches above the flashing with a band 1 inch from the end of the aluminum jacket.

3.2.1.2.4 Penetrating Exterior Walls

Continue the aluminum jacket required for pipe exposed to weather through the sleeve to a point 2 inches beyond the interior surface of the wall.

3.2.1.2.5 Penetrating Roofs

Insulate pipe as required for interior service to a point flush with the top of the flashing and sealed with flashing sealant. Tightly butt the insulation for exterior application to the top of flashing and interior insulation. Extend the exterior aluminum jacket 2 inches down beyond the end of the insulation to form a counter flashing. Seal the flashing and counter flashing underneath with metal jacketing/flashing sealant.

3.2.1.2.6 Hot Water Pipes Supplying Lavatories or Other Similar Heated Service

Terminate the insulation on the backside of the finished wall. Protect the insulation termination with two coats of vapor barrier coating with a minimum total thickness of 1/16 inch applied with glass tape embedded between coats (if applicable). Extend the coating out onto the insulation 2 inches and seal the end of the insulation. Overlap glass tape seams 1 inch. Caulk the annular space between the pipe and wall penetration with approved fire stop material. Cover the pipe and wall penetration with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration at least 3/8 inches.

3.2.1.2.7 Domestic Cold Water Pipes Supplying Lavatories or Other Similar Cooling Service

Terminate the insulation on the finished side of the wall (i.e., insulation must cover the pipe throughout the wall penetration). Protect the insulation with two coats of weather barrier mastic (breather emulsion type weatherproof mastic impermeable to water and permeable to air) with a minimum total thickness of 1/16 inch. Extend the mastic out onto the insulation 2 inches and shall seal the end of the insulation. The annular space between the outer surface of the pipe insulation and caulk the wall penetration with an approved fire stop material having vapor retarder properties. Cover the pipe and wall penetration with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration by at least 3/8 inches.

3.2.1.3 Pipes Passing Through Hangers

Insulation, whether hot or cold application, shall be continuous through hangers. All horizontal pipes 2 inches and smaller shall be supported on hangers with the addition of a Type 40 protection shield to protect the insulation in accordance with MSS SP-58. Whenever insulation shows signs of being compressed, or when the insulation or jacket shows visible signs of distortion at or near the support shield, insulation inserts as specified below for piping larger than 2 inches shall be installed, or factory insulated hangers (designed with a load bearing core) can be used.

3.2.1.3.1 Horizontal Pipes Larger Than 2 Inches at 60 Degrees F and Above

Supported on hangers in accordance with MSS SP-58, and Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.2.1.3.2 Horizontal Pipes Larger Than 2 Inches and Below 60 Degrees F

Supported on hangers with the addition of a Type 40 protection shield in accordance with MSS SP-58. An insulation insert of cellular glass, prefabricated insulation pipe hangers, or perlite above 80 degrees F shall be installed above each shield. The insert shall cover not less than the bottom 180-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 2 inches on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the weight of the pipe from crushing the insulation, as an option to installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert.

3.2.1.3.3 Vertical Pipes

Supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with MSS SP-58 covering the 360-degree arc of the insulation. An insulation insert of cellular glass or calcium silicate shall be installed between each shield and the pipe. The insert shall cover the 360-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 2 inches on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the hanger from crushing the insulation, as an option instead of installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert. The vertical weight of the pipe shall be supported with hangers located in a horizontal section of the pipe. When the pipe riser is longer than 30 feet, the weight of the pipe shall be additionally supported with hangers in the vertical run of the pipe that are directly clamped to the pipe, penetrating the pipe insulation. These hangers shall be insulated and the insulation jacket sealed as indicated herein for anchors in a similar service.

3.2.1.3.4 Inserts

Covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, overlap the adjoining pipe jacket 1-1/2 inches, and seal as required for the pipe jacket. The jacket material used to cover inserts in flexible elastomeric cellular insulation shall conform to ASTM C1136, Type 1, and is allowed to be of a different material than the adjoining insulation material.

3.2.1.4 Flexible Elastomeric Cellular Pipe Insulation

Flexible elastomeric cellular pipe insulation shall be tubular form for pipe sizes 6 inches and less. Grade 1, Type II sheet insulation used on pipes larger than 6 inches shall not be stretched around the pipe. On pipes larger than 12 inches, the insulation shall be adhered directly to the pipe on the lower 1/3 of the pipe. Seams shall be staggered when applying multiple layers of insulation. Sweat fittings shall be insulated with miter-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from miter-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation. Type II requires an additional exterior vapor retarder/barrier covering for high relative humidity and below ambient temperature applications.

3.2.1.5 Pipes in high abuse areas.

In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, welded PVC, stainless steel, aluminum or flexible laminate cladding (comprised of elastomeric, plastic or metal foil laminate) laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket, - less than 0.0000 permeability; (greater than 3 ply, standard grade, silver, white, black and embossed) jackets shall be utilized. Pipe insulation to the 6 foot level shall be protected.

3.2.1.6 Pipe Insulation Material and Thickness

Pipe insulation materials must be as listed in Table 1 and must meet or exceed the requirements of ASHRAE 90.2.

TABLE 1

Insulation Material for Piping

Service	Material	Specification	Type	Class	VR/VB Req'd
Chilled Water (Supply & Return, Dual Temperature Piping, 40 F nominal)					
	Cellular Glass	ASTM C552	II	2	Yes
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		Yes
	Mineral Fiber with Wicking Material	ASTM C547	I		Yes
Heating Hot Water Supply & Return, Heated Oil (Max 250 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	II	2	No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Hot Domestic Water Supply & Recirculating Piping (Max 200 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
Refrigerant Suction Piping (35 degrees F nominal)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Cellular Glass	ASTM C552	II	1	Yes

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
Compressed Air Discharge, Steam and Condensate Return (201 to 250 Degrees F					
	Cellular Glass	ASTM C552	II		No
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Cellular Glass	ASTM C552	III		Yes
Condensate Drain Located Inside Building					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Medium Temperature Hot Water, Steam and Condensate (251 to 350 Degrees F)					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	I or II		No
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
High Temperature Hot Water & Steam (351 to 700 Degrees F)					
	Mineral Fiber	ASTM C547	I	2	No
	Calcium Silicate	ASTM C533	I		No
	Perlite	ASTM C610			No

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
	Cellular Glass	ASTM C552			No
Brine Systems Cryogenics (-30 to 0 Degrees F)					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Brine Systems Cryogenics (0 to 34 Degrees F)					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Note: VR/VB = Vapor Retarder/Vapor Barrier					

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
[Chilled Water (Supply & Return, Dual Temperature Piping, 40 Degrees F nominal)]						
	Cellular Glass	1.5	2	2	2.5	3
	Mineral Fiber with Wicking Material	1	1.5	1.5	2	2
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
[Chilled Water (Supply & Return, Dual Temperature Piping, 40 Degrees F nominal)]						
	Cellular Glass	1.5	1.5	1.5	1.5	2
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Mineral Fiber with Wicking Material	1	1.5	1.5	2	2

TABLE 2

Piping Insulation Thickness (inch)
Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
Heating Hot Water Supply & Return, Heated Oil (Max 250 F)						
	Mineral Fiber	1.5	1.5	2	2	2
	Calcium Silicate	2.5	2.5	3	3	3
	Cellular Glass	2	2.5	3	3	3
	Perlite	2.5	2.5	3	3	3
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Hot Domestic Water Supply & Recirculating Piping (Max 200 F)						
	Mineral Fiber	1	1	1	1.5	1.5
	Cellular Glass	1.5	1.5	1.5	2	2
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Refrigerant Suction Piping (35 degrees F nominal)						
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
Compressed Air Discharge, Steam and Condensate Return (201 to 250 Degrees F						
	Mineral Fiber	1.5	1.5	2	2	2
		1.5*	2*	2.5*	3*	3.5*

TABLE 2

Piping Insulation Thickness (inch)
Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
	Calcium Silicate	2.5	3	4	4	4.5
	Cellular Glass	2	2.5	3	3	3
	Perlite	2.5	3	4	4	4.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel						
	Flexible Elastomeric Cellular	0.5	0.5	0.5	0.5	0.5
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Faced Phenolic Foam	1	1	1	1	1
Condensate Drain Located Inside Building						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Medium Temperature Hot Water, Steam and Condensate (251 to 350 Degrees F)						
	Mineral Fiber	1.5	3	3	4	4
		2.5*	*	3.5*		
	Calcium Silicate	2.5	3.5	4.5	4.5	5
	Perlite	2.5	3.5	4.5	4.5	5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A

TABLE 2

Piping Insulation Thickness (inch)
Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
High Temperature Hot Water & Steam (351 to 700 Degrees F)						
	Mineral Fiber	2.5	3	3	4	4
	Calcium Silicate	4	4.5	6	6	6
	Perlite	4	4.5	6	6	6
Brine Systems Cryogenics (-30 to 0 Degrees F)						
	Cellular Glass	2.5	2.5	3	3	3.5
	Flexible Elastomeric Cellular	1	1	N/A	N/A	N/A
Brine Systems Cryogenics (0 to 34 Degrees F)						
	Cellular Glass	2	2	2	2.5	3
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A

3.2.2 Aboveground Cold Pipelines

The following cold pipelines for minus 30 to plus 60 degrees F, shall be insulated in accordance with Table 2 except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

a. Make-up water.

b. Horizontal and vertical portions of interior roof drains.

c. Refrigerant suction lines.

d. Chilled water.

e. Dual temperature water, i.e. HVAC hot/chilled water.

f. Air conditioner condensate drains.

g. Brine system cryogenics

h. Exposed lavatory drains and domestic water lines serving plumbing fixtures for handicap persons.

i. Domestic cold and chilled drinking water.

3.2.2.1 Insulation Material and Thickness

Insulation thickness for cold pipelines shall be determined using Table 2.

3.2.2.2 Factory or Field applied Jacket

Insulation shall be covered with a factory applied vapor retarder jacket/vapor barrier or field applied seal welded PVC jacket or greater than 3 ply laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, standard grade, sliver, white, black and embossed for use with Mineral Fiber, Cellular Glass, and Phenolic Foam Insulated Pipe. Insulation inside the building, to be protected with an aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, Embossed Silver, White & Black, shall have the insulation and vapor retarder jacket installed as specified herein. The aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, White & Black, shall be installed as specified for piping exposed to weather, except sealing of the laps of the aluminum jacket is not required. In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, aluminum jackets or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, white & black, shall be provided for pipe insulation to the 6 ft level.

3.2.2.3 Installing Insulation for Straight Runs Hot and Cold Pipe

Apply insulation to the pipe with tight butt joints. Seal all butted joints and ends with joint sealant and seal with a vapor retarder coating, greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or PVDC adhesive tape.

3.2.2.3.1 Longitudinal Laps of the Jacket Material

Overlap not less than 1-1/2 inches. Provide butt strips 3 inches wide for circumferential joints.

3.2.2.3.2 Laps and Butt Strips

Secure with adhesive and staple on 4 inch centers if not factory self-sealing. If staples are used, seal in accordance with paragraph STAPLES below. Note that staples are not required with cellular glass systems.

3.2.2.3.3 Factory Self-Sealing Lap Systems

May be used when the ambient temperature is between 40 and 120 degrees F during installation. Install the lap system in accordance with manufacturer's recommendations. Use a stapler only if specifically recommended by the manufacturer. Where gaps occur, replace the section or repair the gap by applying adhesive under the lap and then stapling.

3.2.2.3.4 Staples

Coat all staples, including those used to repair factory self-seal lap systems, with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - 0.0000 perm adhesive tape. Coat all seams, except those on factory self-seal systems, with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.5 Breaks and Punctures in the Jacket Material

Patch by wrapping a strip of jacket material around the pipe and secure it with adhesive, staple, and coat with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. Extend the patch not less than 1-1/2 inches past the break.

3.2.2.3.6 Penetrations Such as Thermometers

Fill the voids in the insulation and seal with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.7 Flexible Elastomeric Cellular Pipe Insulation

Install by slitting the tubular sections and applying them onto the piping or tubing. Alternately, whenever possible slide un-slit sections over the open ends of piping or tubing. Secure all seams and butt joints and seal with adhesive. When using self seal products only the butt joints shall be secured with adhesive. Push insulation on the pipe, never pulled. Stretching of insulation may result in open seams and joints. Clean cut all edges. Rough or jagged edges of the insulation are not be permitted. Use proper tools such as sharp knives. Do not stretch Grade 1, Type II sheet insulation around the pipe when used on pipe larger than 6 inches. On pipes larger than 12 inches, adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

3.2.2.4 Insulation for Fittings and Accessories

a. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant and sealed with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

b. Precut or preformed insulation shall be placed around all fittings and accessories and shall conform to MICA plates except as modified herein: 5 for anchors; 10, 11, and 13 for fittings; 14 for valves; and 17 for flanges and unions. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 2 inches or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow'. Submit a booklet containing completed

MICA Insulation Stds plates detailing each insulating system for each pipe, duct, or equipment insulating system, after approval of materials and prior to applying insulation.

(1) The MICA plates shall detail the materials to be installed and the specific insulation application. Submit all MICA plates required showing the entire insulating system, including plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. The MICA plates shall present all variations of insulation systems including locations, materials, vaporproofing, jackets and insulation accessories.

(2) If the Contractor elects to submit detailed drawings instead of edited MICA Plates, the detail drawings shall be technically equivalent to the edited MICA Plate submittal.

c. Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapor retarder jackets or PVC fitting covers shall be protected with PVDC or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or two coats of vapor retarder coating with a minimum total thickness of 1/16 inch, applied with glass tape embedded between coats. Tape seams shall overlap 1 inch. The coating shall extend out onto the adjoining pipe insulation 2 inches. Fabricated insulation with a factory vapor retarder jacket shall be protected with either greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape, standard grade, silver, white, black and embossed or PVDC adhesive tape or two coats of vapor retarder coating with a minimum thickness of 1/16 inch and with a 2 inch wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, the joints shall be sealed with a vapor retarder coating and a 4 inch wide ASJ tape which matches the jacket of the pipe insulation.

d. Anchors attached directly to the pipe shall be insulated for a sufficient distance to prevent condensation but not less than 6 inches from the insulation surface.

e. Insulation shall be marked showing the location of unions, strainers, and check valves.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Factory precut or premolded insulation segments shall be used under the fitting covers for elbows. Insulation segments shall be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. The covers shall be secured by PVC vapor retarder tape, adhesive, seal welding or with tacks made for securing PVC covers. Seams in the cover, and tacks and laps to adjoining pipe insulation jacket, shall be sealed with vapor retarder tape to ensure that the assembly has a continuous vapor seal.

3.2.3 Aboveground Hot Pipelines

3.2.3.1 General Requirements

All hot pipe lines above 60 degrees F, except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted, shall be insulated in accordance with Table 2. This includes but is not limited to the following:

a. Domestic hot water supply & re-circulating system.

b. Steam.

c. Condensate & compressed air discharge.

d. Hot water heating.

e. Heated oil.

f. Water defrost lines in refrigerated rooms.

Insulation shall be covered, in accordance with manufacturer's recommendations, with a factory applied Type I jacket or field applied aluminum where required or seal welded PVC.

3.2.3.2 Insulation for Fittings and Accessories

Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant. Insulation shall be marked showing the location of unions, strainers, check valves and other components that would otherwise be hidden from view by the insulation.

3.2.3.2.1 Precut or Preformed

Place precut or preformed insulation around all fittings and accessories. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity.

3.2.3.2.2 Rigid Preformed

Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 2 inches or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow".

3.2.4 Piping Exposed to Weather

Piping exposed to weather shall be insulated and jacketed as specified for the applicable service inside the building. After this procedure, a laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability (greater than 3 ply, standard grade, silver, white, black and embossed aluminum jacket, stainless steel or PVC jacket shall be applied.

PVC jacketing requires no factory-applied jacket beneath it, however an all service jacket shall be applied if factory applied jacketing is not furnished. Flexible elastomeric cellular insulation exposed to weather shall be treated in accordance with paragraph INSTALLATION OF FLEXIBLE ELASTOMERIC CELLULAR INSULATION in PART 3.

3.2.4.1 Aluminum Jacket

The jacket for hot piping may be factory applied. The jacket shall overlap not less than 2 inches at longitudinal and circumferential joints and shall be secured with bands at not more than 12 inch centers. Longitudinal joints shall be overlapped down to shed water and located at 4 or 8 o'clock positions. Joints on piping 60 degrees F and below shall be sealed with metal jacketing/flashing sealant while overlapping to prevent moisture penetration. Where jacketing on piping 60 degrees F and below abuts an un-insulated surface, joints shall be caulked to prevent moisture penetration. Joints on piping above 60 degrees F shall be sealed with a moisture retarder.

3.2.4.2 Insulation for Fittings

Flanges, unions, valves, fittings, and accessories shall be insulated and finished as specified for the applicable service. Two coats of breather emulsion type weatherproof mastic (impermeable to water, permeable to air) recommended by the insulation manufacturer shall be applied with glass tape embedded between coats. Tape overlaps shall be not less than 1 inch and the adjoining aluminum jacket not less than 2 inches. Factory preformed aluminum jackets may be used in lieu of the above. Molded PVC fitting covers shall be provided when PVC jackets are used for straight runs of pipe. PVC fitting covers shall have adhesive welded joints and shall be weatherproof laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed, and UV resistant.

3.2.4.3 PVC Jacket

PVC jacket shall be ultraviolet resistant and adhesive welded weather tight with manufacturer's recommended adhesive. Installation shall include provision for thermal expansion.

3.2.4.4 Stainless Steel Jackets

ASTM A167 or ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (0.010 inch), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 1/2 inch.

3.2.5 Below Ground Pipe Insulation

Below ground pipes shall be insulated in accordance with Table 2, except as precluded in subparagraph Pipe Insulation in PART 3. This includes, but is not limited to the following:

a. Heated oil.

b. Domestic hot water.

c. Heating hot water.

d. Dual temperature water.

e. Steam.

f. Condensate.

3.2.5.1 Type of Insulation

Below ground pipe shall be insulated with Cellular Glass insulation, in accordance with manufacturer's instructions for application with thickness as determined from Table 2 (whichever is the most restrictive).

3.2.5.2 Installation of Below ground Pipe Insulation

a. Bore surfaces of the insulation shall be coated with a thin coat of gypsum cement of a type recommended by the insulation manufacturer. Coating thickness shall be sufficient to fill surface cells of insulation. Mastic type materials shall not be used for this coating. Note that unless this is for a cyclic application (i.e., one that fluctuates between high and low temperature on a daily process basis) there is no need to bore coat the material.

b. Stainless steel bands, 3/4 inch wide by 0.020 inch thick shall be used to secure insulation in place. A minimum of two bands per section of insulation shall be applied. As an alternate, fiberglass reinforced tape may be used to secure insulation on piping up to 12 inches in diameter. A minimum of two bands per section of insulation shall be applied.

c. Insulation shall terminate at anchor blocks but shall be continuous through sleeves and manholes.

d. At point of entry to buildings, underground insulation shall be terminated 2 inches inside the wall or floor, shall butt tightly against the aboveground insulation and the butt joint shall be sealed with high temperature silicone sealant and covered with fibrous glass tape.

e. Provision for expansion and contraction of the insulation system shall be made in accordance with the insulation manufacturer's recommendations.

f. Flanges, couplings, valves, and fittings shall be insulated with factory pre-molded, prefabricated, or field-fabricated sections of insulation of the same material and thickness as the adjoining pipe insulation. Insulation sections shall be secured as recommended by the manufacturer.

g. Insulation, including fittings, shall be finished with three coats of asphaltic mastic, with 6 by 5.5 mesh synthetic reinforcing fabric embedded between coats. Fabric shall be overlapped a minimum of 2 inches at joints. Total film thickness shall be a minimum of 3/16 inch. As an alternate, a prefabricated bituminous laminated jacket, reinforced with internal reinforcement mesh, shall be applied to the insulation. Jacketing material and application procedures shall match manufacturer's written instructions. Vapor barrier - less than 0.0000 permeability self adhesive (minimum 2 mils adhesive, 3 mils embossed) jacket greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive), heavy duty, white or natural). Application procedures shall match the manufacturer's written instructions.

h. At termination points, other than building entrances, the mastic and cloth or tape shall cover the ends of insulation and extend 2 inches along the bare pipe.

3.3 DUCT INSULATION SYSTEMS INSTALLATION

Install duct insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions. Duct insulation minimum thickness and insulation level must be as listed in Table 3 and must meet or exceed the requirements of ASHRAE 90.2.

Except for oven hood exhaust duct insulation, corner angles shall be installed on external corners of insulation on ductwork in exposed finished spaces before covering with jacket. Duct insulation shall be omitted on exposed supply and return ducts in air conditioned spaces where the difference between supply air temperature and room air temperature is less than 15 degrees F unless otherwise shown. Air conditioned spaces shall be defined as those spaces directly supplied with cooled conditioned air (or provided with a cooling device such as a fan-coil unit) and heated conditioned air (or provided with a heating device such as a unit heater, radiator or convector).

3.3.1 Duct Insulation Minimum Thickness

Duct insulation minimum thickness in accordance with Table 4.

Table 4 - Minimum Duct Insulation (inches)	
Cold Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5
Warm Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5

3.3.2 Insulation and Vapor Retarder/Vapor Barrier for Cold Air Duct

Insulation and vapor retarder/vapor barrier shall be provided for the following cold air ducts and associated equipment.

a. Supply ducts.

b. Return air ducts.

c. Relief ducts.

d. Flexible run-outs (field-insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes (field-insulated).

l. Supply fans (field-insulated).

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Combustion air intake ducts.

Insulation for rectangular ducts shall be flexible type where concealed, minimum density 3/4 pcf, and rigid type where exposed, minimum density 3 pcf. Insulation for both concealed or exposed round/oval ducts shall be flexible type, minimum density 3/4 pcf or a semi rigid board, minimum density 3 pcf, formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Insulation for all exposed ducts shall be provided with either a white, paint-able, factory-applied Type I jacket or a field applied vapor retarder/vapor barrier jacket coating finish as specified, the total field applied dry film thickness shall be approximately 1/16 inch. Insulation on all concealed duct shall be provided with a factory-applied Type I or II vapor retarder/vapor barrier jacket. Duct insulation shall be continuous through sleeves and prepared openings except firewall penetrations. Duct insulation terminating at fire dampers, shall be continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air and which may be prone to condensate formation. Duct insulation and vapor retarder/vapor barrier shall cover the collar, neck, and un-insulated surfaces of diffusers, registers and grills. Vapor retarder/vapor barrier materials shall be applied to form a complete unbroken vapor seal over the insulation. Sheet Metal Duct shall be sealed in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.3.2.1 Installation on Concealed Duct

a. For rectangular, oval or round ducts, flexible insulation shall be attached by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.

b. For rectangular and oval ducts, 24 inches and larger insulation shall be additionally secured to bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 16 inch centers and not more than 16 inches from duct corners.

c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 16 inch centers and not more than 16 inches from duct corners.

d. Insulation shall be impaled on the mechanical fasteners (self stick pins) where used and shall be pressed thoroughly into the adhesive. Care shall be taken to ensure vapor retarder/vapor barrier jacket joints overlap 2 inches. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type duct hangers.

e. Where mechanical fasteners are used, self-locking washers shall be installed and the pin trimmed and bent over.

f. Jacket overlaps shall be secured with staples and tape as necessary to ensure a secure seal. Staples, tape and seams shall be coated with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

g. Breaks in the jacket material shall be covered with patches of the same material as the vapor retarder jacket. The patches shall extend not less than 2 inches beyond the break or penetration in all directions and shall be secured with tape and staples. Staples and tape joints shall be sealed with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

h. At jacket penetrations such as hangers, thermometers, and damper operating rods, voids in the insulation shall be filled and the penetration sealed with a brush coat of vapor retarder coating or PVDC adhesive tape greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

i. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish or tape with a brush coat of vapor retarder coating.. The coating shall overlap the adjoining insulation and un-insulated surface 2 inches. Pin puncture coatings shall extend 2 inches from the puncture in all directions.

j. Where insulation standoff brackets occur, insulation shall be extended under the bracket and the jacket terminated at the bracket.

3.3.2.2 Installation on Exposed Duct Work

a. For rectangular ducts, rigid insulation shall be secured to the duct by mechanical fasteners on all four sides of the duct, spaced not more than 12 inches apart and not more than 3 inches from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 12 inches and larger. One row shall be provided for each side of duct less than 12 inches. Mechanical fasteners shall be as corrosion resistant as G60 coated galvanized steel, and shall indefinitely sustain a 50 lb tensile dead load test perpendicular to the duct wall.

b. Form duct insulation with minimum jacket seams. Fasten each piece of rigid insulation to the duct using mechanical fasteners. When the height of projections is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over. Vapor retarder/barrier jacket shall be continuous across seams, reinforcing, and projections. When height of projections is greater than the insulation thickness, insulation and jacket shall be carried over. Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors.

c. Impale insulation on the fasteners; self-locking washers shall be installed and the pin trimmed and bent over.

d. Seal joints in the insulation jacket with a 4 inch wide strip of tape. Seal taped seams with a brush coat of vapor retarder coating.

e. Breaks and ribs or standing seam penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 2 inches beyond the break or penetration and shall be secured with tape and stapled. Staples and joints shall be sealed with a brush coat of vapor retarder coating.

f. At jacket penetrations such as hangers, thermometers, and damper operating rods, the voids in the insulation shall be filled and the penetrations sealed with a flashing sealant.

g. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish. The coating shall overlap the adjoining insulation and un-insulated surface 2 inches. Pin puncture coatings shall extend 2 inches from the puncture in all directions.

h. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation with minimum density of 3/4 pcf, attached as in accordance with MICA standards.

3.3.3 Insulation for Warm Air Duct

Insulation and vapor barrier shall be provided for the following warm air ducts and associated equipment:.

a. Supply ducts.

b. Return air ducts.

c. Relief air ducts

d. Flexible run-outs (field insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil-headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes.

l. Supply fans.

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Exhaust ducts passing through concealed spaces exhausting conditioned air.

Insulation for rectangular ducts shall be flexible type where concealed, and rigid type where exposed. Insulation on exposed ducts shall be provided with a white, paint-able, factory-applied Type II jacket, or finished with adhesive finish. Flexible type insulation shall be used for round ducts, with a factory-applied Type II jacket. Insulation on concealed duct shall be provided with a factory-applied Type II jacket. Adhesive finish where indicated to be used shall be accomplished by applying two coats of adhesive with a layer of glass cloth embedded between the coats. The total dry film thickness shall be approximately 1/16 inch. Duct insulation shall be continuous through sleeves and prepared openings. Duct insulation shall terminate at fire dampers and flexible connections.

3.3.3.1 Installation on Concealed Duct

a. For rectangular, oval and round ducts, insulation shall be attached by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.

b. For rectangular and oval ducts 24 inches and larger, insulation shall be secured to the bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 18 inch centers and not more than 18 inches from duct corner.

c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 18 inch centers and not more than 18 inches from duct corners.

d. The insulation shall be impaled on the mechanical fasteners where used. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type hangers.

e. Self-locking washers shall be installed where mechanical fasteners are used and the pin trimmed and bent over.

f. Insulation jacket shall overlap not less than 2 inches at joints and the lap shall be secured and stapled on 4 inch centers.

3.3.3.2 Installation on Exposed Duct

a. For rectangular ducts, the rigid insulation shall be secured to the duct by the use of mechanical fasteners on all four sides of the duct, spaced not more than 16 inches apart and not more than 6 inches from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 12 inches and larger and a minimum of one row for each side of duct less than 12 inches.

b. Duct insulation with factory-applied jacket shall be formed with minimum jacket seams, and each piece of rigid insulation shall be fastened to the duct using mechanical fasteners. When the height of projection is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over the projection. Jacket shall be continuous across seams, reinforcing, and projections. Where the height of projections is greater than the insulation thickness, insulation and jacket shall be carried over the projection.

c. Insulation shall be impaled on the fasteners; self-locking washers shall be installed and pin trimmed and bent over.

d. Joints on jacketed insulation shall be sealed with a 4 inch wide strip of tape and brushed with vapor retarder coating.

e. Breaks and penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 2 inches beyond the break or penetration and shall be secured with adhesive and stapled.

f. Insulation terminations and pin punctures shall be sealed with tape and brushed with vapor retarder coating.

g. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation, minimum density of 3/4 pcf attached by staples spaced not more than 16 inches and not more than 6 inches from the degrees of joints. Joints shall be sealed in accordance with item "d." above.

3.3.4 Ducts Handling Air for Dual Purpose

For air handling ducts for dual purpose below and above 60 degrees F, ducts shall be insulated as specified for cold air duct.

3.3.5 Insulation for Evaporative Cooling Duct

Evaporative cooling supply duct located in spaces not evaporatively cooled, shall be insulated. Material and installation requirements shall be as specified for duct insulation for warm air duct.

3.3.6 Duct Test Holes

After duct systems have been tested, adjusted, and balanced, breaks in the insulation and jacket shall be repaired in accordance with the applicable section of this specification for the type of duct insulation to be repaired.

3.3.7 Duct Exposed to Weather

3.3.7.1 Installation

Ducts exposed to weather shall be insulated and finished as specified for the applicable service for exposed duct inside the building. After the above is accomplished, the insulation shall then be further finished as detailed in the following subparagraphs.

3.3.7.2 Round Duct

Laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - Less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply, heavy duty, white and natural) membrane shall be applied overlapping material by 3 inches no bands or caulking needed - see manufacturer's recommended installation instructions. Aluminum jacket with factory applied moisture retarder shall be applied with the joints lapped not less than 3 inches and secured with bands located at circumferential laps and at not more than 12 inch intervals throughout. Horizontal joints shall lap down to shed water and located at 4 or 8 o'clock position. Joints shall be sealed with metal jacketing sealant to prevent moisture penetration. Where jacketing abuts an un-insulated surface, joints shall be sealed with metal jacketing sealant.

3.3.7.3 Fittings

Fittings and other irregular shapes shall be finished as specified for rectangular ducts.

3.3.7.4 Rectangular Ducts

Two coats of weather barrier mastic reinforced with fabric or mesh for outdoor application shall be applied to the entire surface. Each coat of weatherproof mastic shall be 1/16 inch minimum thickness. The exterior shall be a metal jacketing applied for mechanical abuse and weather protection, and secured with screws or vapor barrier/weatherproofing jacket less than 0.0000 permeability greater than 3 ply, standard grade, silver, white, black, and embossed or greater than 8 ply, heavy duty white and natural. Membrane shall be applied overlapping material by 3 inches. No bands or caulking needed-see manufacturing recommend installation instructions.

3.3.8 Kitchen Exhaust Duct Insulation

NFPA 96 for ovens, griddles, deep fat fryers, steam kettles, vegetable steamers, high pressure cookers, and mobile serving units. Provide insulation with 3/4 inch wide, minimum 0.15 inch thick galvanized steel bands spaced not over 12 inches o.c.; or 16 gauge galvanized steel wire with corner clips under the wire; or with heavy welded pins spaced not over 12 inches apart each way. Do not use adhesives.

3.4 EQUIPMENT INSULATION SYSTEMS INSTALLATION

Install equipment insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

3.4.1 General

Removable insulation sections shall be provided to cover parts of equipment that must be opened periodically for maintenance including vessel covers, fasteners, flanges and accessories. Equipment insulation shall be omitted on the following:

a. Hand-holes.

b. Boiler manholes.

c. Cleanouts.

d. ASME stamps.

e. Manufacturer's nameplates.

f. Duct Test/Balance Test Holes.

3.4.2 Insulation for Cold Equipment

Cold equipment below 60 degrees F: Insulation shall be furnished on equipment handling media below 60 degrees F including the following:

a. Pumps.

b. Refrigeration equipment parts that are not factory insulated.

c. Drip pans under chilled equipment.

d. Cold water storage tanks.

e. Water softeners.

f. Duct mounted coils.

g. Cold and chilled water pumps.

h. Pneumatic water tanks.

i. Roof drain bodies.

j. Air handling equipment parts that are not factory insulated.

k. Expansion and air separation tanks.

3.4.2.1 Insulation Type

Insulation shall be suitable for the temperature encountered. Material and thicknesses shall be as shown in Table 5:

TABLE 5		
Insulation Thickness for Cold Equipment (inches)		
Equipment handling media at indicated temperature		
	Material	Thickness (inches)
35 to 60 degrees F		
	Cellular Glass	1.5
	Flexible Elastomeric Cellular	1
1 to 34 degrees F		
	Cellular Glass	3
	Flexible Elastomeric Cellular	1.5
Minus 30 to 0 degrees F		
	Cellular Glass	3.5
	Flexible Elastomeric Cellular	1.75

3.4.2.2 Pump Insulation

a. Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Joints between sides and between sides and bottom shall be joined by adhesive with lap strips for rigid mineral fiber and contact adhesive for flexible elastomeric cellular insulation. The box shall conform to the requirements of MICA Insulation Stds plate No. 49 when using flexible elastomeric cellular insulation. Joints between top cover and sides shall fit tightly forming a female shiplap joint on the side pieces and a male joint on the top cover, thus making the top cover removable.

b. Exposed insulation corners shall be protected with corner angles.

c. Upon completion of installation of the insulation, including removable sections, two coats of vapor retarder coating shall be applied with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 1/16 inch. A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. Flashing sealant shall be applied to parting line, between equipment and removable section insulation, and at all penetrations.

3.4.2.3 Other Equipment

a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.

b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not more than 12 inch centers except flexible elastomeric cellular which shall be adhered with contact adhesive. Insulation corners shall be protected under wires and bands with suitable corner angles.

c. Cellular glass shall be installed in accordance with manufacturer's instructions. Joints and ends shall be sealed with joint sealant, and sealed with a vapor retarder coating.

d. Insulation on heads of heat exchangers shall be removable. Removable section joints shall be fabricated using a male-female shiplap type joint. The entire surface of the removable section shall be finished by applying two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 1/16 inch.

e. Exposed insulation corners shall be protected with corner angles.

f. Insulation on equipment with ribs shall be applied over 6 by 6 inches by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 2 by 2 inches washers or shall be securely banded or wired in place on 12 inch centers.

3.4.2.4 Vapor Retarder/Vapor Barrier

Upon completion of installation of insulation, penetrations shall be caulked. Two coats of vapor retarder coating or vapor barrier jacket shall be applied over insulation, including removable sections, with a layer of open mesh synthetic fabric embedded between the coats. The total dry thickness of the finish shall be 1/16 inch. Flashing sealant or vapor barrier tape shall be applied to parting line between equipment and removable section insulation.

3.4.3 Insulation for Hot Equipment

Insulation shall be furnished on equipment handling media above 60 degrees F including the following:

a. Converters.

b. Heat exchangers.

c. Hot water generators.

d. Water heaters.

e. Pumps handling media above 130 degrees F.

f. Fuel oil heaters.

g. Hot water storage tanks.

h. Air separation tanks.

i. Surge tanks.

j. Flash tanks.

k. Feed-water heaters.

l. Unjacketed boilers or parts of boilers.

m. Boiler flue gas connection from boiler to stack (if inside).

n. Induced draft fans.

o. Fly ash and soot collectors.

p. Condensate receivers.

3.4.3.1 Insulation

Insulation shall be suitable for the temperature encountered. Shell and tube-type heat exchangers shall be insulated for the temperature of the shell medium.

Insulation thickness for hot equipment shall be determined using Table 6:

TABLE 6		
Insulation Thickness for Hot Equipment (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (inches)
15 psig or 250 degrees F		

TABLE 6		
Insulation Thickness for Hot Equipment (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (inches)
	Rigid Mineral Fiber	2
	Flexible Mineral Fiber	2
	Calcium Silicate/Perlite	4
	Cellular Glass	3
	Faced Phenolic Foam	1.5
	Flexible Elastomeric Cellular (<200 F)	1
200psig or 400 degrees F		
	Rigid Mineral Fiber	3
	Flexible Mineral Fiber	3
	Calcium Silicate/Perlite	4
	Cellular Glass	4
600 degrees F		
	Rigid Mineral Fiber	5
	Flexible Mineral Fiber	6
	Calcium Silicate/Perlite	6
	Cellular Glass	6
600 degrees F: Thickness necessary to limit the external temperature of the insulation to 120 F. Heat transfer calculations shall be submitted to substantiate insulation and thickness selection.		

3.4.3.2 Insulation of Boiler Stack and Diesel Engine Exhaust Pipe

Inside boiler House and mechanical Room, bevel insulation neatly around openings and provide sheet metal insulation stop strips around such openings. Apply a skim coat of hydraulic setting cement directly to insulation. Apply a flooding coat of adhesive over hydraulic setting cement, and while still wet, press a layer of glass cloth or tape into adhesive and seal laps and edges with adhesive. Coat glass cloth with adhesive. When dry, apply a finish coat of adhesive at can-consistency so that when dry no glass weave shall be observed. Provide metal jackets for stacks and exhaust pipes that are located above finished floor and spaces outside boiler house and . Apply metal jackets directly over insulation and secure with 3/4 inch wide metal bands spaced on 18 inch centers. Do not insulate name plates. Insulation type and thickness shall be in accordance with the following Table 7.

TABLE 7						
Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe						
Service & Surface Temperature Range (Degrees F)						
	Material	Outside Diameter (Inches)				
		0.25 - 1.25	1 - 1.67	3.5-5	6 - 10	> or = 11 - 36
Boiler Stack (Up to 400 degrees F)						
	Mineral Fiber ASTM C585 Class B-3, ASTM C547 Class 1, or ASTM C612 Class 1	N/A	N/A	3	3.5	4
	Calcium Silicate ASTM C533, Type 1	N/A	N/A	3	3.5	4
	Cellular Glass ASTM C552, Type II	1.5	1.5	1.5	2	2.5
Boiler Stack (401 to 600 degrees F)						
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	4	4	5
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	4	4	4
	Mineral Fiber/Cellular Glass Composite:					
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	1	1	1	1	2
	Cellular Glass ASTM C552, Type II	2	2	2	2	2

TABLE 7						
Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe						
Service & Surface Temperature Range (Degrees F)						
	Material	Outside Diameter (Inches)				
		0.25 - 1.25	1 - 1.67	3.5-5	6 - 10	> or = 11 - 36
Boiler Stack (601 to 800 degrees F)						
	Mineral Fiber ASTM C547 Class 3, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	4	4	6
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	4	4	6
	Mineral Fiber/Cellular Glass Composite:					
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	2	2	2	3	3
	Cellular Glass ASTM C552, Type II	2	2	2	2	2
Diesel Engine Exhaust (Up to 700 degrees F)						
	Calcium Silicate ASTM C533, Type I or II	3	3.5	4	4	4
	Cellular Glass ASTM C552, Type II	2.5	3.5	4	4.5	6

3.4.3.3 Insulation of Pumps

Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Bottom and sides shall be banded to form a rigid housing that does not rest on the pump. Joints between top cover and sides shall fit tightly. The top cover shall have a joint forming a female shiplap joint on the side pieces and a male joint on the top cover, making the top cover removable. Two coats of Class I adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. The total dry thickness of the finish shall be 1/16 inch. Caulking shall be applied to parting line of the removable sections and penetrations.

3.4.3.4 Other Equipment

a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.

b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not greater than 12 inch centers except flexible elastomeric cellular which shall be adhered. Insulation corners shall be protected under wires and bands with suitable corner angles.

c. On high vibration equipment, cellular glass insulation shall be set in a coating of bedding compound as recommended by the manufacturer, and joints shall be sealed with bedding compound. Mineral fiber joints shall be filled with finishing cement.

d. Insulation on heads of heat exchangers shall be removable. The removable section joint shall be fabricated using a male-female shiplap type joint. Entire surface of the removable section shall be finished as specified.

e. Exposed insulation corners shall be protected with corner angles.

f. On equipment with ribs, such as boiler flue gas connection, draft fans, and fly ash or soot collectors, insulation shall be applied over 6 by 6 inch by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 2 by 2 inch washers or shall be securely banded or wired in place on 12 inch (maximum) centers.

g. On equipment handling media above 600 degrees F, insulation shall be applied in two or more layers with joints staggered.

h. Upon completion of installation of insulation, penetrations shall be caulked. Two coats of adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 1/16 inch. Caulking shall be applied to parting line between equipment and removable section insulation.

3.4.4 Equipment Handling Dual Temperature Media

Below and above 60 degrees F: equipment handling dual temperature media shall be insulated as specified for cold equipment.

3.4.5 Equipment Exposed to Weather

3.4.5.1 Installation

Equipment exposed to weather shall be insulated and finished in accordance with the requirements for ducts exposed to weather in paragraph DUCT INSULATION INSTALLATION.

3.4.5.2 Optional Panels

At the option of the Contractor, prefabricated metal insulation panels may be used in lieu of the insulation and finish previously specified. Thermal performance shall be equal to or better than that specified for field applied insulation. Panels shall be the standard catalog product of a manufacturer of metal insulation panels. Fastenings, flashing, and support system shall conform to published recommendations of the manufacturer for weatherproof installation and shall prevent moisture from entering the insulation. Panels shall be designed to accommodate thermal expansion and to support a 250 pound walking load without permanent deformation or permanent damage to the insulation. Exterior metal cover sheet shall be aluminum and exposed fastenings shall be stainless steel or aluminum.

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SECTION 23 08 00.00 20

COMMISSIONING OF MECHANICAL SYSTEMS
02/21, CHG 1: 05/21

PART 1 GENERAL

Total Building Commissioning (TBCx) is a systematic, quality-focused process for enhancing the delivery of a project that focuses on verifying and documenting that all of the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the project requirements. The purpose is to reduce the cost and performance risks associated with delivering facilities projects, and to increase value to owners, occupants, and users.

1.1 DEFINITIONS

Commissioning Process (Cx) - a quality-focused process for enhancing the delivery of a project. Refer to ASHRAE 202 for a comprehensive description of the commissioning process.

Commissioning Provider (CxC)- The entity hired by the Government, who leads, plans, and coordinates the Commissioning Team. The terms Commissioning Provider, Commissioning Firm, Lead Commissioning Specialist, Commissioning Specialist, and Commissioning Authority (CA or CxA) when used by sustainable Third Party Certification (TPC) programs, are interchangeable.

Commissioning Authority - The Government retains the authority for oversight and assurance of the entire commissioning process, and final approval of all commissioning deliverables.

Government Acceptance Testing Representatives - Government Acceptance Testing Representatives perform the inherently Governmental function of technical oversight and quality assurance for critical systems, and is distinctly separate from the commissioning process. Government Acceptance Testing Representatives witness final testing of critical systems and report systems' acceptance to the COR. Submittals to be surveilled and approved by Government Acceptance Testing Representatives are identified in Section 01 33 00 SUBMITTAL PROCEDURES. Testing required to be witnessed by Government Acceptance Testing Representatives are indentified in system level sections.

1.2 SEQUENCING AND SCHEDULING

Complete functional performance testing prior to performance verification testing required by Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Complete the following prior to starting Functional Performance Tests of mechanical systems:

a. All equipment and systems completed, cleaned, flushed, disinfected, calibrated, tested, and operate in accordance with contract documents and construction plans and specifications

b. Final DALT Report submitted and approved in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC

c. Performance Verification Tests of the controls systems have been completed and the Performance Verification Test Report has been submitted and approved in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

d. The Certificate of Readiness submitted and approved in accordance with Section 01 91 00.15 20 TOTAL BUILDING COMMISSIONING

e. Pre-final Testing, Adjusting, and Balancing Report submitted in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC

f. Air Leakage Test Reports and Diagnostic Test Reports submitted and approved in accordance with Section 07 05 23 PRESSURE TESTING AN AIR BARRIER SYSTEM FOR AIR TIGHTNESS

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Test Equipment; G

SD-06 Test Reports

a. Commisioning Report

1. No later than 14 days after completion of Functional Performance Tests.

1.4 ACCESSIBILITY REQUIREMENTS

Equipment, systems, and devices for commissioned systems must be accessible. Make necessary modifications if systems and devices are not accessible for inspections and testing.

Assist commissioning team in testing by removing equipment covers, opening access panels, and other required activities that assist with visual oversight. Furnish ladders, flashlights, meters, gauges, or other inspection equipment as necessary.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

Provide all testing equipment required to perform testing for the systems to be commissioned, except for equipment specific to and used by TAB as required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Provide a sufficient quantity of two-way radios for each subcontractor. Submit list of Test Equipment and instrumentation to be used for testing including equipment/instrument identification number, equipment application or planned use, manufacturer, make, model, and serial number, and calibration history with certificates. Also list special equipment and proprietary tools specific to a piece of equipment required for testing.

2.1.1 Proprietary Equipment

Provide manufacturer's proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not. Provide manufacturer test equipment, demonstrate its use, and assist in the commissioning process as needed. Provide data logging equipment and software required to test equipment.

2.1.2 Calibration and Accuracy

Comply with equipment manufacturer's test equipment calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to Contracting Officer upon request.

Provide all testing equipment of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. Unless otherwise noted, the following minimum requirements apply: Provide temperature sensors and digital thermometers with a certified calibration within the past year to an accuracy of 0.5 degrees F and a resolution of plus or minus 0.1 degrees F. Provide pressure sensors with an accuracy of plus or minus 2.0 percent of the value range being measured (not full range of meter) and calibrated within the last year.

PART 3 EXECUTION

3.1 MEETINGS

Attend all meetings in accordance with Section 01 91 00.15 10 01 91 00.15 20 TOTAL BUILDING COMMISSIONING.

Provide timely updates on construction schedule changes so Commissioning Provider has scheduling information needed to execute commissioning process efficiently. Notify Contracting Officer of anticipated construction delays to commissioning activities not yet performed or not yet scheduled.

3.2 PREFUNCTIONAL CHECKS

Complete and sign Pre-Functional Checklists using the Commissioning Provider's web-based commissioning software, or as specified by the commissioning plan. Provide manufacturer's installation manual for each type of unit. Perform all work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements.

3.3 STARTUP AND INITIAL CHECKOUT

Document start-up and initial testing procedures including:

a. Startup tests and factory testing reports.

b. Manufacturer's representative start-up, operating, troubleshooting and maintenance procedures.

[c. Additional documentation necessary for third party certification programs.

] d. Perform and clearly document system operational checks and quality control checks as they are completed, and providing a copy to the commissioning team.

e. Correct deficiencies and sign the Certificate of Readiness for each system before functional performance testing

3.4 COMMISSIONING TESTING

Conduct Functional Performance Testing in accordance with Section 01 91 00.15 10 01 91 00.15 20 TOTAL BUILDING COMMISSIONING and requirements in this section. Prior to Functional Performance Testing, complete all prerequisites in accordance with paragraph SEQUENCING AND SCHEDULING.

3.4.1 Preparation

Put equipment and systems into operation and continue operation during each working day of commissioning, as required. Verify temperature and pressure taps in accordance with Contract Documents. Provide a pressure/temperature plug at each water sensor which is an input point to control system.

Perform minor adjustments to equipment and systems during Functional Performance Tests as deemed necessary by the commissioning team. Where calibrated DDC sensors cannot be used to record test data, provide measuring instruments, logging devices, and data acquisition equipment to record data for the complete range of test data for the required test period.

3.4.2 Test Setup

Perform each test under conditions that simulate actual conditions as close as is practically possible. Provide all necessary materials and system modifications to produce the necessary flows, pressures, temperatures, and other conditions necessary to execute the test according to the specified conditions. At completion of the test, return the affected building equipment and systems to their pre-test condition.

3.4.3 Manufacturer's Representative

Provide a factory trained representative authorized by the equipment manufacturer to perform Functional Performance Testing for the following equipment:

[Chillers

][Cooling towers and evaporatively cooled condensers

][Boilers

][Packaged Direct-Expansion Refrigeration Equipment, including variable refrigerant flow (VRF) systems

][Packaged Computer Room [Air Handlers (CRAH)] [Air Conditioners (CRAC)]

][Booster Pumps

][Packaged Air Compressors

][Water Quality and Chemical Treatment Systems

][Solar Water Heating Systems

][Ensure the test representative reviews, approves, and signs the completed field test report. Include person's name with signatures.

]3.4.4 Sample Strategy

Perform Functional Performance Tests using the sample strategy described in Section 01 91 00.15 10 01 91 00.15 20 TOTAL BUILDING COMMISSIONING. Prepare and complete a Functional Performance Test for each item of equipment or system to be tested. During testing, Government representatives may select the specific equipment or system to be tested for sample sizes less than 100 percent.

3.4.5 Simulating Conditions

Functional performance testing is conducted by simulating conditions at control devices to initiate a control system response. Before testing, calibrate all sensors, transducers and devices. Over-writing control input values through the control system is not acceptable unless approved by the Contracting Officer. Specific examples of simulating conditions are provided below. Do not simulate conditions when damage to the system or building may result.

a. When varying static pressures inside ductwork cannot be simulated within the duct, and where a sensor signals the controls system to initiate sequences at various duct static pressures, it is acceptable to simulate the various pressures with a Pneumatic Squeeze-Bulb Type Signaling Device with gauge temporarily attached to the sensing tube leading to the transmitter. It is not acceptable to reset the various set-points, nor to simulate an electric analog signal (unless approved as noted above).

b. Dirty filter pressure drops can be simulated by partially blocking filter face.

c. Freeze-stat safeties can be simulated by packing portion of sensor with ice.

d. High outside air temperatures can be simulated with a hair blower.

e. Raising entering cooling coil temperatures by activating a heating/preheat coil can be used to simulate entering cooling coil conditions.

f. Do not use signal generators to simulate sensor signals unless approved by the Contracting Officer, as noted above, for special cases.

g. Control set points can be altered. For example, to see the air conditioning compressor lockout work at an outside air temperature below 55 degrees F, when the outside air temperature is above 55 degrees F, temporarily change the lockout set point to be 0 degrees F above the current outside air temperature. Caution: Set points are not to be raised or lowered to a point to cause damage to the components, systems, or the building structure and/or contents.

h. Test duct mounted smoke detectors in accordance with the manufacturer's recommendations. Perform the tests with air system at minimum airflow condition.

i. Test current sensing relays used for fan and pump status signals to control system to indicate unit failure and run status by resetting the set point on the relay to simulate a lost belt or unit failure while the unit is running. Confirm that the failure alarm was generated and received at the control system. After the test is conducted, return the set point to its original set-point or a set-point as indicated by the Contracting Officer.

[3.4.6 Duct Air Leakage Test (DALT) Report Review

The Mechanical System Technical Commissioning Specialist must review the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for reviewing the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to DALT Report approval.

][3.4.7 Duct Air Leakage Test (DALT) Report Verification

The Mechanical System Technical Commissioning Specialist must witness the DALT Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for witnessing the DALT Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to DALT Report approval.

][3.4.8 Testing, Adjusting, and Balancing (TAB) Report Review

The Mechanical System Technical Commissioning Specialist must review the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for reviewing the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to TAB Report approval.

][3.4.9 Testing, Adjusting, and Balancing (TAB) Report Verification

The Mechanical System Technical Commissioning Specialist must witness the TAB Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for witnessing the TAB Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to TAB Report approval.

][3.4.10 HVAC Controls Test Procedures, Reports, and Trends Review

The Mechanical System Technical Commissioning Specialist must review the Start-Up Testing Report, PVT Procedures and PVT Reports including endurance testing trend submittals required by Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC[and Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION]. The Mechanical System Technical Commissioning Specialist must review each submittal and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. The Commissioning Specialist is responsible for reviewing the Start-Up Testing Report, PVT Procedures and PVT Reports including endurance testing trend data required by Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC[and Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION] and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to final acceptance.

]3.5 RETESTING REQUIREMENTS

Abort tests if any deficiency prevents successful completion of the test or if any required commissioning team member is not present for the test. Re-test only after all deficiencies identified during the original tests have been corrected.

If sequence of operation in any of Functional Performance Tests fails, the Government's costs for witnessing further demonstration of that test procedure may be assigned to the Contractor as a deduct to their contracted price, including salary, travel costs, and per diem for Government commissioning team members. Correct deficiencies as identified by the commissioning team and retest the systems to be commissioned.

3.6 SYSTEM ACCEPTANCE

Systems may be partially accepted prior to seasonal testing if they comply with all construction contract and accepted design requirements that can be tested during initial Functional Performance Tests. All test procedures must be successful completed prior to full systems acceptance.

[3.7 SEASONAL TESTS

Perform Initial Functional Performance Tests as soon as all contract work is completed, but prior to facility turnover, regardless of the season.

In addition to the Initial Functional Performance Tests, perform Functional Performance Tests of HVAC systems during season of maximum [heating][and][cooling] as defined by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Schedule Seasonal Functional Performance Tests in coordination with the Contracting Officer. Submit Seasonal Test Report within 14 days of test completion.

Execute seasonal functional performance testing, witnessed by the Contracting Officer. Correct deficiencies and make adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

][3.8 FULL-LOAD TESTS

Perform Initial Functional Performance Tests as soon as all contract work is completed, but prior to facility turnover. In addition to the Initial Functional Performance Tests, perform Functional Performance Tests of HVAC systems under full-load conditions.[Develop and implement means of artificial loading to demonstrate the ability of the process cooling systems to handle peak process loads.] Schedule Full-Load Functional Performance Tests in coordination with the Contracting Officer. Submit Full-Load Test Report within 14 days of test completion.

Execute full-load functional performance testing, witnessed by the Contracting Officer. Correct deficiencies and make adjustments to O&M manuals and as-built drawings for applicable issues identified in any full load testing.

]3.9 TRAINING

The Mechanical Systems Technical Commissioning Specialist must review the training plan required by Section 01 78 00 OPERATION AND MAINTENANCE DATA and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel.

The Commissioning Provider is responsible for overseeing and approving the training plan required by Section 01 78 00 OPERATION AND MAINTENANCE DATA and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel.

Coordinate, schedule, and document all required training. At a minimum, include the following items in the training report for commissioned systems:

a. Complete commissioning documentation

b. Complete O&M data

c. Complete Training

d. Purpose of equipment.

e. Principle of how the equipment works.

f. Important parts and assemblies.

g. How the equipment achieves its purpose and necessary operating conditions.

h. Most likely failure modes, causes and corrections.

i. On site demonstration.

j. Provide updates to O&M manuals based on field modifications.

k. Provide training of the post-occupancy operations and maintenance staff.

-- End of Section --

SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC
02/19, CHG 3: 05/21

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system, except for the Front End which is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL (UMCS) FRONT END AND INTEGRATION, suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as indicated and shown and in accordance with Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC,[Section 23 09 93 SEQUENCES OF OPERATION FOR HVAC CONTROL,] Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for LNS LonWorks systems or Niagara LonWorks systems, and Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, and other referenced Sections.

[1.1.1 Control System Vendor Requirement

The control system provided under this Section must be [_____]. Configure the equipment as indicated in [attached configuration setting requirements][the configuration settings drawings][_____].

]1.1.2 Proprietary Systems

1.1.2.1 Proprietary Systems Exempted From Open Protocol Requirements

The following systems are specifically exempted from the open protocol requirements of Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS:

a. A simple split (DX) system consisting of a single indoor unit and a single outdoor unit from the same manufacturer.

b. Systems in Table I (previously approved by the designer in accordance with UFC 3-410-02).

TABLE I: Systems Approved to Use Proprietary Communications		
System	Type (Multi-Split/VRF or Chiller/Boiler Plant)	Proprietary Multi-Split Engineering Tool Software Required (for Multi-Split/VRF only)

c. A system (not already shown Table I) of multiple boilers or multiple chillers communicating with a proprietary network for which an approved request has been obtained and for which: all units are from the same manufacturer, they are all co-located in the same room, the network connecting them is fully contained in that room, and the units are operating using a common "plant" sequence of operation which stages the units in a manner that requires operational parameters be shared between them and which cannot be accomplished with a single lead-lag command from a third-party controller.

1.1.2.2 Implementation of Proprietary Systems

For proprietary systems exempted from open protocol requirements, a proprietary network and DDC hardware communicating via proprietary protocol are permitted. For these systems a building control network meeting the requirements of Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS must also be provided, along with a gateway or interface to connect the proprietary system to the open building control network.

The proprietary system gateway or interface must provide the required functionaliality as shown on the points schedule. Scheduling, alarming, trending, overrides, network inputs, network outputs and other protocol related requirements must be met on the open protocol control system as specified in Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

1.1.2.3 Proprietary Multi-Split Engineering Tool Software

For each permitted proprietary systems in Table 1 shown as requiring Proprietary Multi-Split Engineering Tool Software, provide the software needed to replace a unit and configure the replacement. Submit hard copies of the software user manuals with the software submittal.

Submit Proprietary Multi-Split Engineering Tool Software on CD-ROM as a Technical Data Package. Submit [_____] hard copies of the software user manual for each piece of software.

1.1.3 System Requirements

Provide systems meeting the requirements this Section and other Sections referenced by this Section, and which have the following characteristics:

a. The system implements the control sequences of operation [shown in the Contract Drawings][___] using DDC hardware to control mechanical and electrical equipment

b. The system meet the requirements of this specification as a stand-alone system and does not require connection to any other system.

c. Control sequences reside in DDC hardware in the building. The building control network is not dependent upon connection to a Utility Monitoring and Control System (UMCS) Front End or to any other system for performance of control sequences. To the greatest extent practical, the hardware performs control sequences without reliance on the building network, unless otherwise pre-approved by the Contracting Officer.

d. The hardware is installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

e. All necessary documentation, configuration information, programming tools, programs, drivers, and other software are licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer.

f. Sufficient documentation and data, including rights to documentation and data, are provided such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer.

g. Hardware is installed and configured such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the Contractor, Vendor or Manufacturer.

h. All Niagara Framework components have an unrestricted interoperability license with a Niagara Compatibility Statement (NiCS) following the Tridium Open NiCS Specification and have a value of "ALL" for "Station Compatibility In", "Station Compatibility Out", "Tool Compatibility In" and "Tool Compatibility Out". Note that this will result in the following entries in the license file:

```
accept.station.in="*"
accept.station.out="*"
accept.wb.in="*"
accept.wb.out="*"
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1.1.4 End to End Accuracy

Select products, install and configure the system such that the maximum error of a measured value as read from the DDC Hardware over the network is less than the maximum allowable error specified for the sensor or instrumentation.

1.1.5 Verification of Dimensions

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.1.6 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.2 RELATED SECTIONS

Related work specified elsewhere:

a. Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for LonWorks Systems using LNS or Niagara Framework or Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet systems with or without Niagara Framework.

b. Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

c. Section 23 09 93 SEQUENCES OF OPERATIONS FOR HVAC CONTROLS

d. Section 25 08 10 UTILITY MONITORING AND CONTROL SYSTEMS TESTING

e. Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEMS (UMCS) FRONT END AND INTEGRATION

f. Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS

g. [Section [01 91 00.15 10][01 91 00.15 20] TOTAL BUILDING COMMISSIONING][_____]

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135	(2016) BACnet—A Data Communication Protocol for Building Automation and Control Networks
ASHRAE FUN IP	(2021) Fundamentals Handbook, I-P Edition

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification
CEA-709.3	(1999; R 2015) Free-Topology Twisted-Pair Channel Specification

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA

	20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

TRIDIUM, INC (TRIDIUM)

Niagara Framework	(2012) NiagaraAX User's Guide
Tridium Open NiCS	(2005) Understanding the NiagaraAX Compatibility Statement (NiCS)

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-410-02	(2018; with Change 2, 2021) Direct Digital Control for HVAC and Other Building Control Systems

UNDERWRITERS LABORATORIES (UL)

UL 5085-3	(2006; Reprint Jan 2022) UL Standard for Safety Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers

1.4 DEFINITIONS

The following list of definitions includes terms used in Sections referenced by this Section and are included here for completeness.The definitions contained in this Section may disagree with how terms are defined or used in other documents, including documents referenced by this Section. The definitions included here are the authoritative definitions for this Section and all Sections referenced by this Section.

After each term the protocol related to that term is included in parenthesis.

1.4.1 Alarm Generation (All protocols)

Alarm Generation is the monitoring of a value, comparison of the value to alarm conditions and the creation of an alarm when the conditions set for the alarm are met. Note that this does NOT include delivery of the alarm to the final destination (such as a user interface) - see paragraph ALARM ROUTING in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION.

1.4.2 Application Generic Controller (AGC) (LonWorks)

A device that is furnished with a (limited) pre-established application that also has the capability of being programmed. Further, the ProgramID and XIF file of the device are fixed. The programming capability of an AGC may be less flexible than that of a General Purpose Programmable Controller (GPPC).

1.4.3 Application Specific Controller (ASC) (LonWorks)

A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e Program ID) with configurable settings.

1.4.4 Building Automation and Control Network (BACnet) (BACnet)

The term BACnet is used in two ways. First meaning the BACnet Protocol Standard - the communication requirements as defined by ASHRAE 135 including all annexes and addenda. The second to refer to the overall technology related to the ASHRAE 135 protocol.

1.4.5 BACnet Advanced Application Controller (B-AAC) (BACnet)

A hardware device BTL Listed as a B-AAC, which is required to support BACnet Interoperability Building Blocks (BIBBs) for scheduling and alarming, but is not required to support as many BIBBs as a B-BC.

1.4.6 BACnet Application Specific Controller (B-ASC) (BACnet)

A hardware device BTL Listed as a B-ASC, with fewer BIBB requirements than a B-AAC. It is intended for use in a specific application.

1.4.7 BACnet Building Controller (B-BC) (BACnet)

A hardware device BTL Listed as a B-BC. A general-purpose, field-programmable device capable of carrying out a variety of building automation and control tasks including control and monitoring via direct digital control (DDC) of specific systems and data storage for trend information, time schedules, and alarm data. Like the other BTL Listed controller types (B-AAC, B-ASC etc.) a B-BC device is required to support the server ("B") side of the ReadProperty and WriteProperty services, but unlike the other controller types it is also required to support the client ("A") side of these services. Communication between controllers requires that one of them support the client side and the other support the server side, so a B-BC is often used when communication between controllers is needed.

1.4.8 BACnet Broadcast Management Device (BBMD) (BACnet)

A communications device, typically combined with a BACnet router. A BBMD forwards BACnet broadcast messages to BACnet/IP devices and other BBMDs connected to the same BACnet/IP network. Each IP subnet that is part of a BACnet/IP network must have at least one BBMD. Note there are additional restrictions when multiple BBMDs share an IP subnet.

1.4.9 BACnet/IP (BACnet)

An extension of BACnet, Annex J, defines the use of a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnets that share the same BACnet network number. See also paragraph BACNET BROADCAST MANAGEMENT DEVICE.

1.4.10 BACnet Internetwork (BACnet)

Two or more BACnet networks, connected with BACnet routers. In a BACnet Internetwork, there exists only one message path between devices.

1.4.11 BACnet Interoperability Building Blocks (BIBBs) (BACnet)

A BIBB is a collection of one or more ASHRAE 135 Services intended to define a higher level of interoperability. BIBBs are combined to build the BACnet functional requirements for a device in a specification. Some BIBBs define additional requirements (beyond requiring support for specific services) in order to achieve a level of interoperability. For example, the BIBB DS-V-A (Data Sharing-View-A), which would typically be used by a front-end, not only requires the client to support the ReadProperty Service, but also provides a list of data types (Object / Properties) which the client must be able to interpret and display for the user.

In the BIBB shorthand notation, -A is the client side and -B is the server side.

The following is a list of some BIBBs used by this or referenced Sections:	
DS-COV-A	Data Sharing-Change of Value (A side)
DS-COV-B	Data Sharing-Change of Value (B side)
NM-RC-B	Network Management-Router Configuration (B side)
DS-RP-A	Data Sharing-Read Property (A side)
DS-RP-B	Data Sharing-Read Property (B side)
DS-RPM-A	Data Sharing-Read Property Multiple (A Side)
DS-RPM-B	Data Sharing-Read Property Multiple (B Side)
DS-WP-A	Data Sharing-Write Property (A Side)
DM-TS-B	Device Management-Time Synchronization (B Side)
DM-UTC-B	Device Management-UTC Time Synchronization (B Side)
DS-WP-B	Data Sharing-Write Property (B side)
SCHED-E-B	Scheduling-External (B side)
DM-OCD-B	Device Management-Object Creation and Deletion (B side)
AE-N-I-B	Alarm and Event-Notification Internal (B Side)
AE-N-E-B	Alarm and Event-Notification External (B Side)
T-VMT-I-B	Trending-Viewing and Modifying Trends Internal (B Side)
T-VMT-E-B	Trending-Viewing and Modifying Trends External (B Side)

1.4.12 BACnet Network (BACnet)

In BACnet, a portion of the control Internetwork consisting of one or more segments connected by repeaters. Networks are separated by routers.

1.4.13 BACnet Operator Display (B-OD) (BACnet)

A basic operator interface with limited capabilities relative to a B-OWS. It is not intended to perform direct digital control. A B-OD profile could be used for LCD devices, displays affixed to BACnet devices, handheld terminals or other very simple user interfaces.

1.4.14 BACnet Segment (BACnet)

One or more physical segments interconnected by repeaters (ASHRAE 135).

1.4.15 BACnet Smart Actuator (B-SA) (BACnet)

A simple actuator device with limited resources intended for specific applications.

1.4.16 BACnet Smart Sensor (B-SS) (BACnet)

A simple sensing device with limited resources.

1.4.17 BACnet Testing Laboratories (BTL) (BACnet)

Established by BACnet International to support compliance testing and interoperability testing activities and consists of BTL Manager and the BTL Working Group (BTL-WG). BTL also publishes Implementation Guidelines.

1.4.18 BACnet Testing Laboratories (BTL) Listed (BACnet)

A device that has been listed by BACnet Testing Laboratory. Devices may be certified to a specific device profile, in which case the listing indicates that the device supports the required capabilities for that profile, or may be listed as "other".

1.4.19 Binary (All protocols)

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

1.4.20 Binding (LonWorks)

The act of establishing communications between CEA-709.1-D devices by associating the output of a device to the input of another so that information is automatically (and regularly) sent.

1.4.21 Broadcast (BACnet)

Unlike most messages, which are intended for a specific recipient device, a broadcast message is intended for all devices on the network.

1.4.22 Building Control Network (BCN) (All protocols)

The network connecting all DDC Hardware within a building (or specific group of buildings).

1.4.23 Building Point of Connection (BPOC) (All protocols)

A FPOC for a Building Control System. (This term is being phased out of use in preference for FPOC but is still used in some specifications and criteria. When it was used, it typically referred to a piece of control hardware. The current FPOC definition typically refers instead to IT hardware.)

1.4.24 Channel (LonWorks)

A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 128 devices per channel.

1.4.25 Commandable (All protocols)

See Overridable.

1.4.26 Commandable Objects (BACnet)

Commandable Objects have a Commandable Property, Priority_Array, and Relinquish_Default Property as defined in ASHRAE 135, Clause 19.2, Command Prioritization.

1.4.27 Configurable (All protocols)

A property, setting, or value is configurable if it can be changed via hardware settings on the device, via the use of engineering software or over the control network from the front end, and is retained through (after) loss of power.

In a non-Niagara Framework BACnet system, a property, setting, or value is configurable if it can be changed via one or more of:

1) via BACnet services (including proprietary BACnet services)
2) via hardware settings on the device

In a Niagara Framework BACnet system, a property, setting, or value is configurable if it can be changed via one or more of:

1) via BACnet services (including proprietary BACnet services)
2) via hardware settings on the device
3) via the Niagara Framework

Note this is more stringent than the ASHRAE 135 definition.

1.4.28 Configuration Property (LonWorks)

Controller parameter used by the application which is usually set during installation/testing and seldom changed. For example, the P and I settings of a P-I control loop. Also see paragraph STANDARD CONFIGURATION PROPERTY TYPE (SCPT).

1.4.29 Control Logic Diagram (All protocols)

A graphical representation of control logic for multiple processes that make up a system.

1.4.30 Device (BACnet)

A Digital Controller that contains a BACnet Device Object and uses BACnet to communicate with other devices.

1.4.31 Device Object (BACnet)

Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet Internetwork. This number is often referred to as the device instance or device ID.

1.4.32 Device Profile (BACnet)

A collection of BIBBs determining minimum BACnet capabilities of a device, defined in ASHRAE 135. Standard device profiles include BACnet Advanced Workstations (B-AWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS).

1.4.33 Digital Controller (All protocols)

An electronic controller, usually with internal programming logic and digital and analog input/output capability, which performs control functions.

1.4.34 Direct Digital Control (DDC) (All protocols)

Digital controllers performing control logic. Usually the controller directly senses physical values, makes control decisions with internal programs, and outputs control signals to directly operate switches, valves, dampers, and motor controllers.

1.4.35 Domain (LonWorks)

A grouping of up to 32,385 nodes that can communicate directly with each other. (Devices in different domains cannot communicate directly with each other.) See also Node Address.

1.4.36 Explicit Messaging (LonWorks)

A non-standard and often vendor (application) specific method of communication between devices where each message contains a message code that identifies the type of message and the devices use these codes to determine the action to take when the message is received.

1.4.37 External Interface File (XIF) (LonWorks)

A file which documents a device's external interface, specifically the number and types of LonMark objects, the number, types, directions, and connection attributes of network variables, and the number of message tags.

1.4.38 Field Point of Connection (FPOC) (All protocols)

The FPOC is the point of connection between the UMCS IP Network and the field control network (either an IP network, a non-IP network, or a combination of both). The hardware at this location which provides the connection is generally an IT device such as a switch, IP router, or firewall.

In general, the term "FPOC Location" means the place where this connection occurs, and "FPOC Hardware" means the device that provides the connection. Sometimes the term "FPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

1.4.39 Fox Protocol (Niagara Framework)

The protocol used for communication between components in the Niagara Framework. By default, Fox uses TCP port 1911.

1.4.40 Functional Profile (LonWorks)

A standard description, defined by LonMark, of one or more LonMark Objects used to classify and certify devices.

1.4.41 Gateway (All protocols)

A device that translates from one protocol application data format to another. Devices that change only the transport mechanism of the protocol - "translating" from TP/FT-10 to Ethernet/IP or from BACnet MS/TP to BACnet over IP for example - are not gateways as the underlying data format does not change. Gateways are also called Communications Bridges or Protocol Translators.

A Niagara Framework Supervisory Gateway is one type of Gateway.

1.4.42 General Purpose Programmable Controller (GPPC) (LonWorks)

Unlike an ASC or AGC, a GPPC is not furnished with a fixed application program and does not have a fixed ProgramID or XIF file. A GPPC can be (re-)programmed, usually using vendor-supplied software. When a change to the program affects the external interface (and the XIF file) the ProgramID will change.

1.4.43 IEEE 802.3 Ethernet (All protocols)

A family of local-area-network technologies providing high-speed networking features over various media, typically Cat 5, 5e or Cat 6 twisted pair copper or fiber optic cable.

1.4.44 Internet Protocol (IP, TCP/IP, UDP/IP) (All protocols)

A communication method, the most common use is the World Wide Web. At the lowest level, it is based on Internet Protocol (IP), a method for conveying and routing packets of information over various LAN media. Two common protocols using IP are User Datagram Protocol (UDP) and Transmission Control Protocol (TCP). UDP conveys information to well-known "sockets" without confirmation of receipt. TCP establishes connections, also known as "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

1.4.45 Input/Output (I/O) (All protocols)

Physical inputs and outputs to and from a device, although the term sometimes describes network or "virtual" inputs or outputs. See also "Points".

1.4.46 I/O Expansion Unit (All protocols)

An I/O expansion unit provides additional point capacity to a digital controller

1.4.47 IP subnet (All protocols)

A group of devices which share a defined range IP addresses. Devices on a common IP subnet can share data (including broadcasts) directly without the need for the traffic to traverse an IP router.

1.4.48 JACE (Niagara Framework)

Java Application Control Engine. See paragraph NIAGARA FRAMEWORK SUPERVISORY GATEWAY

1.4.49 Local-Area Network (LAN) (All protocols)

A communication network that spans a limited geographic area and uses the same basic communication technology throughout.

1.4.50 Local Display Panels (LDPs) (All protocols)

A DDC Hardware with a display and navigation buttons, and must provide display and adjustment of points as shown on the Points Schedule and as indicated.

1.4.51 LonMark (LonWorks)

See paragraph LONMARK INTERNATIONAL. Also, a certification issued by LonMark International to CEA-709.1-D devices.

1.4.52 LonMark International (LonWorks)

Standards committee consisting of numerous independent product developers, system integrators and end users dedicated to determining and maintaining the interoperability guidelines for LonWorks. Maintains guidelines for the interoperability of CEA-709.1-D devices and issues the LonMark Certification for CEA-709.1-D devices.

1.4.53 LonMark Interoperability Association (LonWorks)

See paragraph LONMARK INTERNATIONAL.

1.4.54 LonMark Object (LonWorks)

A collection of network variables, configuration properties, and associated behavior defined by LonMark International and described by a Functional Profile. It defines how information is exchanged between devices on a network (inputs from and outputs to the network).

1.4.55 LonWorks (LonWorks)

The term used to refer to the overall technology related to the CEA-709.1-D protocol (sometimes called "LonTalk"), including the protocol itself, network management, interoperability guidelines and products.

1.4.56 LonWorks Network Services (LNS) (LonWorks)

A network management and database standard for CEA-709.1-D devices.

1.4.57 LonWorks Network Services (LNS) Plug-in (LonWorks)

Software which runs in an LNS compatible software tool, typically a network configuration tool. Device configuration plug-ins provide a user friendly method to edit a device's configuration properties.

1.4.58 MAC Address (All protocols)

Media Access Control address. The physical device address that identifies a device on a Local Area Network.

1.4.59 Master-Slave/Token-Passing (MS/TP) (BACnet)

Data link protocol as defined by the BACnet standard. Multiple speeds (data rates) are permitted by the BACnet MS/TP standard.

1.4.60 Monitoring and Control (M&C) Software (All protocols)

The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

1.4.61 Network Number (BACnet)

A site-specific number assigned to each network. This network number must be unique throughout the BACnet Internetwork.

1.4.62 Network Variable (LonWorks)

See paragraph STANDARD NETWORK VARIABLE TYPE (SNVT).

1.4.63 Network Configuration Tool (LonWorks)

The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

1.4.64 Niagara Framework (Niagara Framework)

A set of hardware and software specifications for building and utility control owned by Tridium Inc. and licensed to multiple vendors. The Framework consists of front end (M&C) software, web based clients, field level control hardware, and engineering tools. While the Niagara Framework is not adopted by a recognized standards body and does not use an open licensing model, it is sufficiently well-supported by multiple HVAC vendors to be considered a de-facto Open Standard.

1.4.65 Niagara Framework Supervisory Gateway (Niagara Framework)

DDC Hardware component of the Niagara Framework. A typical Niagara architecture has Niagara specific supervisory gateways at the IP level and other (non-Niagara specific) controllers on field networks (TP/FT-10, MS/TP, etc.) beneath the Niagara supervisory gateways. The Niagara specific controllers function as a gateway between the Niagara framework protocol (Fox) and the field network beneath. These supervisory gateways may also be used as general purpose controllers and also have the capability to provide a web-based user interface.

Note that different vendors refer to this component by different names. The most common name is "JACE"; other names include (but are not limited to)"EC-BOS", "FX-40", "TMN", "SLX" and "UNC".

1.4.66 Node (LonWorks)

A device that communicates using the CEA-709.1-D protocol and is connected to a CEA-709.1-D network.

1.4.67 Node Address (LonWorks)

The logical address of a node on the network, consisting of a Domain number, Subnet number and Node number. Note that the "Node number" portion of the address is the number assigned to the device during installation and is unique within a subnet. This is not the factory-set unique Node ID (see Node ID).

1.4.68 Node ID (LonWorks)

A unique 48-bit identifier assigned (at the factory) to each CEA-709.1-D device. Sometimes called the Neuron ID.

1.4.69 Object (BACnet)

An ASHRAE 135 Object. The concept of organizing BACnet information into standard components with various associated Properties. Examples include Analog Input objects and Binary Output objects.

1.4.70 Object Identifier (BACnet)

A grouping of two Object properties: Object Type (e.g. Analog Value, Schedule, etc.) and Object Instance (in this case, a number). Object Identifiers must be unique within a device.

1.4.71 Object Instance (BACnet)

See paragraph OBJECT IDENTIFIER

1.4.72 Object Properties (BACnet)

Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

1.4.73 Operator Configurable (All protocols)

Operator configurable values are values that can be changed from a single common front end user interface across multiple vendor systems.

For Niagara Framework Systems, a property, setting, or value is Operator Configurable when it is configurable from a Niagara Framework Front End.

For LNS LonWorks systems, Operator Configurable is defined the same as Configurable. See paragraph CONFIGURABLE.

For non Niagara-based BACnet systems, a property, setting, or value in a device is Operator Configurable when it is Configurable and is either:

a. a Writable Property of a Standard BACnet Object; or

b. a Property of a Standard BACnet Object that is Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable.

1.4.74 Override (All protocols)

Changing the value of a point outside of the normal sequence of operation where the change has priority over the sequence and where there is a mechanism for releasing the change such that the point returns to the normal value. Overrides persist until released or overridden at the same or higher priority but are not required to persist through a loss of power. Overrides are often used by operators to change values, and generally originate at a user interface (workstation or local display panel).

1.4.75 Packaged Equipment (All protocols)

Packaged equipment is a single piece of equipment provided by a manufacturer in a substantially complete and operable condition, where the controls (DDC Hardware) are factory installed, and the equipment is sold and shipped from the manufacturer as a single entity. Disassembly and reassembly of a large piece of equipment for shipping does not prevent it from being packaged equipment. Package units may require field installation of remote sensors. Packaged equipment is also called a "packaged unit".

Note industry may use the term "Packaged System" to mean a collection of equipment that is designed to work together where each piece of equipment is packaged equipment and there is a network that connects the equipment together. A "packaged system" of this type is NOT packaged equipment; it is a collection of packaged equipment, and each piece of equipment must individually meet specification requirements.

1.4.76 Packaged Unit (All protocols)

See packaged equipment.

1.4.77 Performance Verification Test (PVT) (All protocols)

The procedure for determining if the installed BAS meets design criteria prior to final acceptance. The PVT is performed after installation, testing, and balancing of mechanical systems. Typically the PVT is performed by the Contractor in the presence of the Government.

1.4.78 Physical Segment (BACnet)

A single contiguous medium to which BACnet devices are attached (ASHRAE 135).

1.4.79 Polling (All protocols)

A device periodically requesting data from another device.

1.4.80 Points (All protocols)

Physical and virtual inputs and outputs. See also paragraph INPUT/OUTPUT (I/O).

1.4.81 Program ID (LonWorks)

An identifier (number) stored in the device that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and the intended device usage.

1.4.82 Proportional, Integral, and Derivative (PID) Control Loop (All protocols)

Three parameters used to control modulating equipment to maintain a setpoint. Derivative control is often not required for HVAC systems (leaving "PI" control).

1.4.83 Proprietary (BACnet)

Within the context of BACnet, any extension of or addition to object types, properties, PrivateTransfer services, or enumerations specified in ASHRAE 135. Objects with Object_Type values of 128 and above are Proprietary Objects. Properties with Property_Identifier of 512 and above are proprietary Properties.

1.4.84 Protocol Implementation Conformance Statement (PICS) (BACnet)

A document, created by the manufacturer of a device, which describes which portions of the BACnet standard may be implemented by a given device. ASHRAE 135 requires that all ASHRAE 135 devices have a PICS, and also defines a minimum set of information that must be in it. A device as installed for a specific project may not implement everything in its PICS.

1.4.85 Repeater (All protocols)

A device that connects two control network segments and retransmits all information received on one side onto the other.

1.4.86 Router (All protocols)

A device that connects two CEA-709.1-D channels (in a LonWorks system) or two ASHRAE 135 networks (in a BACnet system) and controls traffic between the two by retransmitting signals received from one side onto the other based on the signal destination. Routers are used to subdivide a LonWorks control network or a BACnet internetwork and to limit network traffic.

1.4.87 Segment (All protocols)

A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type. For example, in a LonWorks system a TP/FT-10 network with locally powered devices is limited to 64 devices per segment.

1.4.88 Service Pin (LonWorks)

A hardware push-button on a device which causes the device to broadcast a message (over the control network) containing its Node ID and Program ID.

1.4.89 Standard BACnet Objects (BACnet)

Objects with Object_Type values below 128 and specifically enumerated in Clause 21 of ASHRAE 135. Objects which are not proprietary. See paragraph PROPRIETARY.

1.4.90 Standard BACnet Properties (BACnet)

Properties with Property_Identifier values below 512 and specifically enumerated in Clause 21 of ASHRAE 135. Properties which are not proprietary. See Proprietary.

1.4.91 Standard BACnet Services (BACnet)

ASHRAE 135 services other than ConfirmedPrivateTransfer or UnconfirmedPrivateTransfer. See paragraph PROPRIETARY.

1.4.92 Standard Configuration Property Type (SCPT) (LonWorks)

Pronounced skip-it. A standard format type (maintained by LonMark International) for Configuration Properties.

1.4.93 Standard Network Variable Type (SNVT) (LonWorks)

Pronounced snivet. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

1.4.94 Subnet (LonWorks)

Consists of a logical grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Each subnet is assigned a number which is unique within the Domain. See also paragraph NODE ADDRESS.

1.4.95 TP/FT-10 (LonWorks)

A Free Topology Twisted Pair network defined by CEA-709.3. This is the most common media type for a CEA-709.1-D control network.

1.4.96 TP/XF-1250 (LonWorks)

A high speed (1.25 Mbps) twisted pair, doubly-terminated bus network defined by the LonMark Interoperability Guidelines. This media is typically used only as a backbone media to connect multiple TP/FT-10 networks.

1.4.97 User-defined Configuration Property Type (UCPT) (LonWorks)

Pronounced u-keep-it. A Configuration Property format type that is defined by the device manufacturer.

1.4.98 User-defined Network Variable Type (UNVT) (LonWorks)

A network variable format defined by the device manufacturer. Note that UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.4.99 UMCS (All protocols)

UMCS stands for Utility Monitoring and Control System. The term refers to all components by which a project site monitors, manages, and controls real-time operation of HVAC and other building systems. These components include the UMCS "front-end" and all field building control systems connected to the front-end. The front-end consists of Monitoring and Control Software (user interface software), browser-based user interfaces and network infrastructure.

The network infrastructure (the "UMCS Network"), is an IP network connecting multiple building or facility control networks to the Monitoring and Control Software.

1.4.100 UMCS Network (All protocols)

The UMCS Network connects multiple building or facility control networks to the Monitoring and Control Software.

1.4.101 Writable Property (BACnet)

A Property is Writable when it can be changed through the use of one or more of the WriteProperty services defined in ASHRAE 135, Clause 15 regardless of the value of any other Property. Note that in the ASHRAE 135 standard, some Properties may be writable when the Out of Service Property is TRUE; for purposes of this Section, Properties that are only writable when the Out of Service Property is TRUE are not considered to be Writable.

1.5 PROJECT SEQUENCING

TABLE II: PROJECT SEQUENCING lists the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3 EXECUTION (denoted by an 'E' in the 'TYPE' column). TABLE II does not specify overall project milestone and completion dates[; these dates are specified in the contract documents][_____].

a. Sequencing for Submittals: The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within [14][_____] days of notification that the submittal has been rejected. Upon resubmittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: In TABLE II the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE II. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE
1	S	Existing Conditions Report	
2	S	DDC Contractor Design Drawings	

TABLE II. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE
3	S	Manufacturer's Product Data	
4	S	Pre-construction QC Checklist	
5	E	Install Building Control System	AAO #1 thru #4
6	E	Start-Up and Start-Up Testing	ACO #5
7	S	Post-Construction QC Checklist	[[_____] days]ACO #6
8	S	Programming Software Configuration Software Niagara Framework Engineering Tool Niagara Framework Wizards XIF Files LNS Plug-Ins	[[_____] days]ACO #6
9	S	Draft As-Built Drawings Draft LNS Database	[[_____] days]ACO #6
10	S	Start-Up Testing Report	[[_____] days]ACO #6
11	S	PVT Procedures	[[_____] days]before schedule start of #12 and AAO #10
12	S,E	Execute PVT PVT Testing Activities	AAO #9 and #11As indicated in PART 3 of this Section
13	S	PVT Report	[[_____] days]ACO #12 As indicated in PART 3 of this Section
14	S	Controller Application Programs Controller Configuration Settings Niagara Framework Supervisory Gateway Backups Final LNS Database	[[_____] days]AAO #13

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE
15	S	Final As-Built Drawings	[[_____] days]AAO #13
16	S	O&M Instructions	AAO #15
17	S	Training Documentation	AAO #10 and [[_____] days]before scheduled start of #18
18	E	Training	AAO #16 and #17
19	S	Closeout QC Checklist	ACO #18

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

DDC Contractor Design Drawings; G[, [_____]]

Draft As-Built Drawings; G[, [_____]]

Final As-Built Drawings; G[, [_____]]

SD-03 Product Data

Programming Software; G[, [_____]]

Controller Application Programs; G[, [_____]]

Configuration Software; G[, [_____]]

Controller Configuration Settings; G[, [_____]]

Proprietary Multi-Split Engineering Tool Software; G[, [_____]]

Manufacturer's Product Data; G[, [_____]]

XIF files; G[, [_____]]

Draft LNS Database; G[, [_____]]

Final LNS Database; G[, [_____]]

LNS Plug-ins; G[, [_____]]

Niagara Framework Supervisory Gateway Backups; G[, [_____]]

[Niagara Framework Engineering Tool; G[, [_____]]]

Niagara Framework Wizards; G[, [_____]]

SD-05 Design Data

Boiler Or Chiller Plant Gateway Request

SD-06 Test Reports

Existing Conditions Report

Pre-Construction Quality Control (QC) Checklist; G[, [_____]]

Post-Construction Quality Control (QC) Checklist; G[, [_____]]

Start-Up Testing Report; G[, [_____]]

PVT Procedures; G[, [_____]]

PVT Report; G[, [_____]]

Control Contractor's Performance Verification Testing Plan; G

Equipment Supplier's Performance Verification Testing Plan; G

Endurance Testing Results; G

Performance Verification Test Report; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G[, [_____]]

Training Documentation; G[, [_____]]

SD-11 Closeout Submittals

Enclosure Keys; G[, [_____]]

Password Summary Report; G[, [_____]]

Closeout Quality Control (QC) Checklist; G[, [_____]]

1.7 DATA PACKAGE AND SUBMITTAL REQUIREMENTS

Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications must be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered must be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and must contain no proprietary information and be delivered with unrestricted rights.

1.8 SOFTWARE FOR DDC HARDWARE AND GATEWAYS

Provide all software related to the programming and configuration of DDC Hardware and Gateways as indicated. License all Software to the project site. The term "controller" as used in these requirements means both DDC Hardware and Gateways.

1.8.1 Programming Software

For each type of General Purpose Programmable Controller (GPPC), provide the programming software in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. For each type of Application Generic Controller (AGC) provided as part of without a configuration and programming Wizard, provide the programming and configuration software in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of user manuals for each software with the software submittal.

Submit Programming Software on CD-ROM as a Technical Data Package. Submit [_____] hard copies of the software user manual for each piece of software.

1.8.2 Controller Application Programs

For each General Purpose Programmable Controller (GPPC), provide copies of the application program as source code compatible with the programming software for that GPPC in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. For each Application Generic Controller (AGC), provide copies of the application program as source code compatible with the programming and configuration tool (LNS plug-in) for that AGC in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Application Programs on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which application program is associated with each device. Submit [2][_____] copies of the Controller Application Programs CD-ROM.

1.8.3 Configuration Software

For each type of controller, provide the configuration tool software in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of the software user manuals for each software with the software submittal.

Submit Configuration Software on CD-ROM as a Technical Data Package. Submit [_____] hard copies of the software user manual for each piece of software.

1.8.4 Controller Configuration Settings

For each controller, provide copies of the installed configuration settings as source code compatible with the configuration tool software for that controller in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Configuration Settings on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which files are associated with each device. Submit [2][_____] copies of the Controller Configuration Settings CD-ROM.

1.8.5 Programming Software

For each type of programmable controller, provide the programming software in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of software user manuals for each software with the software submittal.

Submit Programming Software on CD-ROM as a Technical Data Package. Submit [_____] hard copies of the software user manual for each piece of software.

1.8.6 Controller Application Programs

For each programmable controller, provide copies of the application program as source code compatible with the programming software for that controller in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Application Programs on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which application program is associated with each device. Submit [2][_____] copies of the Controller Application Programs CD-ROM.

1.8.7 LNS Plug-Ins (for LNS-based LonWorks systems)

Provide LNS Plug-ins in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for each Application Specific Controller and each Application Generic Controller. For LNS Plug-ins distributed under a license, license the Plug-In to the project site. Submit hard copy manuals, if available, for each plug-in provided as part of the LNS- Plug-Ins submittal.

Submit LNS Plug-ins on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which files are associated with each device.

1.8.8 Niagara Framework Wizards (for Niagara LonWorks systems)

For each Application Generic Controller with a Niagara Framework Wizard and for each Application Specific Controller provide Niagara Framework Wizards in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copy manuals, if available, for each Wizard provided as part of the Niagara Framework

Wizards submittal.

Submit Niagara Framework Wizards on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which files are associated with each device. Submit [_____] hard copies of the software user manual, if available, for each Wizard.

1.8.9 Niagara Framework Supervisory Gateway Backups

For each Niagara Framework Supervisory Gateway, provide a backup of all software within the Niagara Framework Supervisory Gateway, including configuration settings. This backup must be sufficient to allow the restoration of the Niagara Framework Supervisory Gateway or the replacement of the Niagara Framework Supervisory Gateway.

Submit backups for each Niagara Framework Supervisory Gateway on CD-ROM as a Technical Data Package. Mark each backup indicating clearly the source Niagara Framework Supervisory Gateway.

[1.8.10 Niagara Framework Engineering Tool(for all Niagara Framework system)

Provide a Niagara Framework Engineering Tool in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS and Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit software user manuals with the Niagara Framework Engineering Tool submittal.

Submit the Niagara Framework Engineering Tool on CD-ROM as a Technical Data Package. Submit [_____] hard copies of the software user manual for the Niagara Framework Engineering Tool.

]1.9 BOILER OR CHILLER PLANT GATEWAY REQUEST

If requesting the use of a gateway to a boiler or chiller plant as indicated in paragraph Proprietary Systems Exempted From Open Protocol Requirements, submit a Boiler or Chiller Plant Gateway Request describing the configuration of the boilers or chillers including model numbers for equipment and controllers, the sequence of operation for the units, and a justification for the need to operate the units on a shared non-LonWorks non-BACnet network.

1.10 QUALITY CONTROL CHECKLISTS

The QC Checklist for LNS-Based LonWorks Systems in APPENDIX A of this Section must be completed by the Contractor's Chief Quality Control (QC) Representative and submitted as indicated.

The QC Checklist for Niagara Framework Based LonWorks Systems in APPENDIX A of this Section must be completed by the Contractor's Chief Quality Control (QC) Representative and submitted as indicated.

The QC Checklist for BACnet Systems in APPENDIX A of this Section must be completed by the Contractor's Chief Quality Control (QC) Representative and submitted as indicated.

The QC Checklist for Niagara Framework Based BACnet Systems in APPENDIX A of this Section must be completed by the Contractor's Chief Quality Control (QC) Representative and submitted as indicated.

The QC Representative must verify each item indicated and initial in the space provided to indicate that the requirement has been met. The QC Representative must sign and date the Checklist prior to submission to the Government.

1.10.1 Pre-Construction Quality Control (QC) Checklist

Complete items indicated as Pre-Construction QC Checklist items in the QC Checklist. Submit [four][_____] copies of the Pre-Construction QC Checklist.

1.10.2 Post-Construction Quality Control (QC) Checklist

Complete items indicated as Post-Construction QC Checklist items in the QC Checklist. Submit [four][_____] copies of the Post-Construction QC Checklist.

1.10.3 Closeout Quality Control (QC) Checklist

Complete items indicated as Closeout QC Checklist items in the QC Checklist. Submit [four][_____] copies of the Closeout QC Checklist.

PART 2 PRODUCTS

Provide products meeting the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for LNS LonWorks systems or Niagara LonWorks systems, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, other referenced Sections, and this Section.

2.1 GENERAL PRODUCT REQUIREMENTS

Units of the same type of equipment must be products of a single manufacturer. Each major component of equipment must have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment must be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products must have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two year use must include applications of equipment and materials under similar circumstances and of similar size. DDC Hardware not meeting the two-year field service requirement is acceptable provided it has been successfully used by the Contractor in a minimum of two previous projects. The equipment items must be supported by a service organization. Items of the same type and purpose must be identical, including equipment, assemblies, parts and components.

2.2 PRODUCT DATA

Provide manufacturer's product data sheets documenting compliance with product specifications for each product provided under Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING

CONTROL SYSTEMS, or this Section. Provide product data for all products in a single indexed compendium, organized by product type.

For all LonWorks hardware: for each manufacturer, model and version (revision) of DDC Hardware indicate the type or types of DDC Hardware the product is being provided as in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS

For all BACnet hardware: for each manufacturer, model and version (revision) of DDC Hardware provide the Protocol Implementation Conformance Statement (PICS) in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Manufacturer's Product Data on CD-ROM.

2.2.1 XIF Files

Provide External Interface Files (XIF Files) for DDC Hardware in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit external interface files (XIF files) as a technical data package for each model of DDC Hardware provided under this specification. Submit XIF files on CD-ROM.

2.3 OPERATION ENVIRONMENT

Unless otherwise specified, provide products rated for continuous operation under the following conditions:

a. Pressure: Pressure conditions normally encountered in the installed location.

b. Vibration: Vibration conditions normally encountered in the installed location.

c. Temperature:

  (1) Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.

  (2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of [-35 to +151 degrees F] [_____] and temperature conditions outside this range normally encountered at the installed location.

d. Humidity: 10 to 95 percent relative humidity, noncondensing and humidity conditions outside this range normally encountered at the installed location.

2.4 WIRELESS CAPABILITY

For products incorporating any wireless capability (including but not limited to radio frequency (RF), infrared and optical), provide products for which wireless capability can be permanently disabled at the device. Optical and infrared capabilities may be disabled via a permanently affixed opaque cover plate.

2.5 ENCLOSURES

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable. Provide two Enclosure Keys for each lockable enclosure on a single ring per enclosure with a tag identifying the enclosure the keys operate. Provide enclosures meeting the following minimum requirements:

2.5.1 Outdoors

For enclosures located outdoors, provide enclosures meeting NEMA 250 [Type 3][Type 4] requirements.

2.5.2 Mechanical and Electrical Rooms

For enclosures located in mechanical or electrical rooms, provide enclosures meeting NEMA 250 [Type 2][Type 4] requirements.

2.5.3 Other Locations

For enclosures in other locations including but not limited to occupied spaces, above ceilings, and in plenum returns, provide enclosures meeting NEMA 250 Type 1 requirements.

2.6 WIRE AND CABLE

Provide wire and cable meeting the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification and referenced specifications.

2.6.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.6.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.6.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

a. minimum 2 inch lay of twist

b. 100 percent shielded pairs

c. at least 300-volt insulation

d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation

e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.6.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.6.5 Transformers

Provide UL 5085-3 approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

PART 3 EXECUTION

[3.1 EXISTING CONDITIONS

3.1.1 Existing Conditions Survey

Perform a field survey, including testing and inspection of the equipment to be controlled and submit an Existing Conditions Report documenting the current status and its impact on the Contractor's ability to meet this specification. For those items considered nonfunctional, document the deficiency in the report including explanation of the deficiencies and estimated costs to correct the deficiencies. As part of the report, define the scheduled need date for connection to existing equipment. Make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime.

Submit [four][_____] copies of the Existing Conditions Report.

3.1.2 Existing Equipment Downtime

Make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime.

3.1.3 Existing Control System Devices

Inspect, calibrate, and adjust as necessary to place in proper working order all existing devices which are to be reused.

]3.2 INSTALLATION

Fully install and test the control system in accordance Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for LNS LonWorks systems or Niagara LonWorks systems, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, and this Section.

3.2.1 Dielectric Isolation

Provide dielectric isolation where dissimilar metals are used for connection and support. Install control system in a matter that provides clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. Install control system such that it does not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.2 Penetrations in Building Exterior

Make all penetrations through and mounting holes in the building exterior watertight.

3.2.3 Device Mounting Criteria

Install devices in accordance with the manufacturer's recommendations and as indicated and shown. Provide a weathershield for all devices installed outdoors. Provide clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. Provide clearance for mechanical and electrical system maintenance; do not not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.4 Labels and Tags

Key all labels and tags to the unique identifiers shown on the As-Built drawings. For labels exterior to protective enclosures provide engraved plastic labels mechanically attached to the enclosure or DDC Hardware. Labels inside protective enclosures may be attached using adhesive, but must not be hand written. For tags, provide plastic or metal tags mechanically attached directly to each device or attached by a metal chain or wire.

a. Label all Enclosures and DDC Hardware.

b. Tag Airflow measurement arrays (AFMA) with flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient.

c. Tag duct static pressure taps at the location of the pressure tap

3.2.5 Surge Protection

3.2.5.1 Power-Line Surge Protection

Protect equipment connected to AC circuits to withstand power-line surges in accordance with IEEE C62.41. Do not use fuses for surge protection.

3.2.5.2 Surge Protection for Transmitter and Control Wiring

Protect DDC hardware against or provided DDC hardware capable of withstanding surges induced on control and transmitter wiring installed outdoors and as shown. Protect equipment against the following two waveforms:

a. A waveform with a 10-microsecond rise time, a 1000-microsecond decay time and a peak current of 60 amps.

b. A waveform with an 8-microsecond rise time, a 20-microsecond decay time and a peak current of 500 amperes.

3.2.6 Basic Cybersecurity Requirements

3.2.6.1 Passwords

For all devices with a password, change the password from the default password. Do not use the same password for more than one device. Coordinate selection of passwords with [_____]. Provide a Password Summary Report documenting the password for each device and describing the procedure to change the password for each device.

Provide [two][_____] hardcopies of the Password Summary Report, each copy in its own sealed envelope.

3.2.6.2 Wireless Capability

Unless otherwise indicated, disable wireless capability (including but not limited to radio frequency (RF), infrared and optical) for all devices with wireless capability. Optical and infrared capabilities may be disabled via a permanently affixed opaque cover plate. Password protecting a wireless connections does not meet this requirement; the wireless capability must be disabled.

3.2.6.3 IP Network Physical Security

Install all IP Network media in conduit. Install all IP devices including but not limited to IP-enabled DDC hardware and IP Network Hardware in lockable enclosures.

3.3 DRAWINGS AND CALCULATIONS

Provide drawings in the form and arrangement indicated and shown. Use the same abbreviations, symbols, nomenclature and identifiers shown. Assign a unique identifier as shown to each control system element on a drawing. When packaging drawings, group schedules by system. When space allows, it is permissible to include multiple schedules for the same system on a single sheet. Except for drawings covering all systems, do not put information for different systems on the same sheet.

Submit hardcopy drawings on [ISO A1 34 by 22 inches][or][A3 17 by 11 inches] sheets, and electronic drawings in PDF and in [AutoCAD][Microstation][Bentley BIM V8][Autodesk Revit 2013] format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule.

a. Submit DDC Contractor Design Drawings consisting of each drawing indicated with pre-construction information depicting the intended control system design and plans. Submit DDC Contractor Design Drawings as a single complete package: [_____] hard copies and [_____] copies on CD-ROM.

b. Submit Draft As-Built Drawings consisting of each drawing indicated updated with as-built data for the system prior to PVT. Submit Draft As-Built Drawings as a single complete package: [_____] hard copies and [_____] copies on CD-ROM.

c. Submit Final As-Built Drawings consisting of each drawing indicated updated with all final as-built data. Final As-Built Drawings as a single complete package: [_____] hard copies and [_____] copies on CD-ROM.

3.3.1 Sample Drawings

Sample drawings in electronic format are available at the Whole Building Design Guide page for this section: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-23-09-00 These drawings may prove useful in demonstrating expected drawing formatting and example content and are provided for illustrative purposes only. Note that these drawings do not meet the content requirements of this Section and must be completed to meet project requirements.

3.3.2 Drawing Index and Legend

Provide an HVAC Control System Drawing Index showing the name and number of the building, military site, State or other similar designation, and Country. In the Drawing Index, list all Contractor Design Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. In the Design Drawing Legend, show and describe all symbols, abbreviations and acronyms used on the Design Drawings. Provide a single Index and Legend for the entire drawing package.

3.3.3 Thermostat and Occupancy Sensor Schedule

Provide a thermostat and occupancy sensor schedule containing each thermostat's unique identifier, room identifier and control features and functions as shown. Provide a single thermostat and occupancy sensor schedule for the entire project.

3.3.4 Valve Schedule

Provide a valve schedule containing each valve's unique identifier, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure to torque data, dimensions, and access and clearance requirements data. In the valve schedule include actuator selection data supported by calculations of the force required to move and seal the valve, access and clearance requirements. Provide a single valve schedule for the entire project.

3.3.5 Damper Schedule

Provide a damper schedule containing each damper's unique identifier, type (opposed or parallel blade), nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges, operation rate, positive positioner range, location of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. Include the AMCA 511 maximum leakage rate at the operating static-pressure differential for each damper in the Damper Schedule. Provide a single damper schedule for the entire project.

3.3.6 Project Summary Equipment Schedule

Provide a project summary equipment schedule containing the manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Provide a single project equipment schedule for the entire project.

3.3.7 Equipment Schedule

Provide system equipment schedules containing the unique identifier, manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Provide a separate equipment schedule for each HVAC system.

3.3.8 Occupancy Schedule

Provide an occupancy schedule drawing containing the same fields as the occupancy schedule Contract Drawing with Contractor updated information. Provide a single occupancy schedule for the entire project.

3.3.9 DDC Hardware Schedule

Provide a single DDC Hardware Schedule for the entire project and including following information for each device.

3.3.9.1 DDC Hardware Identifier

The Unique DDC Hardware Identifier for the device.

3.3.9.2 HVAC System

The system "name" used to identify a specific system (the name used on the system schematic drawing for that system).

3.3.9.3 LonWorks Device Information

3.3.9.3.1 Network Address

The LonWorks Domain, Subnet and Node address for the device.

3.3.9.3.2 Unique Node ID

The Unique 48-bit Node ID associated with the device. (Also referred to as the Neuron ID for some devices)

3.3.9.4 BACnet Device Information

3.3.9.4.1 Device Object Identifier

The Device Object Identifier: The Object_Identifier of the Device Object

3.3.9.4.2 Network Number

The Network Number for the device.

3.3.9.4.3 MAC Address

The MAC Address for the device

3.3.9.4.4 BTL Listing

The BTL Listing of the device. If the device is listed under multiple BTL Profiles, indicate the profile that matches the use and configuration of the device as installed.

3.3.9.4.5 Proprietary Services Information

If the device uses non-standard ASHRAE 135 services as defined and permitted in Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, indicate that the device uses non-standard services and include a description of all non-standard services used. Describe usage and content such that a device from another vendor can interoperate with the device using the non-standard service. Provide descriptions with sufficient detail to allow a device from a different manufacturer to be programmed to both read and write the non-standard service request:

a. read: interpret the data contained in the non-standard service and;

b. write: given similar data, generate the appropriate non-standard service request.

3.3.9.4.6 Alarming Information

Indicate whether the device is used for alarm generation, and which types of alarm generation the device implements: intrinsic, local algorithmic, remote algorithmic.

3.3.9.4.7 Scheduling Information

Indicate whether the device is used for scheduling.

3.3.9.4.8 Trending Information

Indicate whether the device is used for trending, and indicate if the device is used to trend local values, remote values, or both.

3.3.9.5 Niagara Station ID

The Niagara Station ID for each Niagara Framework Supervisory Gateway

3.3.10 Points Schedule

Provide a Points Schedule in tabular form for each HVAC system, with the indicated columns and with each row representing a hardware point, network point or configuration point in the system.

a. When a Points Schedule was included in the Contract Drawing package, use the same fields as the Contract Drawing with updated information in addition to the indicated fields.

b. When Point Schedules are included in the contract package, items requiring contractor verification or input have been shown in angle brackets ("<" and ">"), such as <___> for a required entry or <value> for a value requiring confirmation. Complete all items in brackets as well as any blank cells. Do not modify values which are not in brackets without approval.

Points Schedule Columns must include:

3.3.10.1 Point Name

The abbreviated name for the point using the indicated naming convention.

3.3.10.2 Description

A brief functional description of the point such as "Supply Air Temperature".

3.3.10.3 DDC Hardware Identifier

The Unique DDC Hardware Identifier shown on the DDC Hardware Schedule and used across all drawings for the DDC Hardware containing the point.

3.3.10.4 Settings

The value and units of any setpoints, configured setpoints, configuration parameters, and settings related to each point.

3.3.10.5 Range

The range of values, including units, associated with the point, including but not limited to a zone temperature setpoint adjustment range, a sensor measurement range, occupancy values for an occupancy input, or the status of a safety.

3.3.10.6 Input or Output (I/O) Type

The type of input or output signal associated with the point. Use the following abbreviations for entries in this column:

a. AI: The value comes from a hardware (physical) Analog Input

b. AO: The value is output as a hardware (physical) Analog Output

c. BI: The value comes from a hardware (physical) Binary Input

d. BO: The value is output as a hardware (physical) Binary Output

e. PULSE: The value comes from a hardware (physical) Pulse Accumulator Input

f. NET-IN: The value is provided from the network (generally from another device). Use this entry only when the value is received from another device as part of scheduling or as part of a sequence of operation, not when the value is received on the network for supervisory functions such as trending, alarming, override or display at a user interface.

g. NET-OUT: The value is provided to another controller over the network. Use this entry only when the value is transmitted to another device as part of scheduling or as part of a sequence of operation, not when the value is transmitted on the network for supervisory functions such as trending, alarming, override or display at a user interface.

3.3.10.7 Object and Property Information

The Object Type and Instance Number for the Object associated with the point. If the value of the point is not in the Present_Value Property, then also provide the Property ID for the Property containing the value of the point. Any point that is displayed at the front end or on an LDP, is trended, is used by another device on the network, or has an alarm condition must be documented here.

3.3.10.8 Primary Point Information: SNVT Name

The name of the SNVT used for the point. Any point that is displayed at the front end or on an LDP, is trended, is used by another device on the network, or has an alarm condition must be documented here.

3.3.10.9 Primary Point Information: SNVT Type

The SNVT type used by the point. Provide this information whenever SNVT

Name is required.

3.3.10.10 Niagara Station ID

The Niagara Station ID of the Niagara Framework Supervisory Gateway the point is mapped into.

3.3.10.11 Network Data Exchange Information (Gets Data From, Sends Data To)

Provide the DDC Hardware Identifier of other DDC Hardware the point is shared with.

3.3.10.12 Override Information (Object Type and Instance Number)

For each point requiring an Override and not residing in a Niagara Framework Supervisory Gateway, indicate if the Object for the point is Commandable or, if the use of a separate Object was specifically approved by the Contracting Officer, provide the Object Type and Instance Number of the Object to be used in overriding the point.

3.3.10.13 Override Information (SNVT Name and Type)

For each point requiring an Override and not residing in a Niagara Framework Supervisory Gateway, indicate the SNVT Name and SNVT Type of the network variable used for the override.

3.3.10.14 Trend Object Information

For each point requiring a trend, indicate if the trend is Local or Remote, the trend Object type and the trend Object instance number. For remote trends provide the DDC Hardware Identifier for the device containing the trend Object in the Points Schedule notes.

3.3.10.15 Alarm Information

Indicate the Alarm Generation Type, Event Enrollment Object Instance Number, and Notification Class Object Instance Number for each point requiring an alarm. (Note that not all alarms will have Event Enrollment Objects.)

For Niagara BACnet systems: Indicate the Alarm Generation Type and Notification Class Object Instance Number for each point requiring an alarm. (Note that not all alarms will have a Notification Class Object.)

3.3.10.16 Configuration Information

Indicate the means of configuration associated with each point. For points in a Niagara Framework Supervisory Gateway, indicate the point within the Niagara Framework Supervisory Gateway used to configure the value. For other points:

a. For Operator Configurable Points indicate BACnet Object and Property information (Name, Type, Identifiers) containing the configurable value. Indicate whether the property is writable always, or only when Out_Of_Service is TRUE.

b. For Configurable Points indicate the BACnet Object and Property information as for Operator Configurable points, or identification of the configurable settings from within the engineering software for the device or identification of the hardware settings on the device.

a. Indicate "Plug-In" if the point is configurable via an LNS plug-in. Indicate "Niagara Framework Wizard" if the point is configurable via a Niagara Framework Wizard.

b. If the point is not configurable through an LNS plug-ina Niagara Framework Wizard, indicate the network variable or configuration property used to configure the value.

3.3.11 Riser Diagram

The Riser Diagram of the Building Control Network may be in tabular form, and must show all DDC Hardware and all Network Hardware, including network terminators. For each item, provide the unique identifier, common descriptive name, physical sequential order (previous and next device on the network), room identifier and location within room. A single riser diagram must be submitted for the entire system.

3.3.12 Control System Schematics

Provide control system schematics in the same form as the control system schematic Contract Drawing with Contractor updated information. Provide a control system schematic for each HVAC system.

3.3.13 Sequences of Operation[Including Control Logic Diagrams]

Provide HVAC control system sequence of operation and [control logic diagrams] in the same format as the Contract Drawings. Within these drawings, refer to devices by their unique identifiers. Submit sequences of operation[and control logic diagrams] for each HVAC system

3.3.14 Controller, Motor Starter and Relay Wiring Diagram

Provide controller wiring diagrams as functional wiring diagrams which show the interconnection of conductors and cables to each controller and to the identified terminals of input and output devices, starters and package equipment. Show necessary jumpers and ground connections and the labels of all conductors. Identify sources of power required for control systems and for packaged equipment control systems back to the panel board circuit breaker number, controller enclosures, magnetic starter, or packaged equipment control circuit. Show each power supply and transformer not integral to a controller, starter, or packaged equipment. Show the connected volt-ampere load and the power supply volt-ampere rating. Provide wiring diagrams for each HVAC system.

3.4 CONTROLLER TUNING

Tune each controller in a manner consistent with that described in the ASHRAE FUN IP and in the manufacturer's instruction manual. Tuning must consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop must be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable must settle out at the new setpoint with no more than two (2) oscillations above and below setpoint. Upon settling out at the new setpoint the controller output must be steady. With the exception of naturally slow processes such as zone temperature control, the controller must settle out at the new setpoint within five (5) minutes. Set the controller to its correct setpoint and record and submit the final PID configuration settings with the O&M Instructions and on the associated Points Schedule.

3.5 START-UP

3.5.1 Start-Up Test

Perform the following startup tests for each control system to ensure that the described control system components are installed and functioning per this specification.

Adjust, calibrate, measure, program, configure, set the time schedules, and otherwise perform all necessary actions to ensure that the systems function as indicated and shown in the sequence of operation and other contract documents.

3.5.1.1 Systems Check

An item-by-item check must be performed for each HVAC system

3.5.1.1.1 Step 1 - System Inspection

With the system in unoccupied mode and with fan hand-off-auto switches in the OFF position, verify that power and main air are available where required and that all output devices are in their failsafe and normal positions. Inspect each local display panel [and each M&C Client] to verify that all displays indicate shutdown conditions.

3.5.1.1.2 Step 2 - Calibration Accuracy Check

Perform a two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter by comparing the value from the test instrument to the network value provided by the DDC Hardware. Use digital indicating test instruments, such as digital thermometers, motor-driven psychrometers, and tachometers. Use test instruments with accuracy at least twice as accurate as the specified sensor accuracy and with calibration traceable to National Institute of Standards and Technology standards. Check one the first check point in the bottom one-third of the sensor range, and the second in the top one-third of the sensor range. Verify that the sensing element-to-DDC readout accuracies at two points are within the specified product accuracy tolerances, and if not recalibrate or replace the device and repeat the calibration check.

3.5.1.1.3 Step 3 - Actuator Range Check

With the system running, apply a signal to each actuator through the DDC Hardware controller. Verify proper operation of the actuators and positioners for all actuated devices and record the signal levels for the extreme positions of each device. Vary the signal over its full range, and verify that the actuators travel from zero stroke to full stroke within the signal range. Where applicable, verify that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. For valve actuators and damper actuators, perform the actuator range check under normal system pressures.

3.5.1.2 Weather Dependent Test

Perform weather dependent test procedures in the appropriate climatic season.

3.5.2 Start-Up Testing Report

Submit [4] [_____] copies of the Start-Up Testing Report. The report may be submitted as a Technical Data Package documenting the results of the tests performed and certifying that the system is installed and functioning per this specification, and is ready for the Performance Verification Test (PVT).

3.5.3 Draft LNS Database

Upon completion of the Start-Up Test, submit the Draft LNS Database reflecting the system as installed and configured at the completion of the Start-Up and Start-Up-Testing. The Draft LNS Database must be a complete, fully commissioned LNS database for the complete control network provided under this specification. The Draft LNS database submittal must consist of the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}. For versions of LNS which use credits, the provided LNS Database must include all device credits.

Submit two copies of the fully commissioned, valid draft LNS Database (including all LNS credits) as a Technical Data Package. Submit each copy on a CD-ROM and clearly mark the CD-ROM identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification.

3.6 PERFORMANCE VERIFICATION TEST (PVT)

3.6.1 PVT Procedures

Prepare PVT Procedures based on Section 25 08 10 UTILITY MONITORING AND CONTROL SYSTEM TESTING explaining step-by-step, the actions and expected results that will demonstrate that the control system performs in accordance with the sequences of operation, and other contract documents. Submit [4] [_____] copies of the PVT Procedures. The PVT Procedures may be submitted as a Technical Data Package.

3.6.1.1 Sensor Accuracy Checks

Include a one-point accuracy check of each sensor in the PVT procedures.

3.6.1.2 Temporary Trending Hardware

Unless trending capability exists within the building control system or the building control system is connected to a UMCS or other system which can perform trending, temporarily install hardware on the building control network to perform trending during the endurance test as indicated. Remove the temporary hardware at the completion of all commissioning activities.

3.6.1.3 Endurance Test

Include a [one-week] [_____] endurance test as part of the PVT during which the system is operated continuously.

Use the building control system BACnet Trend Log or Trend Log Multiple Objects to trend all points shown as requiring a trend on the Point Schedule for the entire endurance test. If insufficient buffer capacity exists to trend the entire endurance test, upload trend logs during the course of the endurance test to ensure that no trend data is lost.

Use the building control system Niagara Trend Log Objects to trend all points shown as requiring a trend on the Point Schedule for the entire endurance test. If insufficient buffer capacity exists to trend the entire endurance test, upload trend logs during the course of the endurance test to ensure that no trend data is lost. The PVT must include a methodology to measure and record the network bandwidth usage on each TP/FT-10 channel during the endurance test.

Use the existing trending capabilities or the Temporary Trending Hardware as indicated to trend all points shown as requiring a trend on the Point Schedule for the entire endurance test. The PVT must include a methodology to measure and record the network bandwidth usage on each TP/FT-10 channel during the endurance test.

3.6.1.4 PVT Equipment List

Include in the PVT procedures a control system performance verification test equipment list that lists the equipment to be used during performance verification testing. For each piece of equipment, include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration

3.6.2 PVT Execution

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures approved by the Government, software capable of reading and writing COV Notification Subscriptions, Notification Class Recipient List Properties, event enrollments, demonstrate all physical and functional requirements of the project. Show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. Do not start the performance verification test until after receipt of written permission by the Government, based on Government approval of the PVT Plan and Draft As-Builts and completion of balancing. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. Do not conduct tests during scheduled seasonal off periods of base heating and cooling systems. If the system experiences any failures during the endurance test portion of the PVT, repair the system repeat the endurance test portion of the PVT until the system operates continuously and without failure for the specified endurance test period.

3.6.3 PVT Report

Prepare and submit a PVT report documenting all tests performed during the PVT and their results. Include all tests in the PVT procedures and any additional tests performed during PVT. Document test failures and repairs conducted with the test results.

Submit [four][_____] copies of the PVT Report. The PVT Report may be submitted as a Technical Data Package.

3.6.4 Final LNS Database

Submit a Final LNS Database consisting of the complete, fully commissioned LNS database for the complete control network provided under this specification. Provide the the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}. For versions of LNS which use credits, include all device credits in the provided LNS Database.

Submit two copies of the fully commissioned, valid as-built LNS Database (including all LNS credits) for the complete control network provided under this specification as a Technical Data Package. Submit each copy on CD-ROM and clearly mark the CD-ROM identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification.

3.7 PERFORMANCE VERIFICATION TESTING

3.7.1 General

PVT testing must demonstrate compliance of controls work with contract document requirements and must be performed by the Controls Contractor and Equipment Suppliers. No less than [14][__] calendar days prior to start of controls system installation, meet with the Contracting Office's technical representative (COTR) [and the designing engineer of the HVAC systems], the Contractor's QA representative, the Contractor's Controls Contractor representative,[and the control system Owner] to develop a mutual understanding relate to the details of the PVT work requirements, including required submittals, work schedule, and field quality control.

3.7.2 Performance Verification Testing and Commissioning

PVT testing is a Government quality assurance function that includes systems trending and field tests. Commissioning is a quality control function that is the Commissioning Team’s responsibility to the extent required by this contract.

3.7.3 Performance Verification Testing of Equipment with Packaged Controls

Controls Contractor and Equipment Supplier(s) must share and coordinate PVT testing responsibilities for equipment provided with on-board factory packaged controls such as boiler controllers, dedicated outside air systems (DOAS’s), and packaged pumping systems.

3.7.3.1 Controls Contractor Responsibilities

The Controls Contractor must provide a PVT Plan separate from Equipment Supplier’s performance verification testing plan, perform endurance testing, and perform PVT testing concurrent with Equipment Suppliers’ testing for equipment provided with on-board factory packaged controls to demonstrate the following:

a. Equipment enabling and disabling.

b. Equipment standard and optional control points necessary to accomplish functionality regardless if specified in contract documents or not.

c. Equipment standard and optional alarms critical to safe operation regardless if specified in contract documents or not.

d. All control points added by Controls Contractor in addition to onboard factory packaged controls regardless if specified in contract documents or not.

Refer to paragraphs titled “Performance Verification Test Plan” and “Endurance Testing” for additional information.

3.7.3.2 Equipment Supplier Responsibilities

Each Equipment Supplier must provide PVT Plans separate from Controls Contractor’s plans and perform PVT testing concurrent with Controls Contractor’s testing for their equipment provided with on-board factory packaged controls to demonstrate the following:

a. Equipment standard and optional control features necessary to accomplish functionality regardless if specified in contract documents or not.

b. Equipment standard and optional operation modes necessary to accomplish functionality regardless if specified in contract documents or not.

c. Equipment standard and optional alarm conditions for safe operation regardless if specified in contract documents or not.

Refer to all paragraphs under paragraph titled “Performance Verification Testing” except for section titled “Endurance Testing” for additional information.

3.7.4 Sequencing of Performance Verification Testing Activities

PVT activities must be sequenced with major activities listed below for Test and Balance (TAB) Contractor, Equipment Suppliers, Commissioning Specialists, and others to demonstrate fully functioning systems. Refer to Section 01 32 17.00 20 COST-LOADED NETWORK ANALYSIS SCHEDULES (NAS). Complete the items in TABLE III: SEQUENCING OF PVT TESTING ACTIVITIES as schedule activities or milestones.

TABLE III: SEQUENCING OF PVT TESTING ACTIVITIES

SEQUENCE	ITEM
1	Submission, review, and approval of Control Contractors PVT Plans.
2	Submission, review, and approval of Equipment Suppliers PVT Plans.
3	Submission, review, and approval of certified final Test and Balance Report.
4	Conduct commissioning functional performance tests.
5	Submission, review, and approval of all of the Commissioning Specialists completed functional performance tests.
6	Request Contracting Officer to allow beginning of Government-witnessed PVT testing.

TABLE III: SEQUENCING OF PVT TESTING ACTIVITIES	
SEQUENCE	ITEM
7	Contracting Officers approval to begin PVT testing.
8	Conduct PVT field work.
9	Governments verbal approval of PVT field work for all systems.
10	Conduct Test and Balance verification field work.
11	Governments written approval of Test and Balance verification field work.
12	Submission, review, and approval of endurance testing.
13	Governments written approval of PVT field work for all systems.
14	Facility acceptance recommendation.
15	Submission, review, and approval of Control Contractors PVT Report.
16	Submission, review, and approval of Equipment Suppliers PVT Report.
17	Conduct applicable re-testing and seasonal testing within 10 months of beneficial occupancy.

3.7.4.1 PVT Testing for Multi-Phase Construction

For air moving systems except outside air systems serving multiple phases, all major activities listed in TABLE III through Government's verbal approval of Test and Balance verification field work can be completed by phase if all ductwork construction is completed for that phase.

For primary systems such as chilled water systems, HVAC heating hot water systems, and outside air systems serving multiple phases, all major activities listed listed in TABLE III through Government's verbal approval of Test and Balance verification field work for all air moving systems served by that primary system for that phase must be completed prior to conducting PVT field work for that primary system.

3.7.5 Control Contractor's Performance Verification Testing Plan

Submit a detailed PVT Plan of the proposed control systems testing in this contract for approval prior to its use. Develop and use a single PVT Plan for each system with a unique control sequence. Systems sharing an identical control sequence can be tested using copies of the PVT Plan intended for these systems.

PVT Plans must include system-based, step-by-step test methods demonstrating system performs in accordance with contract document requirements. The Government may provide sample PVT Plans upon request. PVT Plans must include the following:

a. Control sequences from contract documents segmented such that each control algorithm, operation mode, and alarm condition is immediately followed by numbered test methods required to initiate a response, expected response, space for comments, and “pass" or "fail” indication for each expected response.

b. PVT Plans with control sequences from contract documents that are not segmented into parts will not be accepted.

c. Indication where assisting personnel are required such as Mechanical Contractor.

d. Signature and date lines for the Contractor's PVT administrator, Contractor's quality assurance representative, and Contracting Officer's representative acknowledging completion of testing.

3.7.6 Performance Verification Testing Sample Size

PVT testing sample sizes will be as follows:

a. 100-Percent of the following systems:

(1) primary systems including, but not limited to, chilled water and HVAC heating hot water systems

(2) air handling unit systems including all associated fans except for remote exhaust air fans

(3) DOAS’s including all associated fans except for remote exhaust air fans

b. 20-Percent of each set of systems with a shared identical control sequence for systems such as:

(1) air terminal units

(2) exhaust air fans

(3) terminal equipment such as fan coil units and unit heaters

3.7.6.1 Selection of Systems to Test

For sample sets less than 100-percent, the Government will choose which systems will be tested. The Government may require additional testing if previous testing results are inconsistent or demonstrate improper system control as follows:

a. An additional 25-percent after five-percent failure rate of first sample set.

b. 100-percent after any failures occurring in additional sample set.

3.7.7 Conducting Performance Verification Testing

At least 15 days prior to preferred test date, request the Contracting Officer to allow the beginning of Government-witnessed PVT testing. Provide an estimated time table required to perform testing of each system. Furnish personnel, equipment, instrumentation, and supplies necessary to perform all aspects of testing. Testing personnel must be regularly employed in the testing and calibration of control systems. After receipt of Contracting Officer’s approval to begin testing, perform PVT testing using project's as-built (shop) control system drawings, project's design drawings, and approved PVT Plans.

During testing, identify deficiencies that do not meet contract document requirements. Deficiencies must be investigated, corrected with corrections documented, and re-tested at a later date following procedures for the initial PVT testing. The Government may require re-testing of any control system components affected by the original failed test.

3.7.8 Endurance Testing

3.7.8.1 General

Conduct endurance testing in conjunction with the PVT to demonstrate control loop stability and accuracy. For all control loops tested, record trend data of the control variables over time, demonstrating that the control loop responds to a sudden change of the control variable set point without excessive overshoot or undershoot. Conduct endurance testing for each system subject to PVT testing. Systems must be operating as normally anticipated during occupancy throughout endurance testing.

Endurance testing results must clearly demonstrate control loop stability and accuracy. Controlled loop outputs must be stable and accurately maintain each setpoint.

3.7.8.2 Hardware

[Use hardware provided in this contract for testing.] [Use Government furnished hardware for testing if available when endurance testing begins. If unavailable, the Contractor must provide suitable hardware for required testing.]

If insufficient buffer capacity exists to trend the entire endurance test, upload trend data during the course of endurance testing to ensure all trend data is retained. Lost trend data will require retesting of all control points for affected system(s).

3.7.8.3 Endurance Testing Results Format

Submit endurance testing results for each tested system in a graphical format complete with clear indication of value(s) for y-axis, value for x-axis, and legend identifying each trended control point. The number of control points contained on a single graph must be such that all control points can be clearly visible. Control points must be logically grouped such that related points appear on a single graph. In addition, submit a separate comma separated value (CSV) file of raw trend data for each trended system. Each trended control point in CSV file must be clearly identified.

For control points recorded based on change of value, change of value for recording data must be clearly identified for each control point.

3.7.8.4 Endurance Testing Start, Duration, and Frequency

Trending of all control points for a given system must start at an identical date and time regardless of the basis of data collection. Duration of all endurance tests must be at least [one-week][_____].

Unless specified otherwise for control points recorded based on time, frequency of data collection must be [15-minutes] [_____]. Frequency of data collection for specific types of control points is as follows:

3.7.8.4.1 Points Trended at One Minute Intervals

a. Temperature for supply air, return air, mixed air, supply water, and return water

b. Temperature for outside air, supply air, return air and exhaust air entering and leaving energy recovery device

c. Flow for supply air, return air, outside air, chilled water, and HVAC heating hot water

d. Flow for exhaust air associated with energy recovery

e. Relative humidity for outside air and return air

f. Relative humidity for outside air, supply air, return air and exhaust air entering and leaving energy recovery device

g. Command and status for control dampers and control valves

h. Speed for fans and pumps

i. Pressure for fans and pumps

3.7.8.4.2 Points Trended at 15 Minute Intervals

a. Temperature and relative humidity for zones

b. Temperature and relative humidity for outside air not associated with energy recovery

c. Command and status for equipment

d. Pressure relative to the outside for facility

3.7.8.5 Trended Control Points

Trended control points for each system must demonstrate each system performs in accordance with contract document requirements. Trended control points must include, but not be limited to, control points listed in contract document points list.

Minimum control points that are required to be trended for selected systems are listed below. These control points must be trended as applicable to this contract in addition to control points necessary to demonstrate systems perform in accordance with contract document requirements and those listed in contract document's points list.

[3.7.8.5.1 Air-Cooled Chiller Chilled Water System.

a. Chiller(s) command and status

b. Chiller isolation valve(s) command and status

c. Chilled water pump(s) actual speed

d. Chilled water pump(s) setpoint and actual differential pressure

e. Minimum flow bypass control valve command

f. Minimum system flow setpoint and actual flow

g. Chilled water supply setpoint and actual temperature

h. Chilled water return actual temperature

i. Chilled water actual flow

j. Outside air actual dry-bulb temperature

][3.7.8.5.2 HVAC Heating Hot Water System with Boiler.

a. Boiler(s) command and status

b. Boiler(s) isolation valve command and status

c. HVAC heating hot water pump(s) actual speed

d. HVAC heating hot water pump(s) setpoint and actual differential pressure

e. Minimum flow bypass control valve command

f. Minimum system setpoint and actual flow

g. HVAC heating hot water supply setpoint and actual temperature

h. HVAC heating hot water return actual temperature

i. HVAC heating hot water actual flow

j. Outside air actual dry-bulb temperature

][3.7.8.5.3 HVAC Heating Hot Water System with Steam-to-Hot Water Heat Exchanger.

a. Steam control valve(s) command

b. Heat exchanger isolation valve(s) command and status

c. HVAC heating hot water pump(s) actual speed

d. HVAC heating hot water pump(s) setpoint and actual differential pressure

e. Minimum flow bypass control valve command

f. Minimum system setpoint and actual flow

g. HVAC heating hot water supply setpoint and actual temperature

h. HVAC heating hot water return actual temperature

i. HVAC heating hot water actual flow

j. Outside air actual dry-bulb temperature

][3.7.8.5.4 Air Handling Unit with Relief Air Fan

a. Outside air actual dry-bulb temperature

b. Outside air actual relative humidity

c. Outside air setpoint and actual airflow

d. Minimum outside air control damper command

e. Economizer outside air control damper command

f. Facility setpoint and actual relative pressure

g. Return air actual dry-bulb temperature

h. Return air actual relative humidity

i. Return air control damper command

j. Relief air control damper command

h. Relief air fan actual speed

i. Mixed air setpoint and setpoint and actual temperature

j. Preheat coil leaving air setpoint and actual temperature

k. Preheat coil control actuator command

l. Cooling coil leaving air setpoint and actual temperature

m. Cooling coil control valve command

n. Supply air fan actual speed

o. Discharge air actual temperature

p. Supply air fan setpoint and actual static pressure

][3.7.8.5.5 Dedicated Outside Air System (DOAS)

a. Outside air actual dry-bulb temperature

b. Outside air actual relative humidity

c. Outside air isolation damper command and status

d. Outside air setpoint and actual airflow

e. Energy recovery wheel command, status, and actual speed

f. Energy recovery wheel’s OA bypass control damper command and status

g. Energy recovery wheel’s defrost cycle command and status

h. Energy recovery wheel's OA discharge air actual dry-bulb temperature

i. Energy recovery wheel's OA discharge air actual relative humidity

j. Preheat coil leaving air setpoint and actual temperature

h. Preheat coil control actuator command

i. Cooling coil leaving air setpoint and actual temperature

j. Cooling coil control valve command

k. Supply air fan actual speed

l. Reheat coil control valve command

m. Discharge air setpoint and actual temperature

n. Supply air fan setpoint and actual static pressure

o. Facility setpoint and actual relative pressure

p. Return air actual dry-bulb temperature

q. Return air actual relative humidity

r. Energy recovery wheel's EA bypass control damper command and status

s. Energy recovery wheel's EA discharge air actual dry-bulb temperature

t. Energy recovery wheel's EA discharge air actual relative humidity

u. Exhaust air fan actual speed

v. Exhaust air isolation damper command and status

][3.7.8.5.6 Series Fan-Powered Supply Air Terminal Units

a. Zone setpoint and actual dry-bulb temperature

b. Zone actual relative humidity

c. Control damper command

d. Fan command and status

e. Heating coil valve command

f. Airflow actual value

g. Leaving air actual temperature

]3.7.8.6 Endurance Testing Sample Size

Endurance Testing sample sizes ware as follows:

a. 100-Percent of the following systems:

(1) primary systems including, but not limited to, chilled water and

HVAC heating hot water systems

(2) air handling unit systems including all associated fans except for remote exhaust air fans

(3) DOAS's including all associated fans except for remote exhaust air fans

b. 20-Percent of each set of systems with a shared identical control sequence for systems such as:

(1) air terminal units

(2) exhaust air fans

(3) terminal equipment such as fan coil units and unit heaters

3.7.8.6.1 Selection of Systems to Test

For sample sets less than 100-percent, the Government will choose which systems will be tested. The Government may require additional testing if previous testing results are inconsistent or demonstrate improper system control as follows:

a. An additional 25-percent after five-percent failure rate of first sample set.

b. 100-percent after any failures occurring in additional sample set.

3.7.9 Performance Verification Test Report

Submit a PVT Report after receiving Government's written approval of PVT field work that is intended to document test results and final control system sequences and settings prior to turnover. The PVT Report must contain the following:

a. Executive summary that briefly discusses results of each system's endurance testing and PVT testing and conclusions for each system.

b. Endurance testing for each system.

c. Completed PVT Plan for each system used during testing that includes hand written field notes and participant signatures.

d. Blank PVT Plan for each system approved prior to testing that is edited to reflect changes occurring during testing. Edits must be typed and must reflect changes to control sequences from contract documents, must reflect changes to numbered test methods required to initiate a response, and must reflect changes to expected response. Only one blank PVT Plan is required for each set of systems sharing an identical control sequence, such as air terminal units, exhaust air fans, fan coil units and unit heaters.

e. Written certification that the installation and testing of all systems are complete and meet all contract document requirements.

3.8 FINAL LNS DATABASE

Submit a Final LNS Database consisting of the complete, fully commissioned LNS database for the complete control network provided under this specification. Provide the the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}. For versions of LNS which use credits, include all device credits in the provided LNS Database.

Submit two copies of the fully commissioned, valid as-built LNS Database (including all LNS credits) for the complete control network provided under this specification as a Technical Data Package. Submit each copy on CD-ROM and clearly mark the CD-ROM identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification.

3.9 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Provide HVAC control System Operation and Maintenance Instructions which include:

a. "Data Package 3" as indicated in Section 01 78 23 OPERATION AND MAINTENANCE DATA for each piece of control equipment.

b. "Data Package 4" as described in Section 01 78 23 OPERATION AND MAINTENANCE DATA for all air compressors.

c. HVAC control system sequences of operation formatted as indicated.

d. Procedures for the HVAC system start-up, operation and shut-down including the manufacturer's supplied procedures for each piece of equipment, and procedures for the overall HVAC system.

e. As-built HVAC control system detail drawings formatted as indicated.

f. Routine maintenance checklist. Provide the routine maintenance checklist arranged in a columnar format, where the first column lists all installed devices, the second column states the maintenance activity or that no maintenance required, the third column states the frequency of the maintenance activity, and the fourth column is used for additional comments or reference.

g. Qualified service organization list, including at a minimum company name, contact name and phone number.

h. Start-Up Testing Report.

i. Performance Verification Test (PVT) Procedures and Report.

Submit [2] [_____] copies of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions may be submitted as a Technical Data Package.

[3.10 MAINTENANCE AND SERVICE

Provide services, materials and equipment as necessary to maintain the entire system in an operational state as indicated for a period of one year from the date of final acceptance of the project. Minimize impacts on facility operations.

a. The integration of the system specified in this section into a Utility Monitoring and Control System must not, of itself, void the warranty or otherwise alter the requirement for the one year maintenance and service period. Integration into a UMCS includes but is not limited to establishing communication between devices in the control system and the front end or devices in another system.

b. The changing of configuration properties must not, of itself, void the warranty or otherwise alter the requirement for the one year maintenance and service period.

3.10.1 Description of Work

Provide adjustment and repair of the system including the manufacturer's required sensor and actuator (including transducer) calibration, span and range adjustment.

3.10.2 Personnel

Use only service personnel qualified to accomplish work promptly and satisfactorily. Advise the Government in writing of the name of the designated service representative, and of any changes in personnel.

3.10.3 Scheduled Inspections

Perform two inspections at six-month intervals and provide work required. Perform inspections in [June and December][_____]. During each inspection perform the indicated tasks:

a. Perform visual checks and operational tests of equipment.

b. Clean control system equipment including interior and exterior surfaces.

c. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all binary inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining binary inputs and outputs during the second inspection. If more than 20 percent of checked inputs or outputs failed the calibration check during any inspection, check and recalibrate all inputs and outputs during that inspection.

d. Run system software diagnostics and correct diagnosed problems.

e. Resolve any previous outstanding problems.

3.10.4 Scheduled Work

This work must be performed [during regular working hours, Monday through Friday, excluding Federal holidays][_____].

3.10.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel must be available to provide service to the system. A telephone number where the service supervisor can be reached at all times must be provided. Service personnel must be at the site within 24 hours after receiving a request for service. The control system must be restored to proper operating condition as required per Section 01 78 00 CLOSEOUT SUBMITTALS.

3.10.6 Operation

After performing scheduled adjustments and repairs, verify control system operation as demonstrated by the applicable tests of the performance verification test.

3.10.7 Records and Logs

Keep dated records and logs of each task, with cumulative records for each major component, and for the complete system chronologically. Maintain a continuous log for all devices, including initial analog span and zero calibration values and digital points. Keep complete logs and provide logs for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

3.10.8 Work Requests

Record each service call request as received and include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. Submit a record of the work performed within 5 days after work is accomplished.

3.10.9 System Modifications

Submit recommendations for system modification in writing. Do not make system modifications, including operating parameters and control settings, without prior approval of the Government.

]3.11 TRAINING

Conduct a training course for [_____] operating staff members designated by the Government in the maintenance and operation of the system, including specified hardware and software. Conduct [32] [_____] hours of training at the project site within 30 days after successful completion of the performance verification test. The Government reserves the right to make audio and visual recordings (using Government supplied equipment)of the training sessions for later use. Provide audiovisual equipment and other training materials and supplies required to conduct training. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.11.1 Training Documentation

Prepare training documentation consisting of:

a. Course Attendee List: Develop the list of course attendees in coordination with and signed by the [Controls][HVAC][Electrical] shop supervisor.

b. Training Manuals: Provide training manuals which include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. When presenting portions of the course material by audiovisuals, deliver copies of those audiovisuals as a part of the printed training manuals.

3.11.2 Training Course Content

For guidance in planning the required instruction, assume that attendees will have a high school education, and are familiar with HVAC systems. During the training course, cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each controller enclosure, the layout of one of each type of equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. Present the results of the performance verification test and the Start-Up Testing Report as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

3.11.3 Training Documentation Submittal Requirements

Submit hardcopy training manuals and all training materials on CD-ROM. Provide one hardcopy manual for each trainee on the Course Attendee List and [2][_____] additional copies for archive at the project site. Provide [2][_____] copies of the Course Attendee List with the archival copies. Training Documentation may be submitted as a Technical Data Package.

APPENDIX A

QC CHECKLIST FOR LNS-BASED LONWORKS SYSTEMS		
This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such. Instructions: Initial each item in the space provided (|____|) verifying that the requirement has been met.		
This checklist is for (circle one:) Pre-Construction QC Checklist Submittal Post-Construction QC Checklist Submittal Close-out QC Checklist Submittal		
Items verified for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:		
1	All DDC Hardware is numbered on Control System Schematic Drawings.	|____|
2	Signal lines on Control System Schematic are labeled with the signal type.	|____|
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	|____|
Items verified for Post-Construction and Closeout QC Checklist Submittals:		
4	All sequences are performed as specified using DDC Hardware.	|____|
5	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	|____|
6	All DDC Hardware is installed on a TP/FT-10 Channel.	|____|
7	All Application Specific Controllers (ASCs) are LonMark certified.	|____|
8	Communication between DDC Hardware is only via CEA-709.1-D using SNVTs. Other protocols have not been used. Network variables other than SNVTs have not been used.	|____|
9	Explicit messaging has not been used.	|____|
10	Scheduling is performed in DDC Hardware meeting the Simple Schedule Functional Profile	|____|
Items verified for Closeout QC Checklist Submittal:		

QC CHECKLIST FOR LNS-BASED LONWORKS SYSTEMS		
11	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.	|____|
12	Programming software has been submitted for all programmable controllers.	|____|
13	All software has been licensed to the Government.	
14	O&M Instructions have been completed and submitted.	|____|
15	Training course has been completed.	|____|
16	LonWorks Network Services (LNS) Database is up-to-date and accurately represents the final installed system.	|____|
17	LNS Plug-ins have been submitted for all Application Specific Controllers (ASCs).	|____|
18	Programming software has been submitted for all General Purpose Programmable Controllers (GPPCs) and all Application Generic Controllers (AGCs).	|____|
	____________________________ ____________	
	(QC Representative Signature) (Date)	

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED LONWORKS SYSTEMS		
This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such. Instructions: Initial each item in the space provided (|____|) verifying that the requirement has been met.		
This checklist is for (circle one:) Pre-Construction QC Checklist Submittal Post-Construction QC Checklist Submittal Close-out QC Checklist Submittal		
Items verified for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:		
1	All DDC Hardware is numbered on Control System Schematic Drawings.	|____|

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED LONWORKS SYSTEMS		
2	Signal lines on Control System Schematic are labeled with the signal type.	|____|
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	|____|
Items verified for Post-Construction and Closeout QC Checklist Submittals:		
4	All sequences are performed as specified using DDC Hardware.	|____|
5	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	|____|
6	All DDC Hardware except Niagara Framework Supervisory Gateways is installed on a TP/FT-10 Channel.	|____|
7	All Application Specific Controllers (ASCs) are LonMark certified.	|____|
8	Except for communication between two Niagara Framework Supervisory Gateways, Communication between DDC Hardware is only via CEA-709.1-D using SNVTs. Other protocols have not been used. Network variables other than SNVTs have not been used. Communication between Niagara Framework Supervisory Gateways is via Fox Protocol.	|____|
9	Explicit messaging has not been used.	|____|
10	Scheduling, Alarming, and Trending have been implemented using Niagara Framework objects and services.	|____|
Items verified for Closeout QC Checklist Submittal:		
11	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.	|____|
12	Programming software has been submitted for all programmable controllers.	|____|
13	All software has been licensed to the Government.	
14	O&M Instructions have been completed and submitted.	|____|
15	Training course has been completed.	|____|
16	The database in each Niagara Framework Supervisory Gateway is up-to-date and accurately represents the building control network beneath that Niagara Framework Supervisory Gateway.	|____|
17	Niagara Wizards have been submitted for all Application Specific Controllers (ASCs) for which a Wizard is available and for all Application Generic Controllers (AGCs).	|____|

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED LONWORKS SYSTEMS		
18	Programming software has been submitted for all General Purpose Programmable Controllers (GPPCs) and all Application Generic Controllers (AGCs).	|____|
______________________________	______________	
	(QC Representative Signature) (Date)	

QC CHECKLIST FOR BACNET SYSTEMS		
This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such. Instructions: Initial each item in the space provided (|____|) verifying that the requirement has been met.		
This checklist is for (circle one:) Pre-Construction QC Checklist Submittal Post-Construction QC Checklist Submittal Close-out QC Checklist Submittal		
Items verified for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:		
1	All DDC Hardware is numbered on Control System Schematic Drawings.	|____|
2	Signal lines on Control System Schematic are labeled with the signal type.	|____|
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	|____|
Items verified for Post-Construction and Closeout QC Checklist Submittals:		
4	All sequences are performed as specified using DDC Hardware.	|____|
5	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	|____|
Items verified for Closeout QC Checklist Submittal:		

QC CHECKLIST FOR BACNET SYSTEMS		
6	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.	|____|
7	Programming software has been submitted for all programmable controllers.	|____|
8	All software has been licensed to the Government.	
9	O&M Instructions have been completed and submitted.	|____|
10	Training course has been completed.	|____|
11	All DDC Hardware is installed on a BACnet ASHRAE 135 network using either MS/TP in accordance with Clause 9 or IP in accordance with Annex J.	|____|
12	All DDC Hardware is BTL listed.	|____|
13	Communication between DDC Hardware is only via BACnet using standard services, except as specifically permitted by the specification. Non-standard services have been fully documented in the DDC Hardware Schedule.	|____|
14	Scheduling, Alarming, and Trending have been implemented using the standard BACnet Objects for these functions.	|____|
15	All Properties indicated as required to be Writable are Writable and Overrides have been provided as indicated	|____|
	______________________________ ____________	
	(QC Representative Signature) (Date)	

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED BACNET SYSTEMS
This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such. Instructions: Initial each item in the space provided (|____|) verifying that the requirement has been met.
This checklist is for (circle one:) Pre-Construction QC Checklist Submittal Post-Construction QC Checklist Submittal Close-out QC Checklist Submittal

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED BACNET SYSTEMS

Items verified for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:		
1	All DDC Hardware is numbered on Control System Schematic Drawings.	|____|
2	Signal lines on Control System Schematic are labeled with the signal type.	|____|
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	|____|
Items verified for Post-Construction and Closeout QC Checklist Submittals:		
4	All sequences are performed as specified using DDC Hardware.	|____|
5	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	|____|
Items verified for Closeout QC Checklist Submittal:		
6	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.	|____|
7	Programming software has been submitted for all programmable controllers.	|____|
8	All software has been licensed to the Government.	
9	O&M Instructions have been completed and submitted.	|____|
10	Training course has been completed.	|____|
11	All DDC Hardware is installed on a BACnet ASHRAE 135 network using either MS/TP in accordance with Clause 9 or IP in accordance with Annex J.	|____|
12	All DDC Hardware is BTL listed.	|____|
13	Communication between DDC Hardware is only via BACnet using standard services, except as specifically permitted by the specification. Non-standard services have been fully documented in the DDC Hardware Schedule.	|____|
14	Scheduling, Alarming, and Trending have been implemented using Niagara Framework objects and services, and BACnet Instrinsic Alarming as indicated.	|____|
15	All Properties indicated as required to be Writable are Writable and Overrides have been provided as indicated	|____|

____   ____________________

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED BACNET SYSTEMS		
	(QC Representative Signature)	(Date)

-- End of Section --

SECTION 23 09 13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
11/15, CHG 2: 05/21

PART 1 GENERAL

1.1 SUMMARY

This section provides for the instrumentation control system components excluding direct digital controllers, network controllers, gateways etc. that are necessary for a completely functional automatic control system. When combined with a Direct Digital Control (DDC) system, the Instrumentation and Control Devices covered under this section must be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and indicated.

a. Install hardware to perform the control sequences as specified and indicated and to provide control of the equipment as specified and indicated.

b. Install hardware such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

c. Install and configure hardware such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the installing Contractor.

1.1.1 Verification of Dimensions

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.1.2 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.2 RELATED SECTIONS

Related work specified elsewhere.

Section 01 30 00 ADMINISTRATIVE REQUIREMENTS

Section 23 30 00 HVAC AIR DISTRIBUTION

Section 23 05 15 COMMON PIPING FOR HVAC

Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating
AMCA 511	(2010; R 2016) Certified Ratings Program for Air Control Devices

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A269/A269M	(2015; R 2019) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube

ASTM D635	(2018) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics

FLUID CONTROLS INSTITUTE (FCI)

FCI 70-2	(2021) Control Valve Seat Leakage

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.20	(2015; E 2018) Electricity Meters - 0.1, 0.2, and 0.5 Accuracy Classes
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 94	(2013; Reprint Apr 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 555S	(2014; Reprint Oct 2020) UL Standard for Safety Smoke Dampers
UL 1820	(2004; Reprint May 2013) UL Standard for Safety Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics
UL 5085-3	(2006; Reprint Jan 2022) UL Standard for Safety Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers

1.4 SUBMITTALS

Submittal requirements are specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.5 DELIVERY AND STORAGE

Store and protect products from the weather, humidity, and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.6 INPUT MEASUREMENT ACCURACY

Select, install and configure sensors, transmitters and DDC Hardware such that the maximum error of the measured value at the input of the DDC hardware is less than the maximum allowable error specified for the sensor or instrumentation.

1.7 SUBCONTRACTOR SPECIAL REQUIREMENTS

Perform all work in this section in accordance with the paragraph entitled CONTRACTOR SPECIAL REQUIREMENTS in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 General Requirements

All products used to meet this specification must meet the indicated requirements, but not all products specified here will be required by every project. All products must meet the requirements both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1.2 Operation Environment Requirements

Unless otherwise specified, provide products rated for continuous operation under the following conditions:

2.1.2.1 Pressure

Pressure conditions normally encountered in the installed location.

2.1.2.2 Vibration

Vibration conditions normally encountered in the installed location.

2.1.2.3 Temperature

a. Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.

b. Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of [-35 to +151 degrees F] [_____] and temperature conditions outside this range normally encountered at the installed location.

2.1.2.4 Humidity

10 to 95 percent relative humidity, non-condensing and also humidity conditions outside this range normally encountered at the installed location.

2.2 WEATHERSHIELDS

Provide weathershields constructed of galvanized steel painted white, unpainted aluminum, aluminum painted white, or white PVC.

[2.3 TUBING

2.3.1 Copper

Provide ASTM B75/B75M or ASTM B88 rated tubing meeting the following requirements:

a. For tubing 0.375 inch outside diameter and larger provide tubing with minimum wall thickness equal to ASTM B88, Type M

b. For tubing less than 0.375 inch outside diameter provide tubing with minimum wall thickness of 0.025 inch

c. For exposed tubing and tubing for working pressures greater than 30 psig provide hard copper tubing.

d. Provide fittings which are ASME B16.18 or ASME B16.22 solder type using ASTM B32 95-5 tin-antimony solder, or which are ASME B16.26 compression type.

2.3.2 Stainless Steel

For stainless steel tubing provide tubing conforming to ASTM A269/A269M

2.3.3 Plastic

Provide plastic tubing with the burning characteristics of linear low-density polyethylene tubing which is self-extinguishing when tested in accordance with ASTM D635, has UL 94 V-2 flammability classification or better, and which withstands stress cracking when tested in accordance with ASTM D1693. Provide plastic-tubing bundles with Mylar barrier and flame-retardant polyethylene jacket.

2.3.4 Polyethylene Tubing

Provide flame-resistant, multiple polyethylene tubing in flame-resistant protective sheath with mylar barrier, or unsheathed polyethylene tubing in rigid metal, intermediate metal, or electrical metallic tubing conduit for areas where tubing is exposed. Single, unsheathed, flame-resistant polyethylene tubing may be used where concealed in walls or above ceilings and within control panels. Do not provide polyethylene tubing for [systems indicated as critical and] smoke removal systems, or for systems with working pressures over 30 psig. Provide compression or brass barbed push-on type fittings. Provide extruded seamless polyethylene tubing conforming to the following:

a. Minimum Burst Pressure Requirements: 100 psig at 75 degrees F to 25 psig at 150 degrees F.

b. Stress Crack Resistance: ASTM D1693, 200 hours minimum.

c. Tensile Strength (Minimum): ASTM D638, 1100 psi.

d. Flow Rate (Average): ASTM D1238, 0.30 decigram per minute.

e. Density (Average): ASTM D792, 57.5 pounds per cubic feet.

f. Burn rate: ASTM D635

g. Flame Propagation: UL 1820, less than 5 feet ASTM D635

h. Average Optical Density: UL 1820, less than 0.15 ASTM D635

]2.4 WIRE AND CABLE

Provide wire and cable meeting the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification and referenced specifications.

2.4.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.4.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.4.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

a. minimum 2 inch lay of twist

b. 100 percent shielded pairs

c. at least 300-volt insulation

d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation

e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.4.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.4.5 Transformers

Provide UL 5085-3 approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

2.5 AUTOMATIC CONTROL VALVES

Provide valves with stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Provide valves with bodies meeting ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure. Unless otherwise specified or indicated, provide valves meeting FCI 70-2 [Class III leakage rating][Class IV leakage rating]. Provide valves rated for modulating or two-position service as indicated, which close against a differential pressure indicated as the Close-Off pressure and which are Normally-Open, Normally-Closed, or Fail-In-Last-Position as indicated.

2.5.1 Valve Type

2.5.1.1 Liquid Service 150 Degrees F or Less

Use either globe valves or ball valves except that butterfly valves may be used for sizes 4 inch and larger.

2.5.1.2 Liquid Service Above 150 Degrees F

a. Two-position valves: Use either globe valves or ball valves except that butterfly valves may be used for sizes 4 inch and larger.

b. Modulating valves: Use globe valves except that butterfly valves may be used for sizes 4 inch and larger.

2.5.1.3 Steam Service

Use globe valves except that butterfly valves may be used for sizes 4 inch and larger.

2.5.2 Valve Flow Coefficient and Flow Characteristic

2.5.2.1 Two-Way Modulating Valves

Provide the valve coefficient (Cv) indicated. Provide equal-percentage flow characteristic for liquid service except for butterfly valves. Provide linear flow characteristic for steam service except for butterfly valves.

2.5.2.2 Three-Way Modulating Valves

Provide the valve coefficient (Cv) indicated. Provide linear flow characteristic with constant total flow throughout full plug travel.

2.5.3 Two-Position Valves

Use full line size full port valves with maximum available (Cv).

2.5.4 Globe Valves

2.5.4.1 Liquid Service Not Exceeding 150 Degrees F

a. Valve body and body connections:

   (1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends

   (2) valves from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch valves with threaded connections; 2-1/2 to 3 inches valves with flanged connections

b. Internal valve trim: Brass or bronze.

c. Stems: Stainless steel.

d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.5.4.2 Liquid Service Not Exceeding 250 Degrees F

a. Valve body and body connections:

   (1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends

   (2) valves from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch valves with threaded connections; 2-1/2 to 3 inches valves with flanged connections

b. Internal trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

c. Provide valves with non-metallic parts suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.

d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol

2.5.4.3 Hot water service 250 Degrees F and above

a. Provide valve bodies conforming to ASME B16.34 Class 300. For valves 1 inch and larger provide valves with bodies which are carbon steel, globe type with welded ends. For valves smaller than 1 inch provide valves with socket-weld ends. Provide valves with virgin polytetrafluoroethylene (PTFE) packing. Provide valve and actuator combinations which are normally closed.

b. Internal trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

2.5.4.4 Steam Service

For steam service, provide valves meeting the following requirements:

a. Valve body and connections:

(1) valves 1-1/2 inches and smaller: complete body of brass or bronze, with threaded or union ends

(2) valves from 2 inches to 3 inches inclusive: body of brass, bronze, or carbon steel

(3) valves 4 inches and larger: body of carbon steel. 2 inch valves with threaded connections; valves2-1/2 inches and larger with flanged connections.

b. Internal Trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

c. Valve sizing: sized for [15 psig] [_____] inlet steam pressure with a maximum [12 psi] [_____] differential through the valve at rated flow, except where indicated otherwise.

2.5.5 Ball Valves

2.5.5.1 Liquid Service Not Exceeding 150 Degrees F

a. Valve body and connections:

(1) valves 1-1/2 inches and smaller: bodies of brass or bronze, with threaded or union ends

(2) valves from 2 inches to 3 inches inclusive: bodies of brass, bronze, or iron. 2 inch valves with threaded connections; valves from 2-1/2 to 3 inches with flanged connections.

b. Ball: Stainless steel or nickel-plated brass or chrome-plated brass.

c. Seals: Reinforced Teflon seals and EPDM O-rings.

d. Stem: Stainless steel, blow-out proof.

e. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.5.6 Butterfly Valves

Provide butterfly valves which are threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies or with ductile iron bodies in accordance with ASTM A536. Provide butterfly valves with non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -20 to +250 degrees F. Provide valves with rated Cv of the Cv at 70 percent (60 degrees) open position. Provide valves meeting FCI 70-2 Class VI leakage rating.

2.5.7 Pressure Independent Control Valves (PICV)

Provide pressure independent control valves which include a regulator valve which maintains the differential pressure across a flow control valve. Pressure independent control valves must accurately control the flow from 0-100 percent full rated flow regardless of changes in the piping pressure and not vary the flow more than plus or minus 5 percent at any given flow control valve position when the PICV differential pressure lies between the manufacturer's stated minimum and maximum. The rated minimum differential pressure for steady flow must not exceed 5 psid across the PICV. Provide either globe or ball type valves meeting the indicated requirements for globe and ball valves. Provide valves with a flow tag listing full rated flow and minimum required pressure drop. Provide valves with factory installed Pressure/Temperature ports ("Pete's Plugs") to measure the pressure drop to determine the valve flow rate.

2.5.8 Duct-Coil and Terminal-Unit-Coil Valves

For duct or terminal-unit coils provide control valves with either [flare-type][screw type] or solder-type ends. Provide flare nuts for each flare-type end valve.

2.6 DAMPERS

2.6.1 Damper Assembly

Provide single damper sections with blades no longer than 48 inches and which are no higher than 72 inches and damper blade width of 8 inches or less. When larger sizes are required, combine damper sections. Provide dampers made of steel, or other materials where indicated and with assembly frames constructed of 0.07 inch minimum thickness [galvanized][stainless] steel channels with mitered and welded corners. Steel channel frames constructed of 0.06 inch minimum thickness are acceptable provided the corners are reinforced.

a. Flat blades must be made rigid by folding the edges. Blade-operating linkages must be within the frame so that blade-connecting devices within the same damper section must not be located directly in the air stream.

b. Damper axles must be 1/2 inch minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically must be supported by thrust bearings.

c. Provide dampers which do not exceed a pressure drop through the damper of 0.04 inches water gauge at 1000 ft/min in the wide-open position. Provide dampers with frames not less than 2 inch in width. Provide dampers which have been tested in accordance with AMCA 500-D.

2.6.2 Operating Linkages

For operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, provide links able to withstand a load equal to at least 300 percent of the maximum required damper-operating force without deforming. Rod lengths must be adjustable. Links must be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises must be brass, bronze, or stainless steel. Adjustments of crank arms must control the open and closed positions of dampers.

2.6.3 Damper Types

2.6.3.1 Flow Control Dampers

Provide parallel-blade or opposed blade type dampers for outside air, return air, relief air, exhaust, face and bypass dampers as indicated on the Damper Schedule. Blades must have interlocking edges. The channel frames of the dampers must be provided with jamb seals to minimize air leakage. Unless otherwise indicated, dampers must meet AMCA 511 [Class 1A][Class 1][Class 2] requirements. Outside air damper seals must be suitable for an operating temperature range of -40 to +167 degrees F. Dampers must be rated at not less than 2000 ft/min air velocity.

2.6.3.2 Mechanical Rooms and Other Utility Space Ventilation Dampers

Provide utility space ventilation dampers as indicated. Unless otherwise indicated provide AMCA 511 class 3 dampers. Provide dampers rated at not less than 1500 ft/min air velocity.

2.6.3.3 Smoke Dampers

Provide smoke-damper and actuator assemblies which meet the current requirements of NFPA 90A, UL 555, and UL 555S. For combination fire and smoke dampers provide dampers rated for 250 degrees F Class II leakage per UL 555S.

2.7 SENSORS AND INSTRUMENTATION

Unless otherwise specified, provide sensors and instrumentation which incorporate an integral transmitter. Sensors and instrumentation, including their transmitters, must meet the specified accuracy and drift requirements at the input of the connected DDC Hardware's analog-to-digital conversion.

2.7.1 Analog and Binary Transmitters

Provide transmitters which match the characteristics of the sensor. Transmitters providing analog values must produce a linear 4-20 mAdc, 0-10 Vdc signal corresponding to the required operating range and must have zero and span adjustment. Transmitters providing binary values must have dry contacts rated at 1A at 24 Volts AC.

2.7.2 Network Transmitters

Sensors and Instrumentation incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS when used in a Lonworks network, or the requirements of 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND

OTHER BUILDING CONTROL SYSTEMS when used in a BACnet network.

2.7.3 Temperature Sensors

Provide the same sensor type throughout the project. Temperature sensors may be provided without transmitters. Where transmitters are used, the range must be the smallest available from the manufacturer and suitable for the application such that the range encompasses the expected range of temperatures to be measured. The end to end accuracy includes the combined effect of sensitivity, hysteresis, linearity and repeatability between the measured variable and the end user interface (graphic presentation) including transmitters if used.

2.7.3.1 Sensor Accuracy and Stability of Control

2.7.3.1.1 Conditioned Space Temperature

Plus or minus 0.5 degree F over the operating range.

2.7.3.1.2 Unconditioned Space Temperature

a. Plus or minus 1 degree F over the range of 30 to 131 degrees F AND

b. Plus or minus 4 degrees F over the rest of the operating range.

2.7.3.1.3 Duct Temperature

Plus or minus 0.5 degree F

2.7.3.1.4 Outside Air Temperature

a. Plus or minus 2 degrees F over the range of -30 to +130 degrees F AND

b. Plus or minus 1 degree F over the range of 30 to 130 degrees F.

2.7.3.1.5 High Temperature Hot Water

Plus or minus 3.6 degrees F.

2.7.3.1.6 Chilled Water

Plus or minus 0.8 degrees F over the range of 35 to 65 degrees F.

2.7.3.1.7 Dual Temperature Water

Plus or minus 2 degrees F.

2.7.3.1.8 Heating Hot Water

Plus or minus 2 degrees F.

2.7.3.1.9 Condenser Water

Plus or minus 2 degrees F.

2.7.3.2 Transmitter Drift

The maximum allowable transmitter drift: 0.25 degrees F per year.

2.7.3.3 Point Temperature Sensors

Point Sensors must be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.7.3.4 Temperature Sensor Details

2.7.3.4.1 Room Type

Provide the sensing element components within a decorative protective cover suitable for surrounding decor.

2.7.3.4.2 Duct Probe Type

Ensure the probe is long enough to properly sense the air stream temperature.

2.7.3.4.3 Duct Averaging Type

Continuous averaging sensors must be one foot in length for each 1 square foot of duct cross-sectional area, and a minimum length of 5 feet.

2.7.3.4.4 Pipe Immersion Type

For pipes with larger than 3 inch diameter, provide minimum 3 inch immersion. For pipes with less than 3 inch diameter, provide immersion at least half the diameter of the pipe. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells must be stainless steel when used in steel piping, and brass when used in copper piping.

2.7.3.4.5 Outside Air Type

Provide the sensing element rated for outdoor use

2.7.4 Relative Humidity Sensor

Relative humidity sensors must use bulk polymer resistive or thin film capacitive type non-saturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors must include removable protective membrane filters. Where required for exterior installation, sensors must be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration. When used indoors, the sensor must be capable of being exposed to a condensing air stream (100 percent relative humidity) with no adverse effect to the sensor's calibration or other harm to the instrument. The sensor must be of the wall-mounted or duct-mounted type, as required by the application, and must be provided with any required accessories. Sensors used in duct high-limit applications must have a bulk polymer resistive sensing element. Duct-mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. Relative humidity (RH) sensors must measure relative humidity over a range of 0 percent to 100 percent with an accuracy of plus or minus [2][3] percent. RH sensors must function over a temperature range of 40 to 135 degrees F and must not drift more than 1 percent per year.

2.7.5 Carbon Dioxide (CO2) Sensors

Provide photometric type CO2 sensors with integral transducers and linear output. Carbon dioxide (CO2) sensors must measure CO2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersible infrared (NDIR) technology with an accuracy of plus or minus 50 ppm and a maximum response time of 1 minute. The sensor must be rated for operation at ambient air temperatures within the range of 32 to 122 degrees F and relative humidity within the range of 20 to 95 percent (non-condensing). The sensor must have a maximum drift of 2 percent per year. The sensor chamber must be manufactured with a non-corrosive material that does not affect carbon dioxide sample concentration. Duct mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The sensor must have a calibration interval no less than 5 years.

2.7.6 Differential Pressure Instrumentation

2.7.6.1 Differential Pressure Sensors

Provide Differential Pressure Sensors with ranges as indicated or as required for the application. Pressure sensor ranges must not exceed the high end range indicated on the Points Schedule by more than 50 percent. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The accuracy must be plus or minus 1 percent of full scale. The sensor must have a maximum drift of 2 percent per year

2.7.6.2 Differential Pressure Switch

Provide differential pressure switches with a user-adjustable setpoint which are sized for the application such that the setpoint is between 25 percent and 75 percent of the full range. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The switch must have two sets of contacts and each contact must have a rating greater than it's connected load. Contacts must open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as indicated.

2.7.7 Flow Sensors

2.7.7.1 Airflow Measurement Array (AFMA)

2.7.7.1.1 Airflow Straightener

Provide AFMAs which contain an airflow straightener if required by the AFMA manufacturer's published installation instructions. The straightener must be contained inside a flanged sheet metal casing, with the AFMA located as specified according to the published recommendation of the AFMA manufacturer. In the absence of published documentation, provide airflow straighteners if there is any duct obstruction within 5 duct diameters upstream of the AFMA. Air-flow straighteners, where required, must be constructed of 0.125 inch aluminum honeycomb and the depth of the straightener must not be less than 1.5 inches.

2.7.7.1.2 Resistance to Airflow

The resistance to air flow through the AFMA, including the airflow straightener must not exceed 0.085 inch water gauge at an airflow of 2,000 fpm. AFMA construction must be suitable for operation at airflows of up to 5000 fpm over a temperature range of 40 to 120 degrees F.

2.7.7.1.3 Outside Air Temperature

In outside air measurement or in low-temperature air delivery applications, provide an AFMA certified by the manufacturer to be accurate as specified over a temperature range of [-20 to +120 degrees F] [_____].

2.7.7.1.4 Pitot Tube AFMA

Each Pitot Tube AFMA must contain an array of velocity sensing elements. The velocity sensing elements must be of the multiple pitot tube type with averaging manifolds. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published installation instructions of the AFMA manufacturer.

a. Pitot Tube AFMAs for use in airflows over 600 fpm must have an accuracy of plus or minus 5 percent over a range of 500 to 2500 fpm.

b. Pitot Tube AFMAs for use in airflows under 600 fpm must have an accuracy of plus or minus 5 percent over a range of 125 to 2500 fpm.

2.7.7.1.5 Electronic AFMA

Each electronic AFMA must consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published application data of the AFMA manufacturer. Electronic AFMAs must have an accuracy of plus or minus 5 percent over a range of 125 to 5,000 fpm and the output must be temperature compensated over a range of 32 to 212 degrees F.

2.7.7.1.6 Fan Inlet Measurement Devices

Fan inlet measurement devices cannot be used unless indicated on the drawings or schedules.

2.7.7.2 Orifice Plate

Orifice plate must be made of an austenitic stainless steel sheet of 0.125 inch nominal thickness with an accuracy of plus or minus 1 percent of full flow. The orifice plate must be flat within 0.002 inches. The orifice surface roughness must not exceed 20 micro-inches. The thickness of the cylindrical face of the orifice must not exceed 2 percent of the pipe inside diameter or 12.5 percent of the orifice diameter, whichever is smaller. The upstream edge of the orifice must be square and sharp. Where orifice plates are used, concentric orifice plates must be used in all applications except steam flow measurement in horizontal pipelines.

2.7.7.3 Flow Nozzle

Flow nozzle must be made of austenitic stainless steel with an accuracy of plus or minus 1 percent of full flow. The inlet nozzle form must be elliptical and the nozzle throat must be the quadrant of an ellipse. The thickness of the nozzle wall and flange must be such that distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline must not cause the accuracy to degrade beyond the specified limit. The outside diameter of the nozzle flange or the design of the flange facing must be such that the nozzle throat must be centered accurately in the pipe.

2.7.7.4 Venturi Tube

Venturi tube must be made of cast iron or cast steel and must have an accuracy of plus or minus 1 percent of full flow. The throat section must be lined with austenitic stainless steel. Thermal expansion characteristics of the lining must be the same as that of the throat casting material. The surface of the throat lining must be machined to a plus or minus 50 micro inch finish, including the short curvature leading from the converging entrance section into the throat.

2.7.7.5 Annular Pitot Tube

Annular pitot tube must be made of austenitic stainless steel with an accuracy of plus or minus 2 percent of full flow and a repeatability of plus or minus 0.5 percent of measured value. The unit must have at least one static port and no less than four total head pressure ports with an averaging manifold.

2.7.7.6 Insertion Turbine Flowmeter

Provide dual axial turbine flowmeter with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Insertion Turbine Flowmeter accuracy must be plus or minus 0.5 percent of rate at calibrated velocity., within plus or minus of rate over a 10:1 turndown and within plus or minus 2 percent of rate over a 50:1 turndown. Repeatability must be plus or minus 0.25 percent of reading. The meter flow sensing element must operate over a range suitable for the installed location with a pressure loss limited to 1 percent of operating pressure at maximum flow rate. The flowmeter ,must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs. The turbine rotor assembly must be constructed of Series 300 stainless steel and use Teflon seals.

2.7.7.7 Vortex Shedding Flowmeter

Vortex Shedding Flowmeter accuracy must be within plus or minus 0.8 percent of the actual reading over the range of the meter. Steam meters must contain density compensation by direct measurement of temperature. Mass flow inferred from specified steam pressure are not acceptable. The flow meter body must be made of austenitic stainless steel and include a weather tight NEMA 4X electronics enclosure. The vortex shedding flowmeter body must not require removal from the piping in order to replace the shedding sensor.

2.7.7.8 Ultrasonic Flow Meter

Provide Ultrasonic Flow Meters complete with matched transducers, self aligning installation hardware and transducer cables. Ultrasonic transducers must be optimized for the specific pipe and process conditions for the application. The flow meter accuracy must plus or minus 1 percent of rate from 0 to 40 ft/sec. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc output.

2.7.7.9 Insertion Magnetic Flow Meter

Provide insertion type magnetic flowmeters with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Flowmeter accuracy must be no greater than plus or minus 1 percent of rate from 2 to 20 feet/sec. Wetted material parts must be 300 series stainless steel. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs.

2.7.7.10 Positive Displacement Flow Meter

The flow meter must be a direct reading, gerotor, nutating disc or vane type displacement device rated for liquid service as indicated. A counter must be mounted on top of the meter, and must consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote reading. The totalizer must have a six digit register to indicate the volume passed through the meter in [liters] [gallons], and a sweep-hand dial to indicate down to 0.25 gallons. The pulse transmitter must have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter must have a bronze body with threaded or flanged connections as required for the application. Output accuracy must be plus or minus 2 percent of the flow range. The maximum pressure drop at full flow must be 5 psig.

2.7.7.11 Flow Meters, Paddle Type

Sensor must be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy must be plus or minus 1 percent of rate of flow, minimum operating flow velocity must be 1 foot per second. Sensor repeatability and linearity must be plus or minus 1 percent. Materials which will be wetted must be made from non-corrosive materials and must not contaminate water. The sensor must be rated for installation in pipes of 3 to 40 inch diameters. The transmitter housing must be a NEMA 250 Type 4 enclosure.

2.7.7.12 Flow Switch

Flow switch must have a repetitive accuracy of plus or minus 10 percent of actual flow setting. Switch actuation must be adjustable over the operating flow range, and must be sized for the application such that the setpoint is between 25 percent and 75 percent of the full range.. The switch must have Form C snap-action contacts, rated for the application. The flow switch must have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system must be rated for use in corrosive environments encountered.

2.7.7.13 Gas Flow Meter

Gas flow meter must be diaphragm or bellows type (gas positive displacement meters) for flows up to 2500 SCFH and axial flow turbine type for flows above 2500 SCFH, designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter must have a minimum turndown ratio of 10 to 1 with an accuracy of plus or minus 1 percent of actual flow rate. The meter index must include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. The electrical impulse dry contact output must not require field adjustment or calibration. The electrical impulse dry contact output must have a minimum resolution of 100 cubic feet of gas per pulse and must not exceed 15 pulses per second at the design flow.

2.7.8 Electrical Instruments

Provide Electrical Instruments with an input range as indicated or sized for the application. Unless otherwise specified, AC instrumentation must be suitable for 60 Hz operation.

2.7.8.1 Current Transducers

Current transducers must accept an AC current input and must have an accuracy of plus or minus [0.5] [2] percent of full scale. The device must have a means for calibration. Current transducers for variable frequency applications must be rated for variable frequency operation.

2.7.8.2 Current Sensing Relays (CSRs)

Current sensing relays (CSRs) must provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current sensing relays must be of split-core design. The CSR must be rated for operation at 200 percent of the connected load. Voltage isolation must be a minimum of 600 volts. The CSR must auto-calibrate to the connected load or be adjustable and field calibrated. Current sensors for variable frequency applications must be rated for variable frequency operation.

2.7.8.3 Voltage Transducers

Voltage transducers must accept an AC voltage input and have an accuracy of plus or minus 0.25 percent of full scale. The device must have a means for calibration. Line side fuses for transducer protection must be provided.

2.7.8.4 Energy Metering

2.7.8.4.1 Watt or Watthour Transducers

Watt transducers must measure voltage and current and must output kW or kWh or both kW and kWh as indicated. kW outputs must have an accuracy of plus or minus 0.5 percent over a power factor range of 0.1 to 1. kWh outputs must have an accuracy of plus or minus 0.5 percent over a power factor range of 0.1 to 1.

2.7.8.4.2 Watthour Revenue Meter (with and without Demand Register)

All Watthour revenue meters must measure voltage and current and must be in accordance with ANSI C12.1 with an ANSI C12.20 Accuracy class of [0.5] [0.2] and must have pulse initiators for remote monitoring of Watthour consumption. Pulse initiators must consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets must be in accordance with NEMA/ANSI C12.10. Watthour revenue meters with demand registers must output instantaneous demand in addition to the pulse initiators.

2.7.8.4.3 Steam Meters

Steam meters must be the vortex type, with pressure compensation, a minimum turndown ratio of 10 to 1, and an output signal compatible with the DDC system.

2.7.8.4.4 Hydronic BTU Meters

The BTU meter is to be supplied with wall mount hardware and be capable of being installed remote from the flow meter. The BTU meter must include an LCD display for local indication of energy rate and for display of parameters and settings during configuration. Each BTU meter must be factory configured for its specific application and be completely field configurable by the user via a front panel keypad (no special interface device or computer required). The unit must output Energy Rate, Energy Total, Flow Rate, Supply Temperature, and Return Temperature. An integral transmitter is to provide a linear analog or configurable pulse output signal representing the energy rate; and the signal must be compatible with building automation system DDC Hardware to which the output is connected.

2.7.9 pH Sensor

The sensor must be suitable for applications and chemicals encountered in water treatment systems of boilers, chillers and condenser water systems. Construction, wiring, fittings and accessories must be corrosion and chemical resistant with fittings for tank or suspension installation. Housing must be polyvinylidene fluoride with O-rings made of chemical resistant materials which do not corrode or deteriorate with extended exposure to chemicals. The sensor must be encapsulated. Periodic replacement must not be required for continued sensor operation. Sensors must use a ceramic junction and pH sensitive glass membrane capable of withstanding a pressure of 100 psig at 150 degrees F. The reference cell must be double junction configuration. Sensor range must be 0 to 12 pH, stability 0.05, sensitivity 0.02, and repeatability of plus or minus 0.05 pH value, response of 90 percent of full scale in one second and a linearity of 99 percent of theoretical electrode output measured at 76 degrees F.

2.7.10 Oxygen Analyzer

Oxygen analyzer must consist of a zirconium oxide sensor for continuous sampling and an air-powered aspirator to draw flue gas samples. The analyzer must be equipped with filters to remove flue air particles. Sensor probe temperature rating must be 815 degrees F. The sensor assembly must be equipped for flue flange mounting.

2.7.11 Carbon Monoxide Analyzer

Carbon monoxide analyzer must consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting must be provided. Both assemblies must include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer must be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices must be provided. Unit must read parts per million (ppm) of carbon monoxide in the range of [_____] to [_____] ppm and the response time must be less than 3 seconds to 90 percent value. Unit measurement range must not exceed specified range by more that 50 percent. Repeatability must be plus or minus 1 percent of full scale with an accuracy of plus or minus 1 percent of full scale.

2.7.12 Occupancy Sensors

Occupancy sensors must have occupancy-sensing sensitivity adjustment and an adjustable off-delay timer with a setpoint of 15 minutes. Adjustments accessible from the face of the unit are preferred. Occupancy sensors must be rated for operation in ambient air temperatures ranging from 40 to 95 degrees F or temperatures normally encountered in the installed location. Sensors integral to wall mount on-off light switches must have an auto-off switch. Wall switch sensors must be decorator style and must fit behind a standard decorator type wall plate. All occupancy sensors, power packs, and slave packs must be UL listed. In addition to any outputs required for lighting control, the occupancy sensor must provide an output for the HVAC control system.

2.7.12.1 Passive Infrared (PIR) Occupancy Sensors

PIR occupancy sensors must have a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 20 feet unless otherwise indicated or specified. PIR Sensors must provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area, room or space. PIR sensors must be immune to false triggering from RFI and EMI.

2.7.12.2 Ultrasonic Occupancy Sensors

Ultrasonic sensors must operate at a minimum frequency 32 kHz and must be designed to not interfere with hearing aids.

2.7.12.3 Dual-Technology Occupancy Sensor (PIR and Ultrasonic)

Dual-Technology Occupancy Sensors must meet the requirements of both PIR and Ultrasonic Occupancy Sensors.

2.7.13 Vibration Switch

Vibration switch must be solid state, enclosed in a NEMA 250 Type 4 or Type 4X housing with sealed wire entry. Unit must have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range must be a true rms reading, suitable for the application. The unit must include either displacement response for low speed or velocity response for high speed application. The frequency range must be at least 3 Hz to 500 Hz. Contact time delay must be 3 seconds. The unit must have independent start-up and running delay on each switch contact. Alarm limits must be adjustable and setpoint accuracy must be plus or minus 10 percent of setting with repeatability of plus or minus 2 percent.

2.7.14 Conductivity Sensor

Sensor must include local indicating meter and must be suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as indicated. Sensor must sense from 0 to 10 microSeimens per centimeter (µS/cm) for distillation systems, 0 to 100 µS/cm for boiler, chilled water, and potable water systems and 0 to 1000 µS/cm for condenser water systems. Contractor must field verify the ranges for particular applications and adjust the range as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 2 percent of the full scale reading. Sensor must have automatic zeroing and must require no periodic maintenance or recalibration.

2.7.15 Compressed Air Dew Point Sensor

Sensor must be suitable for measurement of dew point from -40 +80 degrees F over a pressure range of 0 to 150 psig. The transmitter must provide both dry bulb and dew point temperatures on separate outputs. The end to end accuracy of the dew point must be plus or minus 5 degrees F and the dry bulb must be plus or minus 1 degree F. Sensor must be automatic zeroing and must require no normal maintenance or periodic recalibration.

2.7.16 NOx Monitor

Monitor must continuously monitor and give local indication of boiler stack gas for NOx content. It must be a complete system designed to verify compliance with the Clean Air Act standards for NOx normalized to a 3 percent oxygen basis and must have a range of from 0 to 100 ppm. Sensor must be accurate to plus or minus 5 ppm. Sensor must output NOx and oxygen levels and binary output that changes state when the NOx level is above a locally adjustable NOx setpoint. Sensor must have normal, trouble and alarm lights. Sensor must have heat traced lines if the stack pickup is remote from the sensor. Sensor must be complete with automatic zero and span calibration using a timed calibration gas system, and must not require periodic maintenance or recalibration.

2.7.17 Turbidity Sensor

Sensor must include a local indicating meter and must be suitable for measurement of turbidity of water. Sensor must sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range must be field-verified for the particular application and adjusted as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 5 percent of full scale reading. Sensor must have automatic zeroing and must not require periodic maintenance or recalibration.

2.7.18 Chlorine Detector

The detector must measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of plus or minus 1 percent of full scale and an accuracy of plus or minus 2 percent of full scale. The Chlorine Detector transmitter must be housed in a non-corrosive NEMA 250 Type 4X enclosure. Detector must include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.7.19 Floor Mounted Leak Detector

Leak detectors must use electrodes mounted at slab level with a minimum built-in-vertical adjustment of 0.125 inches. Detector must have a binary output. The indicator must be manual reset type.

2.7.20 Temperature Switch

2.7.20.1 Duct Mount Temperature Low Limit Safety Switch (Freezestat)

Duct mount temperature low limit switches (Freezestats) must be manual reset, low temperature safety switches at least 1 foot long per square foot of coverage which must respond to the coldest 18 inch segment with an accuracy of plus or minus 3.6 degrees F. The switch must have a field-adjustable setpoint with a range of at least 30 to 50 degrees F. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon drop of temperature below setpoint as indicated and must remain in this state until reset.

2.7.20.2 Pipe Mount Temperature Limit Switch (Aquastat)

Pipe mount temperature limit switches (aquastats) must have a field adjustable setpoint between 60 and 90 degrees F, an accuracy of plus or minus 3.6 degrees F and a 10 degrees F fixed deadband. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon change of temperature above or below setpoint as indicated.

2.7.21 Damper End Switches

Each end switch must be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure must be suitable for mounting on the duct exterior and must permit setting the position of the trip lever that actuates the switch. The trip lever must be aligned with the damper blade.

End switches integral to an electric damper actuator are allowed as long as at least one is adjustable over the travel of the actuator.

2.7.22 Air Quality Sensors

Provide full spectrum air quality sensors using a hot wire element based on the Taguchi principle. The sensor must monitor a wide range of gaseous volatile organic components common in indoor air contaminants like paint fumes, solvents, cigarette smoke, and vehicle exhaust. The sensor must automatically compensate for temperature and humidity, have span and calibration potentiometers, operate on 24 VDC power with output of 0-10 VDC, and have a service rating of 32 to 140 degrees F and 5 to 95 percent relative humidity.

[2.8 INDICATING DEVICES

All indicating devices must display readings in [metric (SI)][English (inch-pound)] units.

2.8.1 Thermometers

Provide bi-metal type thermometers at locations indicated. Thermometers must have either 9 inch long scales or 3.5 inch diameter dials, with insertion, immersion, or averaging elements. Provide matching thermowells for pipe-mounted installations. Select scale ranges suitable for the intended service, with the normal operating temperature near the scale's midpoint. The thermometer's accuracy must be plus or minus 2 percent of the scale range.

2.8.1.1 Piping System Thermometers

Piping system thermometers must have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9 inch scale. Piping system thermometers must have an accuracy of plus or minus 1 percent of scale range. Thermometers for piping systems must have rigid stems with straight, angular, or inclined pattern. Thermometer stems must have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem must be filled with a heat-transfer medium.

2.8.1.2 Air-Duct Thermometers

Air-duct thermometers must have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.8.2 Pressure Gauges

Provide pipe-mounted pressure gauges at the locations indicated. Gauges must conform to ASME B40.100 and have a 4 inch diameter dial and shutoff cock. Select scale ranges suitable for the intended service, with the normal operating pressure near the scale's midpoint. The gauge's accuracy must be plus or minus 2 percent of the scale range.

Gauges must be suitable for field or panel mounting as required, must have black legend on white background, and must have a pointer traveling through a 270-degree arc. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus 3 percent of scale range. Gauges must meet requirements of ASME B40.100.

2.8.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements must be a minimum of 3.5 inch (nominal) size with two sets of pressure taps, and must have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus two percent of scale range.

[2.8.4 Pressure Gauges for Pneumatic Controls

Gauges must [have a 0 to 30 psi scale][sufficient scale to display the full range of expected pressures] with 1 psi graduations.

]]2.9 OUTPUT DEVICES

2.9.1 Actuators

Actuators must be electric (electronic) [or pneumatic as indicated]. All actuators must be normally open (NO), normally closed (NC) or fail-in-last-position (FILP) as indicated. Normally open and normally closed actuators must be of mechanical spring return type. Electric actuators must have an electronic cut off or other means to provide burnout protection if stalled. Actuators must have a visible position indicator. [Electric actuators must provide position feedback to the controller as indicated.] Actuators must smoothly and fully open or close the devices to which they are applied. Electric actuators must have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators must be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators must provide an output signal identical to its input signal to the additional devices. [Pneumatic actuators must be rated for 25 psi operating pressure except for high-pressure cylinder-type actuators.] All actuators must be rated for their operating environment. Actuators used outdoors must be designed and rated for outdoor use. Actuators under continuous exposure to water, such as those used in sumps, must be submersible.

Actuators incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of Section [23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

2.9.1.1 Valve Actuators

Valve actuators must provide shutoff pressures and torques as indicated on the Valve Schedule.

2.9.1.2 Damper Actuators

Damper actuators must provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation and torque must be at least 6 inch-pounds/1 square foot of damper area for opposed blade dampers and 9 inch-pounds/1 square foot of damper area for parallel blade dampers.

[2.9.1.3 Positive Positioners

Positive positioners must be a pneumatic relay with a mechanical position feedback mechanism and an adjustable operating range and starting point.

]2.9.1.4 Electric Actuators

Each actuator must have distinct markings indicating the full-open and full-closed position Each actuator must deliver the torque required for continuous uniform motion and must have internal end switches to limit the travel, or be capable of withstanding continuous stalling without damage. Actuators must function properly within 85 to 110 percent of rated line voltage. Provide actuators with hardened steel running shafts and gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch-pounds..

a. Two-position actuators must be single direction, spring return, or reversing type. Two position actuator signals may either be the control power voltage or line voltage as needed for torque or appropriate interlock circuits.

b. Modulating actuators must be capable of stopping at any point in the cycle, and starting in either direction from any point. Actuators must be equipped with a switch for reversing direction, and a button to disengage the clutch to allow manual adjustments. Provide the actuator with a hand crank for manual adjustments, as applicable. Modulating actuator input signals can either be a 4 to 20 mAdc or a 0-10 VDC signal.

c. Floating or pulse width modulation actuators are acceptable for non-fail safe applications unless indicated otherwise provided that the floating point control (timed actuation) must have a scheduled re-calibration of span and position no more than once a day and no less than once a week. The schedule for the re-calibration should not affect occupied conditions and be staggered between equipment to prevent falsely loading or unloading central plant equipment.

[2.9.1.5 Pneumatic Actuators

Provide piston or diaphragm type actuators with replaceable diaphragm/piston.

]2.9.2 Solenoid-Operated Electric to Pneumatic Switch (EPS)

Solenoid-Operated Electric to Pneumatic Switches (EPS) must accept a voltage input to actuate its air valve. Each valve must have three-port operation: common, normally open, and normally closed. Each valve must have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection must be a 0.38 inch NPT threaded connection. Valves must be rated for 50 psig.

2.9.3 Electric to Pneumatic Transducers (EP)

Electric to Pneumatic Transducers (EPs) must convert either a 4-20 mAdc input signal, a 0-10 Vdc input signal to a proportional 0 to 20 psig pneumatic output. The EP must withstand pressures at least 150 percent of the system supply air pressure (main air). EPs must include independent offset and span adjustment. Steady state air consumption must not be greater than 0.05 scfm. EPs must have a manual adjustable override for the EP pneumatic output. EPs must have sufficient output capacity to provide full range stroke of the actuated device in both directions within [90][_____] seconds.

2.9.4 Relays

Relays must have contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light must be lit when the coil is energized and off when coil is not energized.

Control relay contacts must have utilization category and ratings selected for the application. Each set of contacts must incorporate a normally open (NO), normally closed (NC) and common contact. Relays must be rated for a minimum life of one million operations.

2.10 USER INPUT DEVICES

User Input Devices, including potentiometers, switches and momentary contact push-buttons. Potentiometers must be of the thumb wheel or sliding bar type. Momentary Contact Push-Buttons may include an adjustable timer for their output. User input devices must be labeled for their function.

2.11 MULTIFUNCTION DEVICES

Multifunction devices are products which combine the functions of multiple sensor, user input or output devices into a single product. Unless otherwise specified, the multifunction device must meet all requirements of each component device. Where the requirements for the component devices conflict, the multifunction device must meet the most stringent of the requirements.

2.11.1 Current Sensing Relay Command Switch

The Current Sensing Relay portion must meet all requirements of the Current Sensing Relay input device. The Command Switch portion must meet all requirements of the Relay output device except that it must have at least one normally-open (NO) contact.

Current Sensing Relays used for Variable Frequency Drives must be rated for

Variable Frequency applications unless installed on the source side of the drive. If used in this situation, the threshold for showing status must be set to allow for the VFD's control power when the drive is not enabled and provide indication of operation when the drive is enabled at minimum speed.

2.11.2 Space Sensor Module

Space Sensor Modules must be multifunction devices incorporating a temperature sensor and one or more of the following as specified and indicated on the Space Sensor Module Schedule:

a. A temperature indicating device.

b. A User Input Device which must adjust a temperature setpoint output.

c. A User Input Momentary Contact Button and an output to the control system indicating zone occupancy.

d. A three position User Input Switch labeled to indicate heating, cooling and off positions ('HEAT-COOL-OFF' switch) and providing corresponding outputs to the control system.

e. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and providing corresponding output to the control system..

f. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and providing corresponding outputs to the control system.

Space Sensor Modules cannot contain mercury (Hg).

[2.12 COMPRESSED AIR STATIONS

2.12.1 Air Compressor Assembly

Air compressors for pneumatic control systems must be the tank-mounted, electric motor driven, air cooled, reciprocating type with integral [duplex motors and compressors][single motor and compressor], tank, controller, [alternator switch,]pressure switch, belt guard[s], pressure relief valve, automatic moisture drain valve and must be supported by a steel base mounted on an air storage tank. Compressor piston speeds must not exceed 450 fpm. Provide compressors with a dry-type combination intake air filter and silencer with baked enamel steel housing. The filter must be 99 percent efficient at 10 microns. The pressure switch must start the compressor[s] at 70 psig and stop the compressor[s] at 90 psig. The relief valve must be set for 10 to 25 psig above the control switch cut-off pressure. Provide compressor capacity suitable for not more than a [33] [50] percent run time, at full system control load. Compressors must have a combination type magnetic starter with undervoltage protection and thermal-overload protection for each phase and must automatically restart after a power outage. Motors 0.5 hp and larger must be three-phase.[

A second (duplex arrangement) compressor of capacity equal to the primary compressor must be provided, with interlocked control to provide automatic changeover upon malfunction or failure of either compressor. A manual selector switch must be provided to index the lead compressor including the automatic changeover.]

2.12.2 Compressed Air Station Specialties

2.12.2.1 Refrigerated Air Dryers

Provide each air compressor tank with a refrigerant air dryer sized for continuous operation at full delivery capacity of the compressor. The air must be dried at a pressure of not less than 70 psi to a temperature not greater than 35 degrees F and an ambient air temperature between 55 and 95 degrees F. The dryer must be provided with an automatic condensate drain trap with manual override feature with an adjustable cycle and drain time. Locate each dryer in the air piping between the tank and the pressure-reducing station. The refrigerant used in the dryer must be one of the fluorocarbon gases and have an Ozone Depletion Potential of not more than 0.05. A five micron pre-filter and coalescing-type 0.03 micron oil removal filter with shut-off valves must be provided in the dryer discharge.

2.12.2.2 Compressed Air Discharge Filters

Provide a disposable type in-line filter in the incoming pneumatic main at each pneumatic control panel. The filter must be capable of eliminating 99.99 percent of all liquid or solid contaminants 0.1 micron or larger. Provide the filter with fittings that allow easy removal/replacement. Each filter bowl must be rated for 150 psi maximum working pressure. A pressure regulator, with high side and low side pressure gauges, and a safety valve must be provided downstream of the filter.

2.12.2.3 Air Pressure-Reducing Stations

Provide air compressors with a pressure-reducing valve (PRV) with a field adjustable range of 0 to 50 psig discharge pressure, at an inlet pressure of 70 to 90 psig. Provide a factory-set pressure relief valve downstream of the PRV to relieve over-pressure. Provide a pressure gage upstream of the PRV with range of 0 to 100 psig and downstream of the PRV with range of. For two-pressure control systems, provide an additional PRV and downstream pressure gage. Pressure regulators of the relieving type must not be used.

2.12.2.4 Flexible Pipe Connections

The flexible pipe connections must be designed for 150 psi and 250 degrees F service, and must be constructed of rubber or tetrafluoroethylene resin tubing with a reinforcing protective cover of braided corrosion-resistant steel, bronze, monel, or galvanized steel. The connectors must be suitable for the service intended and must have threaded or soldered ends. The length of the connectors must be as recommended by the manufacturer for the service intended.

2.12.2.5 Vibration Isolation Units

The vibration isolation units must be standard products with published loading ratings, and must be single rubber-in-shear, double rubber-in-shear, or spring type.

2.12.3 Compressed Air Tanks

The air storage tank must be fabricated for a working pressure of not less than 200 psi and constructed and certified in accordance with ASME BPVC SEC VIII D1. The tank must be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 20 psi. The tank must be provided with an automatic condensate drain trap with manual override feature. Provide drain valve and piping routing the drainage to a floor sink or other safe and visible drainage location.

]PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General Installation Requirements

Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.

3.1.1.1 Device Mounting Criteria

All devices must be installed in accordance with manufacturer's recommendations and as specified and indicated. Control devices to be installed in piping and ductwork must be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements must not be used except as specified. Spare thermowells must be installed adjacent to each thermowell containing a sensor and as indicated. Devices located outdoors must have a weathershield.

3.1.1.2 Labels and Tags

Match labels and tags to the unique identifiers indicated on the As-Built drawings. Label all enclosures and instrumentation. Tag all sensors and actuators in mechanical rooms. Tag airflow measurement arrays to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Tag duct static pressure taps at the location of the pressure tap. Provide plastic or metal tags, mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures must be engraved plastic and mechanically attached to the enclosure or instrumentation. Labels inside protective enclosures may attached using adhesive, but must not be hand written.

3.1.2 Weathershield

Provide weathershields for sensors located outdoors. Install weathershields such that they prevent the sun from directly striking the sensor and prevent rain from directly striking or dripping onto the sensor. Install weather shields with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. When installing weathershields near outside air intake ducts, install them such that normal outside air flow does not cause rainwater to strike the sensor.

3.1.3 Room Instrument Mounting

Mount room instruments, including but not limited to wall mounted non-adjustable space sensor modules and sensors located in occupied spaces, [60][48] inches above the floor unless otherwise indicated. Install adjustable devices to be ADA compliant unless otherwise indicated on the Room Sensor Schedule:

a. Space Sensor Modules for Fan Coil Units may be either unit or wall mounted but not mounted on an exterior wall.

b. Wall mount all other Space Sensor Modules.

3.1.4 Indication Devices Installed in Piping and Liquid Systems

Provide snubbers for gauges in piping systems subject to pulsation. For gauges for steam service use pigtail fittings with cock. Install thermometers and temperature sensing elements in liquid systems in thermowells. Provide spare Pressure/Temperature Ports (Pete's Plug) for all temperature and pressure sensing elements installed in liquid systems for calibration/testing.

3.1.5 Occupancy Sensors

Provide a sufficient quantity of occupancy sensors to provide complete coverage of the area (room or space). Occupancy sensors are to be ceiling mounted. Install occupancy sensors in accordance with NFPA 70 requirements and the manufacturer's instructions. Do not locate occupancy sensors within 6 feet of HVAC outlets or heating ducts, or where they can "see" beyond any doorway. Installation above doorway(s) is preferred. Do not use ultrasonic sensors in spaces containing ceiling fans. Install sensors to detect motion to within 2 feet of all room entrances and to not trigger due to motion outside the room. Set the off-delay timer to [15][_____] minutes unless otherwise indicated. Adjust sensors prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc. For each controlled area, provide one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

3.1.6 Switches

3.1.6.1 Temperature Limit Switch

Provide a temperature limit switch (freezestat) to sense the temperature at the location indicated. Provide a sufficient number of temperature limit switches (freezestats) to provide complete coverage of the duct section but no less than 1 foot in length per square foot of cross sectional area. Install manual reset limit switches in approved, accessible locations where they can be reset easily. Install temperature limit switch (freezestat) sensing elements in a side-to-side (not top-to-bottom) serpentine pattern with the relay section at the highest point and in accordance with the manufacturer's installation instructions.

3.1.6.2 Hand-Off Auto Switches

Wire safety controls such as smoke detectors and freeze protection thermostats to protect the equipment during both hand and auto operation.

3.1.7 Temperature Sensors

Install temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate and install sensors according to manufacturer’s instructions. Select sensors only for intended application as designated or recommended by manufacturer.

3.1.7.1 Room Temperature Sensors

Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of all user-adjustable sensors [5 feet above the finished floor][48 inches above the floor to meet ADA requirements][at the height[s] indicated]. Non user-adjustable sensors can be mounted as indicated in paragraph ROOM INSTRUMENT MOUNTING.

3.1.7.2 Duct Temperature Sensors

3.1.7.2.1 Probe Type

Place tip of the sensor in the middle of the airstream or in accordance with manufacturer's recommendations or instructions.Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. When installed in insulated duct, provide enclosure or stand off fitting to accommodate the thickness of duct insulation to allow for maintenance or replacement of the sensor and wiring terminations. Seal the duct insulation penetration vapor tight.

3.1.7.2.2 Averaging Type

Weave the sensing element in a serpentine fashion from side to side perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports in accordance with manufacturer's installation instructions. Avoid tight radius bends or kinking of the sensing element. Prevent contact between the sensing element and the duct or air handler internals. Provide a duct access door at the sensor location. The access door must be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit, maximum 18 by 18 inches. For sensors inside air handlers, the sensors must be fully accessible through the air handler's access doors without removing any of the air handler's internals.

3.1.7.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. When installed on insulated piping, provide stand enclosure or stand off fitting to accommodate the thickness of the pipe insulation and allow for maintenance or replacement of the sensor or wiring terminations. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells must not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior ensuring contact between the sensor and the well.

3.1.7.4 Outside Air Temperature Sensors

Provide outside air temperature sensors on the building's north side with a protective weather shade that does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain. Location must not be near exhaust hoods and other areas such that it is not influenced by radiation or convection sources which may affect the reading. Provide a shield to shade the sensor from direct sunlight.

3.1.8 Air Flow Measurement Arrays (AFMA)

Locate Outside Air AFMAs downstream from the Outside Air filters.

Install AFMAs with the manufacturer's recommended minimum distances between upstream and downstream disturbances. Airflow straighteners may be used to reduce minimum distances as recommended by the AFMA manufacturer.

3.1.9 Duct Static Pressure Sensors

Locate the duct static pressure sensing tap at 75 percent of the distance between the first and last air terminal units [as indicated on the design documents]. If the transmitter output is a 0-10Vdc signal, locate the transmitter in the same enclosure as the air handling unit (AHU) controller for the AHU serving the terminal units. If a remote duct static pressure sensor is to be used, run the signal wire back to the controller for the air handling unit.

3.1.10 Relative Humidity Sensors

Install relative humidity sensors in supply air ducts at least 10 feet downstream of humidity injection elements.

3.1.11 Meters

3.1.11.1 Flowmeters

Install flowmeters to ensure minimum straight unobstructed piping for at least 10 pipe diameters upstream and at least 5 pipe diameters downstream of the flowmeter, and in accordance with the manufacturer's installation instructions.

3.1.11.2 Energy Meters

Locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous demand/energy and other variables as indicated.

3.1.12 Dampers

3.1.12.1 Damper Actuators

Provide spring return actuators which fail to a position that protects the served equipment and space on all control dampers related to freeze protection or force protection. For all outside, makeup and relief dampers provide dampers which fail closed. Terminal fan coil units, terminal VAV units, convectors, and unit heaters nay be non-spring return unless indicated otherwise. Do not mount actuators in the air stream. Do not connect multiple actuators to a common drive shaft. Install actuators so that their action seal the damper to the extent required to maintain leakage at or below the specified rate and so that they move the blades smoothly throughout the full range of motion.

3.1.12.2 Damper Installation

Install dampers straight and true, level in all planes, and square in all dimensions. Dampers must move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error. External linkages must operate smoothly over the entire range of motion, without deformation or slipping of any connecting rods, joints or brackets that will prevent a return to it's normal position. Blades must close completely and leakage must not exceed that specified at the rated static pressure. Provide structural support for multi-section dampers.

Acceptable methods of structural support include but are not limited to U-channel, angle iron, corner angles and bolts, bent galvanized steel stiffeners, sleeve attachments, braces, and building structure. Where multi-section dampers are installed in ducts or sleeves, they must not sag due to lack of support. Do not use jackshafts to link more than three damper sections. Do not use blade to blade linkages. Install outside and return air dampers such that their blades direct their respective air streams towards each other to provide for maximum mixing of air streams.

3.1.13 Valves

Install the valves in accordance with the manufacturer's instructions.

3.1.13.1 Valve Actuators

Provide spring return actuators on all control valves where freeze protection is required. Spring return actuators for terminal fan coil units, terminal VAV units, convectors, and unit heaters are not required unless indicated otherwise.

3.1.14 Thermometers and Gauges

[3.1.14.1 Local Gauges for Actuators

Provide a pressure gauge at each pneumatic control input and output. Pneumatic actuators must have an accessible and visible pressure gauge installed in the tubing lines at the actuator as indicated.

]3.1.14.2 Thermometers

Mount devices to allow reading while standing on the floor or ground, as applicable.

3.1.15 Wire and Cable

Provide complete electrical wiring for the Control System, including wiring to transformer primaries. Wire and Cable must be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Instrumentation grounding must be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Test installed ground rods as specified in IEEE 142. Cables and conductor wires must be tagged at both ends, with the identifier indicated on the shop drawings. Electrical work must be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as indicated. Wiring external to enclosures must be run in raceways[, except low-voltage control and low-voltage network wiring may be installed as follows:

a. plenum rated cable in suspended ceilings over occupied spaces may be run without raceways

b. nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.]

Install control circuit wiring not in raceways in a neat and safe manner. Wiring must not use the suspended ceiling system (including tiles, frames or hangers) for support. Where conduit or raceways are required, control circuit wiring must not run in the same conduit/raceway as power wiring over 50 volts. Run all circuits over 50 volts in conduit, metallic tubing, covered metal raceways, or armored cable.

3.1.16 Copper Tubing

Provide hard-drawn copper tubing in exposed areas and either hard-drawn or annealed copper tubing in concealed areas. Use only tool-made bends. Use only brass or copper solder joint type fittings, except for connections to apparatus. For connections to apparatus use brass compression type fittings.

3.1.17 Plastic Tubing

Install plastic tubing within covered raceways or conduit except when otherwise specified. Do not use plastic tubing for applications where the tubing could be subjected to a temperature exceeding 130 degrees F. For fittings, use brass or acetal resin of the compression or barbed push-on type for instrument service. Except in walls and exposed locations, plastic multitube instrument tubing bundle without conduit or raceway protection may be used where a number of air lines run to the same points, provided the multitube bundle is enclosed in a protective sheath, is run parallel to the building lines and is adequately supported as specified.

[3.1.18 Pneumatic Lines

Run tubing concealed in finished areas, run tubing exposed in unfinished areas like mechanical rooms. For tubing enclosed in concrete, provide rigid metal conduit. Run tubing parallel and perpendicular to building walls. Use 5 foot maximum spacing between tubing supports. With the compressor turned off, test each tubing system pneumatically at 1.5 times the working pressure and prove it air tight, locating and correcting leaks as applicable. Caulking joints is not permitted. Do not run tubing and electrical power conductors in the same conduit.

a. Install pneumatic lines must such that they are not exposed to outside air temperatures. Conceal pneumatic lines except in mechanical rooms and other areas where other tubing and piping is exposed.

b. Install all tubes and tube bundles exposed to view in lines parallel to the lines of the building. Route tubing in mechanical/electrical so that the lines are easily traceable.

c. Purge air lines of dirt, impurities and moisture before connecting to the control equipment. Number-code or color-code air lines and key the coding in the As-Built Drawings for future identification and servicing the control system.

3.1.18.1 Pneumatic Lines In Mechanical/Electrical Spaces

In mechanical/electrical spaces, use plastic or copper tubing for pneumatic lines. Install horizontal and vertical runs of plastic tubing or soft copper tubing min raceways or rigid conduit dedicated to tubing. Support dedicated raceways, conduit, and hard copper tubing not installed in raceways every 6 feet for horizontal runs and every 8 feet for vertical runs.

3.1.18.2 Pneumatic Lines External to Mechanical/Electrical Spaces

External to mechanical/electrical spaces, use plastic tubing in raceways not containing power wiring or copper tubing with sweat fittings. Support raceways and tubing not in raceways every 8 feet. For pneumatic lines concealed in walls use hard-drawn copper tubing or plastic tubing in rigid conduit. Plastic tubing in a protective sheath, run parallel to the building lines and supported as specified, may be used above accessible ceilings and in other concealed but accessible locations.

3.1.18.3 Terminal Single Lines

For terminal single lines use hard-drawn copper tubing, except when the run is less than 12 inches in length, flexible polyethylene may be used.

3.1.18.4 Connection to Liquid and Steam Lines

Use [copper][Series 300 stainless steel] with [brass compression][stainless-steel compression] fittings for connection of sensing elements and transmitters to liquid and steam lines.

3.1.18.5 Connection to Ductwork

Use plastic tubing for connections to sensing elements in ductwork.

3.1.18.6 Tubing in Concrete

Install tubing in concrete in rigid conduit. Install tubing in walls containing insulation, fill, or other packing materials in raceways dedicated to tubing.

3.1.18.7 Tubing Connection to Actuators

For final connections to actuators use plastic tubing no more than 12 inches long and unsupported at the actuator.

]3.1.19 Compressed Air Stations

Mount the air compressor assembly on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. Connect the air line to the tank with a flexible pipe connector. Provide compressed air station specialties with required tubing, including condensate tubing to a floor drain. Compressed air stations must deliver control air meeting the requirements of ISA 7.0.01. Provide foundations and housekeeping pads for the HVAC control system air compressors [in accordance with the air compressor manufacturer's instructions][as specified in Section 23 30 00 HVAC AIR DISTRIBUTION].

-- End of Section --

SECTION 23 09 13.34 40

CONTROL VALVES, SELF-CONTAINED
02/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME BPVC SEC VI	(2017) BPVC Section VI-Recommended Rules for the Care and Operation of Heating Boilers

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(2020) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A463/A463M	(2015; R 2020; E 2020) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM B61	(2015; R 2021) Standard Specification for Steam or Valve Bronze Castings

1.2 ADMINISTRATIVE REQUIREMENTS

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

Submit fabrication drawings for self-contained control and relief valves, including part numbers and exploded views.

Submit a list of product installations for self-contained control and relief valves, identifying a minimum of five installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Self-Contained Temperature Control Valves; G[, [____]]

Self-Contained Temperature-Regulator Valves; G[, [____]]

Rate-of-Flow Controller; G[, [____]]

Nonmodulating Float Valve; G[, [____]]

Water Pressure Regulating Valve; G[, [____]]

Water Pressure Relief Valve; G[, [____]]

Pilot-Operated Pressure Relief Valve; G[, [____]]

Relief Valves for Electric Water Heaters; G[, [____]]

Sample Warranty; G[, [____]]

SD-07 Certificates

List of Product Installations; G[, [____]]

Certificates of Conformance; G[, [____]]

Manufacturer's Warranty; G[, [____]]

SD-06 Test Reports

Test Reports; G[, [____]]

1.4 QUALITY ASSURANCE

Submit certificates of conformance for the following items, showing conformance with the referenced standards contained in this section:

a. Self-Contained Temperature Control Valves

b. Self-Contained Temperature Regulator Valves

c. Rate-of-Flow Controller

d. Nonmodulating Float Valve

e. Water Pressure Regulating Valve

f. Water Pressure Relief Valve

g. Pilot-Operated Pressure Relief Valve

h. Relief Valves for Electric Water Heaters

Submit a copy of the manufacturer's sample warranty to the Contracting Officer for review.

PART 2 PRODUCTS

2.1 SELF-CONTAINED TEMPERATURE-CONTROL VALVES

Provide self-contained temperature-control valves that meet the following requirements:

[a. Type I, Class II (integral temperature-sensing units for very hot water).

][b. Type II, Class 2, Style A (remote temperature-sensing units for very hot water with a single temperature-sensing control element).

] Mount the set-point adjustment on the cabinet of the convector; ensure that the control knob is accessible on the cabinet surface.

Wall-mount the set-point adjustment and thermostat for finned-tube radiation. Provide nickel-plated brass thermostat surfaces.

Provide armored capillary tubing, with the remote element at least 18 inches long and contained within a guard.

Provide renewable valve disks.

[2.2 SELF-CONTAINED TEMPERATURE-REGULATOR VALVES

Provide direct-operated, self-contained valves, with an[ASTM B61, (bronze)][ASTM A126 (cast iron)] body rated not less than 125 pounds per square inch (psi) of saturated working steam pressure. Provide with screwed body end connections. Ensure that the trim is corrosion-resistant AISI Type 300 Series steel. Provide valves that have a hardened replaceable seat and plug, or faced with a cobalt-chromium-tungsten alloy to produce a surface with resistance to impact and wire-drawing and with a Brinell hardness of at least 450. Fit packed steam valves with tetrafluoroethylene packing, and spring-load and self-adjust. Ensure that the valves are single-seated, suitable for dead-end service, and fail-safe. Mount a remote Class I or Class III filled-bulb element in a nonferrous separable socket. Ensure that valves maintain the set-point temperature, plus or minus 5 degrees F, with the set point at or near the midpoint of the adjustable element range.

][2.3 RATE-OF-FLOW CONTROLLER

Provide a hydraulically operated, pilot-controlled diaphragm globe valve for a rate-of-flow controller, with the pilot control configured to actuate by differential pressure produced across an orifice installed at the inlet. Ensure that the flow rate is adjusted by varying the spring-loading on the pilot. Provide a valve with cast-iron valve body conforming to ASTM A48/A48M, with 125-pound ASME B16.1 flanges. Ensure that the valve trim is the manufacturer's standard bronze or AISI 18-8 corrosion-resistant steel, that the orifice plate is made of AISI Type 303 corrosion-resistant steel, and the diaphragm and seal are Buna-N. Ensure that the maximum-service-pressure rating is not less than 175 psi at 180 degrees F.

][2.4 NONMODULATING FLOAT VALVE

Provide a nonmodulating float valve that is pilot-controlled, diaphragm-actuated, spring-loaded, single-seated, and hydraulically operated. Mount the pilot valve on the main valve or remotely mount the pilot valve within the cooling tower basin. Ensure that the main valve body is cast iron conforming to ASTM A48/A48M with screwed ends for sizes smaller than 2 inches iron pipe size (ips) and flanges conforming to ASME B16.1 for sizes 2 inch ips and larger, with a brass or bronze pilot valve body, with main and pilot valve trim, including linkage and float, made of the manufacturer's standard bronze-copper or AISI Type 300 series corrosion-resistant steel. Ensure that diaphragm materials and seals are Buna-N, and that this valve has a maximum-service-pressure rating is not less than 175 psi at 180 degrees F. Ensure that the valve operation is the nonslam type.

][2.5 WATER PRESSURE-REGULATING VALVE

Provide a direct-acting pressure-regulating valve conforming to ASSE 1003.

Ensure that the pressure-regulating valve does not stick or allow pressure to build up on the low side. Set the valve to maintain a terminal pressure of approximately 5 psi in excess of the static head on the system and operate within a 2-pound maximum variation regardless of initial pressure fluctuation, and without objectionable noise.

][2.6 WATER PRESSURE-RELIEF VALVE

Construct, label, and install the pressure-relief valve in accordance with ASME BPVC SEC VI. Ensure that the relieving capacity is as specified by the referenced publication, with valves of nonferrous construction, complete with a test lever.

][2.7 PILOT-OPERATED PRESSURE-RELIEF VALVE

Provide a pilot-operated pressure-relief valve that is hydraulically operated and has pilot-controlled modulating, with an adjustable set point over the indicated range. Provide a cast-iron valve body conforming to ASTM A48/A48M, with 125 psi ASME B16.1 flanges. Include the with manufacturer's standard brass, bronze, or corrosion-resistant steel valve trim. Provide pilot control with AISI Type 303 or 304 corrosion-resistant steel trim with Buna-N diaphragm and seal material. Ensure that this valve has a maximum-service-pressure rating of at least 175 psi at 180 degrees F.

][2.8 RELIEF VALVES FOR ELECTRIC WATER HEATERS

Provide temperature- and pressure-relief valves conforming to ASTM A463/A463M. Install Type I (combination pressure- and temperature-relief) valves when the heat input is less than 100,000 Btu per hour and when the storage is less than 120 gallons. If either or both of the specified conditions will be reached or exceeded, install Type II (temperature relief, water-rated) or Type III (temperature relief, steam-rated) valves. Install vacuum-relief valves on each cold-water branch connection to an electric water heater at an elevation above the top of the heater. Design vacuum relief valves to prevent damage to the water heater from a reverse flow vacuum.

]PART 3 EXECUTION

3.1 INSTALLATION

Submit installation drawings for self-contained control and relief valves. Install valves as specified in accordance with the manufacturer's recommendations and Section 23 05 15 COMMON PIPING FOR HVAC.

[3.2 FIELD QUALITY CONTROL

3.2.1 Test Reports

After the installation has been completed, test the system components and submit [_____] copies of the test reports to the Contracting Officer. Remove and replace defective components at no cost to the Government. Retest components and submit reports to the Contracting Officer.

]3.3 CLOSEOUT ACTIVITIES

Submit [_____] copies of the manufacturer's warranty, to the Contracting Officer before project closeout. Ensure that the warranty has been signed by the Authority Having Jurisdiction (AHJ) and is assigned to the Government.

-- End of Section --

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SECTION 23 09 23.02

BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS
02/19, CHG 1: 02/20

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system, except for the front end which is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL (UMCS) FRONT END AND INTEGRATION, suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown and in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.1.1 System Requirements

Provide a system meeting the requirements of both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section and with the following characteristics:

a. Except for Gateways, the control system must be an open implementation of BACnet technology using ASHRAE 135 and Fox as the communications protocols. The system must use standard ASHRAE 135 Objects and Properties and the Niagara Framework. The system must use standard ASHRAE 135 Services and the Niagara Framework exclusively for communication over the network. Gateways to packaged units must communicate with other DDC hardware using ASHRAE 135 or the Fox protocol exclusively and may communicate with packaged equipment using other protocols. The control system must be installed such that any two ASHRAE 135 devices on the Internetwork can communicate using standard ASHRAE 135 Services.

   Except for Gateways, the control system must be an open implementation of BACnet technology using ASHRAE 135 as the communications protocol. The system must use standard ASHRAE 135 Objects and Properties. The system must use standard ASHRAE 135 Services exclusively for communication over the network. Gateways to packaged units must communicate with other DDC hardware using ASHRAE 135 exclusively and may communicate with packaged equipment using other protocols. The control system must be installed such that any two devices on the Internetwork can communicate using standard ASHRAE 135 Services.

b. Install and configure control hardware to provide ASHRAE 135 Objects and Properties or Niagara Framework Objectsas indicated and as needed to meet the requirements of this specification.

c. Use Niagara Framework hardware and software exclusively for scheduling, trending, and communication with a front end (UMCS). Use Niagara Framework or standard BACnet Objects and services for alarming. Use the Fox protocol for all communication between Niagara Framework Supervisory Gateways; use the ASHRAE 135 protocol for all other building communication. [Niagara Framework Supervisory Gateway must serve web pages as specified.]

d. Use Niagara Framework [AX][Version 4.0 or later][either AX or Version 4.0 or later].

1.1.2 Verification of Specification Requirements

Review all specifications related to the control system installation and advise the Contracting Officer of any discrepancies before performing any work. If Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC or any other Section referenced in this specification is not included in the project specifications advise the Contracting Officer and either obtain the missing Section or obtain Contracting Officer approval before performing any work.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135	(2016) BACnet—A Data Communication Protocol for Building Automation and Control Networks

BACNET INTERNATIONAL (BTL)

BTL Guide	(v.49; 2017) BACnet Testing Laboratory Implementation Guidelines

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3	(2018) Ethernet

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-485	(1998a; R 2012) Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

TRIDIUM, INC (TRIDIUM)

Niagara Framework	(2012) NiagaraAX User's Guide
Tridium Open NiCS	(2005) Understanding the NiagaraAX Compatibility Statement (NiCS)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 916	(2015; Reprint Oct 2021) UL Standard for Safety Energy Management Equipment

1.3 DEFINITIONS

For definitions related to this section, see Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.4 SUBMITTALS

Submittal requirements related to this Section are specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

PART 2 PRODUCTS

All products used to meet this specification must meet the indicated requirements, but not all products specified here will be required by every project. All products must meet the requirements both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1 NETWORK HARDWARE

2.1.1 BACnet Router

All BACnet Routers must be BACnet/IP Routers and must perform layer 3 routing of ASHRAE 135 packets over an IP network in accordance with ASHRAE 135 Annex J and Clause 6. The router must provide the appropriate connection to the IP network and connections to one or more ASHRAE 135 MS/TP networks. Devices used as BACnet Routers must meet the requirements for DDC Hardware, and except for Niagara Framework Supervisory Gateways, devices used as BACnet routers must support the NM-RC-B BIBB.

2.1.2 BACnet Gateways

In addition to the requirements for DDC Hardware, the BACnet Gateway must be a Niagara Framework Supervisory Gateway or must meet the following requirements:

a. It must perform bi-directional protocol translation from one non-ASHRAE 135 protocol to ASHRAE 135. BACnet Gateways must incorporate a network connection to an ASHRAE 135 network (either BACnet over IP in accordance with Annex J or MS/TP) and a separate connection appropriate for the non-ASHRAE 135 protocol and media.

b. It must retain its configuration after a power loss of an indefinite time, and must automatically return to their pre-power loss state once power is restored.

c. It must allow bi-directional mapping of data between the non-ASHRAE 135 protocol and Standard Objects as defined in ASHRAE 135. It must support the DS-RP-B BIBB for Objects requiring read access and the DS-WP-B BIBB for Objects requiring write access.

d. It must support the DS-COV-B BIBB.

Although Gateways must meet DDC Hardware requirements , except for Niagara Framework Supervisory Gateways, they are not DDC Hardware and must not be used when DDC Hardware is required. (Niagara Framework Supervisory Gateways are both Gateways and DDC Hardware.)

2.1.3 Ethernet Switch

Ethernet Switches [must be managed switches and]must autoconfigure between 10,100 and 1000 megabits per second (MBPS).

2.2 CONTROL NETWORK WIRING

a. BACnet MS/TP communications wiring must be in accordance with ASHRAE 135. The wiring must use shielded, three wire (twisted-pair with reference) cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors must be less than 30 pF per foot.

b. Building Control Network Backbone IP Network must use Ethernet media. Ethernet cables must be CAT-5e at a minimum and meet all requirements of IEEE 802.3 [and [_____]].

2.3 DIRECT DIGITAL CONTROL (DDC) HARDWARE

2.3.1 General Requirements

All DDC Hardware must meet the following requirements:

a. It must be locally powered and must incorporate a light to indicate the device is receiving power.

b. It must conform to the BTL Guide

c. It must be BACnet Testing Laboratory (BTL) Listed.

d. The Manufacturer's Product Data submittal for each piece of DDC Hardware must include the Protocol Implementation Conformance Statement (PICS) for that hardware as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

e. It must communicate and be interoperable in accordance with ASHRAE 135 and have connections for BACnet IP or MS/TP control network wiring.

f. Other than devices controlling terminal units or functioning solely as a BACnet Router, it must support DS-COV-B, DS-RPM-A and DS-RPM-B BIBBs.

g. Devices supporting the DS-RP-A BIBB must also support the DS-COV-A BIBB.

h. Application programs, configuration settings and communication information must be stored in a manner such that they persist through loss of power:

(1) Application programs must persist regardless of the length of time power is lost.

(2) Configured settings must persist for any loss of power less than 2,500 hours.

(3) Communication information, including but not limited to COV subscriptions, event reporting destinations, Notification Class Object settings, and internal communication settings, must persist for any loss of power less than 2,500 hours.

i. Internal Clocks:

(1) Clocks in DDC Hardware incorporating a Clock must continue to function for 120 hours upon loss of power to the DDC Hardware.

(2) DDC Hardware incorporating a Clock must support the DM-TS-B or DM-UTC-B BIBB.

j. It must have all functionality indicated and required to support the application (Sequence of Operation or portion thereof) in which it is used, including but not limited to providing Objects or Niagara Framework Points as specified and as indicated on the Points Schedule.

k. In addition to these general requirements and the DDC Hardware Input-Output (I/O) Function requirements, all DDC Hardware must also meet any additional requirements for the application in which it is used (e.g. scheduling, alarming, trending, etc.).

l. It must meet FCC Part 15 requirements and have UL 916 or equivalent safety listing.

m. Except for Niagara Framework Supervisory Gateways, Device must support Commandable Objects to support Override requirements as detailed in PART 3 EXECUTION

n. User interfaces which allow for modification of Properties or settings must be password-protected.

o. Devices communicating BACnet MS/TP must meet the following requirements:

(1) Must have a configurable Max_Master Property.

(2) DDC Hardware other than hardware controlling a single terminal unit must have a configurable Max_Info_Frames Property.

(3) Must respond to any valid request within 50 msec with either the appropriate response or with a response of "Reply Postponed".

(4) Must use twisted pair with reference and shield (3-wire media) wiring[, or twisted pair with shield (2-wire media) wiring and use half-wave rectification].

p. Devices communicating BACnet/IP must use UDP Port 0xBAC0. Devices with configurable UDP Ports must default to 0xBAC0.

q. All Device IDs, Network Numbers, and BACnet MAC addresses of devices must be fully configurable without limitation, except MS/TP MAC addresses may be limited by ASHRAE 135 requirements.

r. Except for Niagara Framework Supervisory Gateways, DDC Hardware controlling a single terminal unit must have:

(1) Objects (including the Device Object) with an Object Name Property of at least 8 characters in length.

(2) A configurable Device Object Name.

(3) A configurable Device Object Description Property at least 16 characters in length.

s. Except for Objects in either Niagara Framework Supervisory Gateways or DDC Hardware controlling a single terminal unit, all Objects (including Device Objects) must:

(1) Have a configurable Object Name Property of at least 12 characters in length.

(2) Have a configurable Object Description Property of at least 24 characters in length.

t. For programmable DDC Hardware, provide and license to the project site all programming software required to program the Hardware in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

u. For programmable DDC Hardware, provide copies of the installed application programs (all software that is not common to every controller of the same manufacturer and model) as source code compatible with the supplied programming software in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The submitted application program must be the complete application necessary for controller to function as installed and be sufficient to allow replacement of the installed controller with another controller of the same type.

2.3.2 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions must meet the following requirements:

2.3.2.1 Analog Inputs

DC Hardware analog inputs (AIs) must be implemented using ASHRAE 135 Analog Input Objects and perform analog to digital (A-to-D) conversion with a minimum resolution of 8 bits plus sign or better as needed to meet the accuracy requirements specified in Section 23 09 00. Signal conditioning including transient rejection must be provided for each analog input. Analog inputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. The AI must incorporate common mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

2.3.2.2 Analog Outputs

DDC Hardware analog outputs (AOs) must be implemented using ASHRAE 135 Analog Output Objects and perform digital to analog (D-to-A) conversion with a minimum resolution of 8 bits plus sign, and output a signal with a range of 4-20 mAdc or 0-10 Vdc. Analog outputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. DDC Hardware with Hand-Off-Auto (H-O-A) switches for analog outputs must provide for overriding the output [to 0 percent and to 100 percent][through the range of 0 percent to 100 percent]

2.3.2.3 Binary Inputs

DDC Hardware binary inputs (BIs) must be implemented using ASHRAE 135 Binary Input Objects and accept contact closures and must ignore transients of less than 5 milli-second duration. Protection against a transient 50VAC must be provided.

2.3.2.4 Binary Outputs

DDC Hardware binary outputs (BOs) must be implemented using ASHRAE 135

Binary Output Objects and provide relay contact closures or triac outputs for momentary and maintained operation of output devices. DDC Hardware with H-O-A switches for binary outputs must provide for overriding the output open or closed.

2.3.2.4.1 Relay Contact Closures

Closures must have a minimum duration of 0.1 second. Relays must provide at least 180V of isolation. Electromagnetic interference suppression must be provided on all output lines to limit transients to 50 Vac. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.2.4.2 Triac Outputs

Triac outputs must provide at least 180 V of isolation. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.2.5 Pulse Accumulator

DDC Hardware pulse accumulators must be implemented using either an ASHRAE 135 Accumulator Object or an ASHRAE 135 Analog Value Object where the Present_Value is the totalized pulse count. Pulse accumulators must accept contact closures, ignore transients less than 5 msec duration, protect against
transients of 50 VAC, and accept rates of at least 20 pulses per second.

2.3.2.6 ASHRAE 135 Objects for Hardware Inputs and Outputs

The requirements for use of ASHRAE 135 objects for hardware input and outputs includes devices where the hardware sensor or actuator is integral to the controller (e.g. a VAV box with integral damper actuator, a smart sensor, a VFD, etc.)

[2.3.2.7 Integrated H-O-A Switches

Where integrated H-O-A switches are provided on hardware outputs, controller must provide means of monitoring position or status of H-O-A switch. This feedback may be provided via the Niagara Framework or via any valid BACnet method, including the use of proprietary Objects, Properties, or Services.

]2.3.3 Local Display Panel (LDP)

The Local Display Panels (LDPs) must be DDC Hardware with a display and navigation buttons or a touch screen display, and must provide display and adjustment of Niagara Framework points or ASHRAE 135 Properties as indicated on the Points Schedule and as specified. LDPs must be either BTL Listed as a B-OD, B-OWS, B-AWS, or be an integral part of another piece of DDC Hardware listed as a B-BC. For LDPs listed as B-OWS or B-AWS, the hardware must be BTL listed and the product must come factory installed with all applications necessary for the device to function as an LDP.

The adjustment of values using display and navigation buttons must be password protected.

2.3.4 Expansion Modules and Tethered Hardware

A single piece of DDC Hardware may consist of a base unit and also:

a. An unlimited number of hardware expansion modules, where the individual hardware expansion modules are designed to directly connect, both mechanically and electrically, to the base unit hardware. The expansion modules must be commercially available as an optional add-on to the base unit.

b. A single piece of hardware connected (tethered) to a base unit by a single cable where the cable carries a proprietary protocol between the base unit and tethered hardware. The tethered hardware must not contain control logic and be commercially available as an optional add-on to the base unit as a single package.

Note that this restriction on tethered hardware does not apply to sensors or actuators using standard binary or analog signals (not a communications protocol); sensors or actuators using standard binary or analog signals are not considered part of the DDC Hardware.

Hardware capable of being installed stand-alone, or without a separate base unit, is DDC Hardware and must not be used as expansion modules or tethered hardware.

2.3.5 Supervisory Control Requirements

2.3.5.1 Scheduling Hardware

DDC Hardware used for scheduling must meet the following requirements:

a. It must be BTL Listed as a B-BC and support the SCHED-E-B BIBB.

b. It is preferred, but not required, that devices support the DM-OCD-B BIBB on all Calendar and Schedule Objects, such that a front end BTL listed as a B-AWS may create or delete Calendar and Schedule Objects. It is also preferred but not required that devices supporting the DM-OCD-B BIBB accept any valid value for properties of Calendar and Schedule Objects. Note that there are additional requirements in the EXECUTION Part of this Section for Devices which do not support the DM-OCD-B BIBB as specified.

c. The Date_List property of all Calendar Objects must be writable.

d. The Present_Value Property of Schedule must support the following values: 1, 2, 3, 4.

2.3.5.2 Alarm Generation Hardware

Non-Niagara Framework DDC Hardware used for alarm generation must meet the following requirements:

a. Device must support the AE-N-I-B BIBB

b. The Recipient_List Property must be Writable for all Notification Class Objects used for alarm generation.

c. For all Objects implementing Intrinsic Alarming, the following Properties must be Writable:

(1) Time_Delay
(2) High_Limit

(3) Low_Limit
(4) Deadband
(5) Event_Enable
(6) If the issue date of this project specification is after 1 January 2016, Time_Delay_Normal must be writable.

d. It is preferred, but not required, that devices support the DM-OCD-B BIBB on all Notification Class Objects. It is also preferred, but not required that devices supporting the DM-OCD-B BIBB accept any valid value as an initial value for properties of Notification Class Objects.

d. For Event Enrollment Objects used for alarm generation, the following Properties must be Writable:

(1) Event_Parameters
(2) Event_Enable
(3) If the issue date of this project specification is after 1 January 2016, Time_Delay_Normal must be writable.

e. It is preferred, but not required, that devices support the DM-OCD-B BIBB on all Notification Class Objects and Event Enrollment Objects, such that a front end BTL listed as a B-AWS may create or delete Notification Class Objects and Event Enrollment Objects. It is also preferred, but not required that devices supporting the DM-OCD-B BIBB accept any valid value as an initial value for properties of Notification Class Objects and Event Enrollment Objects. Note that there are additional requirements in the EXECUTION Part of this Section for devices which do not support the DM-OCD-B BIBB as specified.

f. Devices provided to meet the the requirements indicated under "Support for Future Alarm Generation" in the EXECUTION part of this specification must support the AE-N-E-B BIBB.

2.3.5.3 Trending Hardware

DDC Hardware used for collecting trend data must meet the following requirements:

a. Device must support Trend Log or Trend Log Multiple Objects.

b. Device must support the T-VMT-I-B BIBB.

c. Devices provided to meet the EXECUTION requirement for support of Future Trending must support the T-VMT-E-B BIBB.

d. The following properties of all Trend Log or Trend Log Multiple Objects must be present and Writable:

Start_Time
Stop_Time
Log_DeviceObjectProperty
Log Interval Log interval must support an interval of at least 60 minutes duration.

e. Trend Log Objects must support using Intrinsic Reporting to send a BUFFER_FULL event.

f. The device must have a Notification Class Object for the BUFFER_FULL event. The Recipient_List Property must be Writable.

g. Devices must support values of at least 1,000 for Buffer_Size Properties.

h. It is preferred, but not required, that devices support the DM-OCD-B BIBB on all Trend Log Objects, such that a front end BTL listed as a A-AWS may create or delete Trend Log Objects. It is also preferred, but not required that devices supporting the DM-OCD-B BIBB accept any valid value as an initial value for properties of Trend Log Objects. Note that there are additional EXECUTION requirements for devices which do not support the DM-OCD-B BIBB as specified.

2.3.6 Niagara Framework Supervisory Gateway

Any device implementing the Niagara Framework is a Niagara Framework Supervisory Gateway and must meet these requirements. In addition to the general requirements for all DDC Hardware, Niagara Framework Supervisory Gateway Hardware must:

a. Be direct digital control hardware.

b. Have an unrestricted interoperability license and its Niagara Compatibility Statement (NiCS) must follow the Tridium Open NiCS Specification.

c. Manage communications between a field control network and the Niagara Framework Monitoring and Control Software, and between itself and other Niagara Framework Supervisory Gateways. Niagara Framework Supervisory Gateway Hardware must use Fox protocol for communication with other Niagara Framework Components, regardless of the manufacturer of the other components.

d. Be fully programmable using the Niagara Framework Engineering Tool and must support the following:

(1) Time synchronization, Calendar, and Scheduling using Niagara Scheduling Objects

(2) Alarm generation and routing using the Niagara Alarm Service

(3) Trending using the Niagara History Service and Niagara Trend Log Objects

(4) Integration of field control networks using the Niagara Framework Engineering Tool

(5) Configuration of integrated field control system using the Niagara Framework Engineering Tool when supported by the field control system

e. Meet the following minimum hardware requirements:

(1) [One][Two] 10/100/1000 Mbps Ethernet Port(s)

(2) One or more MS/TP ports.[

(3) Central Processing Unit of 600 Mhz or higher.][

(4) Embedded operating system.]

f. Provide access to field control network data and supervisory functions via web interface and support a minimum of 16 simultaneous users.

Note: implementation of this capability may not be required on all projects.

g. Submit a backup of each Niagara Framework Supervisory Gateway as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The backup must be sufficient to restore a Niagara Framework Supervisory Gateway to the final as-built condition such that a new Niagara Framework Supervisory Gateway loaded with the backup is indistinguishable in functionality from the original.

2.4 NIAGARA FRAMEWORK ENGINEERING TOOL

The Niagara Framework Engineering Tool must be Niagara Workbench or an equivalent Niagara Framework engineering tool software must:

a. Have an unrestricted interoperability license and its Niagara Compatibility Statement (NiCS) must follow the Tridium Open NiCS Specification.

b. Be capable of performing network configuration for Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.

c. Be capable of programming and configuring of Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.

d. Be capable of discovery of Niagara Framework Supervisory Gateways and all points mapped into each Niagara Framework Supervisory Gateway and making these points accessible to Niagara Framework Monitoring and Control Software.

Monitoring and Control Software is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION.

PART 3 EXECUTION

3.1 CONTROL SYSTEM INSTALLATION3.1.1 Niagara Framework Engineering Tool

[The project site currently has the [_____] Niagara Framework Engineering Tool. If this software is not adequate for programming the Niagara Framework Supervisory Gateways provided under this project, provide a Niagara Framework Engineering Tool.][Provide a Niagara Framework Engineering Tool.]

3.1.2 Building Control Network (BCN)

Install the Building Control Network (BCN) as a single BACnet Internetwork consisting of a single IP network as the BCN Backbone and zero or more BACnet MS/TP networks. Note that in some cases there may only be a single device on the BCN Backbone.

Except for the IP Network and as permitted for the non-BACnet side of Gateways, use exclusively ASHRAE 135 networks.

3.1.2.1 Building Control Network IP Backbone

Install IP Network Cabling in conduit. Install Ethernet Switches in lockable enclosures. Install the Building Control Network (BCN) IP

Backbone such that it is available at the Facility Point of Connection (FPOC) location [as indicated][_____]. When the FPOC location is a room number, provide sufficient additional media to ensure that the Building Control Network (BCN) IP Backbone can be extended to any location in the room.

Use UDP port 0xBAC0 for all BACnet traffic on the IP network. (Note that in a Niagara Framework system there may not be BACnet traffic on the IP Network)

3.1.2.2 BACnet MS/TP Networks

When using MS/TP, provide MS/TP networks in accordance with ASHRAE 135 and in accordance with the ASHRAE 135 figure "Mixed Devices on 3-Conductor Cable with Shield" (Figure 9-1.4 in the 2012 version of ASHRAE 135). Ground the shield at the BACnet Router and at no other point. Ground the reference wire at the BACnet Router through a 100 ohm resistor and do not ground it at any other point. In addition:

a. Provide each segment in a doubly terminated bus topology in accordance with TIA-485.

b. Provide each segment with 2 sets of network bias resistors in accordance with ASHRAE 135, with one set of resistors at each end of the MS/TP network.

c. Use 3 wire (twisted pair and reference) with shield media for all MS/TP media installed inside. Use fiber optic isolation in accordance with ASHRAE 135 for all MS/TP media installed outside buildings, or between multiple buildings.

d. For 18 AWG cable, use segments with a maximum length of 4000 ft. When using greater distances or different wire gauges comply with the electrical specifications of TIA-485.

e. For each controller that does not use the reference wire provide transient suppression at the network connection of the controller if the controller itself does not incorporate transient suppression.

f. Install no more than 32 devices on each MS/TP segment. Do not use MS/TP to MS/TP routers.

g. Connect each MS/TP network to the BCN backbone via a Niagara Framework Supervisory Gateway configured as a BACnet Router.

h. For BACnet Routers, configure the MS/TP MAC address to 0. Assign MAC Addresses to other devices consecutively beginning at 1, with no gaps.

i. Configure the Max_Master Property of all devices to be 31.

3.1.2.3 Building Control Network (BCN) Installation

Provide a building control network meeting the following requirements:

a. Install all DDC Hardware connected to the Building Control Network.

b. Where multiple pieces of DDC Hardware are used to execute one sequence, install all DDC Hardware executing that sequence on a single MS/TP network dedicated to that sequence.

c. Traffic between BACnet networks must be exclusively via BACnet routers.

d. Use the Fox protocol for all traffic both originating and terminating at Niagara Framework components. Use the Fox protocol for all traffic originating or terminating at a Niagara Framework UMCS (including traffic to or from a future UMCS). All other traffic, including traffic between ASHRAE 135 devices and traffic between Niagara Framework Supervisory Gateways and ASHRAE 135 devices must be in accordance with ASHRAE 135.

3.1.3 DDC Hardware

Install all DDC Hardware that connects to an IP network in lockable enclosure. Install other DDC Hardware that is not in suspended ceilings in [lockable]enclosures. For all DDC hardware with a user interface, coordinate with site to determine proper passwords and configure passwords into device.

a. Except for zone sensors (thermostats), install all Tethered Hardware within 6 feet of its base unit.

b. Install and configure all BTL-Listed devices in a manner consistent with their BTL Listing such that the device as provided still meets all requirements necessary for its BTL Listing.

c. Install and configure all BTL-Listed devices in a manner consistent with the BTL Device Implementation Guidelines such that the device as provided meets all those Guidelines.

3.1.3.1 Device Identifiers, Network Addresses, and IP addresses

a. Do not use any Device Identifier or Network Number already used by another BACnet system at the project site. [Coordinate Device IDs and Network Numbers with the installation. The installation POC is [_____]] [Use Device IDs within the range of [_____] to [_____] and Network Numbers in the range of [_____] to [_____]].

b. [Use IP addresses within the range of [_____] to [_____]] [Coordinate device IP addresses with installation. The installation POC is [_____]].

3.1.3.2 ASHRAE 135 Object Name Property and Object Description Property

Configure the Object_Names and Object_Descriptions properties of all ASHRAE 135 Objects (including Device Objects) as indicated on the Points Schedule (Point Name and Point Description) and as specified. At a minimum:

a. Except for DDC Hardware controlling a single terminal unit, configure the Object_Name and Object_Description properties of all Objects (including Device Objects) as indicated on the Points Schedule and as specified.

b. In DDC Hardware controlling a single terminal unit, configure the Device Object_Name and Device Object_Description as indicated on the Points Schedule and as specified.

When Points Schedule entries exceed the length limitations in the device, notify [_____] and provide recommended alternatives for approval.

3.1.3.3 Niagara Framework Point Names and Descriptions

Configure the names and descriptions of all Points in Niagara Framework Supervisory Gateways as indicated on the Points Schedule and as specified.

3.1.3.4 Niagara Station IDs

Ensure that Niagara Station IDs of new Niagara Framework Supervisory Gateways are maintained as unique within UMCS front-end, including ensuring they do not conflict with any existing Niagara Station ID.

3.1.3.5 Hand-Off-Auto (H-O-A) Switches

Provide Hand-Off-Auto (H-O-A) switches [for all DDC Hardware analog outputs and binary outputs used for control of systems other than terminal units,]as specified and as indicated on the Points Schedule. Provide H-O-A switches that are integral to the controller hardware, an external device co-located with (in the same enclosure as) the controller, integral to the controlled equipment, or an external device co-located with (in the same enclosure as) the controlled equipment.

a. For H-O-A switches integral to DDC Hardware, meet the requirements specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.

b. For external H-O-A switches used for binary outputs, provide for overriding the output open or closed.

c. For eternal H-O-A switches used for analog outputs, provide for overriding [to 0 percent or 100 percent][through the range of 0 percent to 100 percent].

3.1.3.6 Local Display Panels

Provide LDPs to display and override values of points in a Niagara Framework Supervisory Gateway or ASHRAE 135 Object Properties as indicated on the Points Schedule. Install LDPs displaying points for anything other than a terminal unit in the same room as the equipment. Install LDPs displaying points for only terminal units [in a mechanical room central to the group of terminal units it serves][_____]. For LDPs using WriteProperty to commandable objects to implement an override, write values with priority 9.

3.1.3.7 MS/TP Slave Devices

Configure all MS/TP devices as Master devices. Do not configure any devices to act as slave devices.

3.1.3.8 Change of Value (COV) and Read Property

a. To the greatest extent possible, configure all devices to support the SubscribeCOV service (the DS-COV-B BIBB). At a minimum, all devices supporting the DS-RP-B BIBB, other than devices controlling only a single terminal unit, must be configured to support the DS-COV-B BIBB.

b. Whenever supported by the server side, configure client devices to use the DS-COV-A BIBB.

3.1.3.9 Engineering Units

[Configure devices to use SI (Metric) units as follows:

a. Temperature in degrees C

b. Air or natural gas flows in Liters per Second (LPS)

c. Water flow in Liters per Second (LPS)

d. Steam flow in kilograms per second (kg/s)

e. Differential Air pressures in Pascals (Pa)

f. Water, steam and natural gas pressures in kiloPascals (kPa)

g. Enthalpy in kiloJoules per kilogram (kJ/kg)

h. Heating and Cooling Energy in kilowatt-hours (kWh)

i. Heating and Cooling load in kilowatts (kW)

j. Electrical Power: kilowatts (kW)

k. Electrical Energy: kilowatt-hours (kWh)][Configure devices to use English (Inch-Pound) engineering units as follows:

a. Temperature in degrees F

b. Air or natural gas flows in cubic feet per minute (CFM)

c. Water in gallons per minute (GPM)

d. Steam flow in pounds per hour (pph)

e. Differential Air pressures in inches of water column (IWC)

f. Water, steam, and natural gas pressures in PSI

g. Enthalpy in BTU/lb

h. Heating and cooling energy in MBTU (1MBTU = 1,000,000 BTU))

i. Cooling load in tons (1 ton = 12,000 BTU/hour)

j. Heating load in MBTU/hour (1MBTU = 1,000,000 BTU)

k. Electrical Power: kilowatts (kW)

l. Electrical Energy: kilowatt-hours (kWh)]

3.1.3.10 Occupancy Modes

Use the following correspondence between value and occupancy mode whenever an occupancy state or value is required:

a. OCCUPIED mode: a value of one
b. UNOCCUPIED mode: a value of two
c. WARM-UP/COOL-DOWN (PRE-OCCUPANCY) mode: a value of three

Note that elsewhere in this Section the Schedule Object is required to also support a value of four, which is reserved for future use. Also note that the behavior of a system in each of these occupancy modes is indicated in the sequence of operation for the system.

3.1.3.11 Use of BACnet Objects

Except as specifically indicated for Niagara Framework Objects, Use only standard non-proprietary ASHRAE 135 Objects and services to accomplish the project scope of work as follows:

a. Use Analog Input or Analog Output Objects for all analog hardware I/O. Do not use Analog Value Object for analog hardware I/O) .

b. Use Binary Input or Binary Output Objects for all binary hardware I/O. Do not use Binary Value Objects for binary hardware I/O.

c. Use Analog Value Objects for analog setpoints.

d. Use Accumulator Objects or Analog Value Objects for pulse inputs.

e. For occupancy modes, use Multistate Value Objects and the correspondence between value and occupancy mode specified in paragraph OCCUPANCY MODES.

f. Use Schedule Objects and Calendar Objects for all scheduling. Use Trend Log Objects or Trend Log Multiple Objects for all trending and Notification Class Objects for trend log upload. Use a combination of Event Enrollment Objects,Intrinsic Alarming, and Notification Class Objects for alarm generation.

f. Use a combination of Niagara Framework Alarm Extensions and Alarm Services, Intrinsic Alarming, and Notification Class Objects for alarm generation.

g. For all other points shown on the Points Schedule as requiring an ASHRAE 135 Object, use the Object type shown on the Points Schedule or, if no Object Type is shown, use a standard Object appropriate to the point.

3.1.3.11.1 Niagara Framework Objects

Points in the Niagara Framework Supervisory Gateway, even if used in a sequence or are shown on the Points Schedule, are not required to be exposed as BACnet Objects unless they are required to be available on the network by another device or sequence of operation (i.e. there is some other reason they are needed).

Use a Niagara Framework Supervisory Gateway as specified for all scheduling and trending. Use a Niagara Framework Supervisory Gateway as specified for all alarming except for intrinsic alarming.

3.1.3.12 Use of Standard BACnet Services

Except as noted in this paragraph, for all DDC Hardware (including Niagara Frameworks Supervisory Gateways when communicating with non-Niagara Framework DDC Hardware) use Standard BACnet Services as defined in this specification (which excludes some ASHRAE 135 services) exclusively for application control functionality and communication.

DDC Hardware that cannot meet this requirement may use non-standard services provided they can provide identical functionality using Standard BACnet Services when communicating with BACnet devices from a different vendor. When implementing non-standard services, document all non-standard services in the DDC Hardware Schedule as specified and as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

3.1.3.13 Device Application Configuration

a. For every property, setting or value shown on the Points Schedule or otherwise indicated as Configurable, provide a value that is retained through loss of power and can be changed via one or more of:

(1) BACnet services (including proprietary services)

(2) Hardware settings on the device

(3) The Niagara Framework

b. For every property, setting or value in non-Niagara Framework Hardware shown on the Points Schedule or otherwise indicated as Operator Configurable, provide a value that is retained through loss of power and can be changed via one or more of:

(1) A Writable Property of a standard BACnet Object

(2) A Property of a standard BACnet Object that is Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable.

(3) Using some other method supported by a Niagara Framework Supervisory Gateway

c. Configure Niagara Framework Supervisory Gateways such that the property, setting or value is configurable from a Niagara Framework Front End.

d. For every property, setting or value in a Niagara Framework Supervisory Gateway which is shown on the Points Schedule or otherwise indicated as Operator Configurable, configure the value to be configurable from within the Niagara Framework such that it can be configured from a system graphic page at a Niagara Framework Front End.

3.1.3.14 Niagara Framework Engineering Tool

Use the Niagara Framework Engineering Tool to fully discover the field control system and make all field control system information available to the Niagara Framework Supervisory Gateway. Ensure that all points on the points schedule are available to the front end via the Fox protocol.

[3.1.3.15 Graphics and Web Pages

Configure Niagara Framework Supervisory Gateways to use web pages to provide a graphical user interface including System Displays[using the project site sample displays], including overrides, as indicated on the Points Schedule and as specified. Label all points on displays with [full English language descriptions][the point name as indicated on the Points Schedule][the point description as indicated on the Points Schedule][_____]. Configure user permissions for access to and executions of action using graphic pages. Coordinate user permissions with [the [Controls] [HVAC] [Electrical] shop supervisor][_____]. Configure the web server to use HTTPS based on the Transport Layer Security (TLS) protocol in accordance with RFC 5246 using a Government furnished certificate.

]3.1.4 Scheduling, Alarming, Trending, and Overrides

3.1.4.1 Scheduling

Configure schedules in BACnet Scheduling Objects to schedule systems as indicated on the Points Schedule and as specified using the indicated correspondence between value and occupancy mode. If no devices supports both the SCHED-E-B and DM-OCD-B BIBBS for Schedule Objects, provide [5][_____] blank Schedule Objects in DDC Hardware BTL listed as B-BCs and supporting the SCHED-E-B BIBB for later use by the site.
Configure schedules in Niagara Framework Supervisory Gateway using Niagara Schedule Objects as indicated on the Points Schedule and as specified. When the schedule is controlling occupancy modes in DDC Hardware other than a Niagara Framework Supervisory Gateway use the indicated correspondence between value and occupancy mode.

Provide a separate schedule for each AHU including it's associated Terminal Units and for each stand-alone Terminal Unit (those not dependent upon AHU service)[or group of stand-alone Terminal Units acting according to a common schedule[as indicated]].

3.1.4.2 Alarm Configuration

Configure alarm generation and management as indicated on the Points Schedule and as specified. Configure alarm generation in Niagara Framework Supervisory Gateways using Niagara Framework Alarm Extensions and Alarm Services or in other DDC Hardware (not Niagara Framework Supervisory Gateways) using ASHRAE 135 Intrinsic Alarming. Configure alarm management and routing for all alarms, including those generated via intrinsic alarming in other devices, in the Niagara Framework Supervisory Gateway such that the alarms are able to be accessed from the Niagara Framework Front End.

Where Intrinsic Alarming is used, configure intrinsic alarming as specified in paragraph "Configuration of ASHRAE 135 Intrinsic Alarm Generation". Configure a Niagara Framework Supervisory Gateway to provide a means to configure the intrinsic alarm parameters such that the Intrinsic Alarm is configurable from the front end via the Niagara Framework.

3.1.4.3 Configuration of ASHRAE 135 Intrinsic Alarm Generation

Intrinsic alarm generation must meet the following requirements:

Configure alarm generation as indicated on the Points Schedule and as specified using Intrinsic Alarming in accordance with ASHRAE 135 or Algorithmic Alarming in accordance with ASHRAE 135. Alarm generation must meet the following requirements:

a. Send alarm events as Alarms (not Events).

b. Use the ConfirmedNotification Service for alarm events.

c. For alarm generation, support two priority levels for alarms: critical and non-critical. Configure the Priority of Notification Class Objects to use Priority 112 for critical and 224 for non-critical alarms.

d. Number of Notification Class Objects for Alarm Generation:

(1) If the device implements non-critical alarms, or if any Object in the device supports Intrinsic Alarms, then provide a single Notification Class Object specifically for (shared by) all non-critical alarms.

(2) If the device implements critical alarms, provide a single Notification Class Object specifically for (shared by) all critical alarms.

(3) If the device implements both critical and non-critical alarms, provide both Notification Class Objects (one for critical, one for non-critical).

(4) If the device controls equipment other than a single terminal unit, provide both Notification Class Objects (one for critical, one for non-critical) even if no alarm generation is required at time of installation.

e. For all intrinsic alarms configure the Limit_Enable Property to set both HighLimitEnable and LowLimitEnable to TRUE. If the specified alarm conditions are for a single-sided alarm (only High_Limit used or only Low_Limit used) assign a value to the unused limit such that the unused alarm condition will not occur.

f. For all objects supporting intrinsic alarming, even if no alarm generation is required during installation, configure the following Properties as follows:

(1) Notification_Class to point to the non-Critical Notification Class Object in that device.

(2) Limit_Enable to enable both the HighLimitEnable and LowLimitEnable

(3) Notify_Type to Alarm

g. Use of alarm generation types:

(1) Only use algorithmic alarm generation when intrinsic alarm generation is not supported by the device or object, or when the specific alarm conditions cannot be implemented using intrinsic alarm generation.

(2) Only use remote alarm generation when the alarm cannot be generated using intrinsic or local algorithmic alarm generation on the device containing the referenced property. If remote alarm generation is used, use the same DDC Hardware for all remote alarm generation within a single sequence.

g. Configure the Recipient_List Property of the Notification Class Object to point to the Niagara Framework Supervisory Gateway managing the alarm.

3.1.4.4 Support for Future Alarm Generation

For every piece of DDC Hardware, support future alarm generation capabilities by supporting either intrinsic or additional algorithmic alarming. Provide one of the following:

a. Support intrinsic alarming for every Object used by the application in that device.

b. Support additional Event_Enrollment Objects. For DDC hardware controlling a single terminal unit, support at least one additional object. Otherwise, support at least [4][_____] additional Objects. Support additional Event_Enrollment Objects via one of the following:

(1) Provide unused Event_Enrollment Objects on that device.

(2) Support the DM-OCD-B BIBB and the creation of sufficient Event_Enrollment Objects on that device.

(3) Provide one or more devices in the IP network that support the AE-N-E-B BIBB and have unused Event_Enrollment Objects.

(4) Provide one or more devices on the IP network that support the AE-N-E-B BIBB, the DM-OCD-B BIBB, and the creation of sufficient Event_Enrollment Objects.

The total number of Event_Enrollment Objects required by the project is the sum of the individual device requirements, and the distribution of Event_Enrollment Objects among devices is not further restricted. (Note this allows a single device to contain many Event_Enrollment Objects satisfying the requirements for multiple devices.)

3.1.4.5 Trend Log Configuration

a. Configure trends in Trend Log or Trend Log Multiple Objects as indicated on the Points Schedule and as specified.

b. Configure all trend logs (including any provided to support future trends) to save data on regular intervals using the BUFFER_FULL event to request trend upload from the front end.

c. Configure Trend Log Objects with a minimum Buffer_Size property value of 1,000 and Trend Log Multiple Objects with a minimum Buffer_Size property value of 1,000 per point trended (for example, a Trend Log Multiple Object used to trend 3 points must have a Buffer_Size Property value of at least 3,000).

d. Configure a Notification Class Object in devices doing trending (including devices supporting future trends) to handle the BUFFER_FULL event.

e. When possible, trend each point using an Object in the device containing the point. When it is necessary to trend using a an Object in another device, all trends not on the same Device as the Object being trended must be on a singe device (i.e. all Trend Log and Trend Log Multiple Objects used for remote trending within a sequence must be on the same device).

f. For each trend log, including any trend logs provided to support future trending, configure the following properties as specified:

(1) Logging_Type: Set to Polling

(2) Stop_When_Full: Set to Wrap Around

(3) Buffer_Size: Set to 400 or greater.

(4) Notification_Threshold: Set to 90 percent of full

(5) Notification_Class: Set to the Notification Class Object in that device

(6) Event_Enable: Set to TRUE

(7) Log_Interval: Set to 15 minutes.

g. Future Trending support. Provide support for future trending:

(1) Provide one or more devices on the Building Control Network Backbone IP network which support both the T-VMT-E-B and DM-OCD-B BIBBs for Trend Log Objects. Provide sufficient devices to support the creation of at least [[_____] additional Trend Log Objects][one additional Trend Log Object for every terminal unit plus 4 additional Trend Log Objects for every non-terminal unit].

(2) Provide [[_____] additional Trend Log Objects][one additional Trend Log Object for every terminal unit plus 4 additional Trend Log Objects for every non-terminal unit] in one or more devices on the Building Control Network Backbone IP network that support the T-VMT-E-B BIBB for later use by the site.

(3) A combination of these two methods is permitted provided the total required number of Trend Log Objects is met.

3.1.4.6 Trending

Perform all trending using a Niagara Framework Supervisory Gateway using Niagara Framework History Extensions and Niagara Framework History Service exclusively.

3.1.4.7 Overrides

Provide an override for each point shown on the Points Schedule as requiring an override. Use the Niagara Framework for all overrides to points in Niagara Framework Supervisory Gateways. For overrides to other points, provide an override to a point in a Niagara Framework Supervisory Gateway via the Niagara Framework where the Niagara Framework Supervisory Gateway overrides the other point as specified.

Unless otherwise approved, provide Commandable Objects to support all Overrides in non-Niagara Framework Supervisory Gateway DDC Hardware. With specific approval from the Contracting Officer, Overrides for points which are not hardware outputs and which are in DDC hardware controlling a single terminal unit may support overrides via an additional Object provided for the override. No other means of implementing Overrides may be used.

a. Where Commandable Objects are used, ensure that WriteProperty service requests with a Priority of 10 or less take precedence over the SEQUENCE VALUE and that WriteProperty service request with a priority of 11 or more have a lower precedence than the SEQUENCE VALUE.

b. For devices implementing overrides via additional Objects, provide

Objects which are NOT Written to as part of the normal Sequence of Operations and are Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable. Use this point as an Override of the normal value when Out_Of_Service is TRUE and the normal value otherwise. Note these Objects may be modified as part of the sequence via local processes, but must not be modified by local processes when Out_Of_Service is TRUE.

3.1.5 BACnet Gateways

The requirements in this paragraph do not themselves permit the installation of hardware not meeting the other requirements of this section. Except for proprietary systems specifically indicated in Section 23 09 00, all control hardware installed under this project must meet the requirements of this specification, including the control hardware providing the network interface for a package unit or split system specified under another section. Only use gateways to connect to pre-existing control devices, and to proprietary systems specifically permitted by Section 23 09 00.

3.1.5.1 General Gateway Requirements

Provide BACnet Gateways to connect non-BACnet control hardware in accordance with the following:

a. Configure gateways to map writable data points in the controlled equipment to Writable Properties of Standard Objects, or to Niagara Framework points, as indicated in the Points Schedule and as specified.

b. Configure gateway to map readable data points in the controlled equipment to Readable Properties of Standard Objects, or to Niagara Framework points, as indicated in the Points Schedule and as specified.

c. Configure gateway to support the DS-COV-B BIBB for all points mapped to BACnet Objects.

d. Do not use non-BACnet control hardware for controlling built-up units or any other equipment that was not furnished with factory-installed controls. (Note: A Niagara Framework Supervisory Gateway is BACnet control hardware.)

e. Do not use non-BACnet control hardware for system scheduling functions.

f. Each gateway must communicate with and perform protocol translation for non-BACnet control hardware controlling one and only one package unit or a single non-BACnet system specifically permitted by Section 23 09 00.

g. Connect one network port on the gateway to the Building Control Backbone IP Network or to a BACnet MS/TP network and the other port to the single piece of controlled equipment or the non-BACnet system specifically permitted by Section 23 09 00..

h. For gateways to existing package units or simple split systems, non-BACnet network wiring connecting the gateway to the package unit must not exceed 10 feet in length and must connect to exactly two devices: the controlled equipment (packaged unit) or split system interface and the gateway.

-- End of Section --

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SECTION 23 11 20

FACILITY GAS PIPING
05/20

PART 1 GENERAL

1.1 SUMMARY

This specification section applies to gas piping installed within buildings incidental underground piping under building, above ground steel piping and corrugated stainless steel tubing (CSST) both outside (up to 5 feet beyond exterior walls) and within buildings in compliance with NFPA 54/AGA Z223.1, "National Fuel Gas Code" NFPA 58, "Fuel Gas Piping".

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.1	(2000) Diaphragm Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
AGA ANSI B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA ANSI B109.3	(2019) Rotary-Type Gas Displacement Meters
AGA ANSI B109.4	(2016) Self-Operated Diaphragm-Type Natural Gas Service Regulators for Nominal Pipe Size 1¼ inches (32 mm) and Smaller with Outlet Pressures of 2 psig (13.8 kPa) and Less
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service
AGA Z223.1	(2012) National Fuel Gas Code

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.1/CSA 1.1	(2018) Household Cooking Gas Appliances
ANSI Z21.15/CSA 9.1	(2021) Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves
ANSI Z21.18/CSA 6.3	(2007; R 2017) Gas Appliance Pressure Regulators
ANSI Z21.21/CSA 6.5	(2019) Automatic Valves for Gas Appliances
ANSI Z21.24/CSA 6.10	(2022) Connectors for Gas Appliances

ANSI Z21.41/CSA 6.9	(2014; R 2019) Quick-Disconnect Devices for Use with Gas Fuel Appliances
ANSI Z21.69/CSA 6.16	(2015; R 2020) Connectors for Movable Gas Appliances
ANSI Z21.78/CSA 6.20	(2010; R 2020) Standard Specification for Combination Gas Controls for Gas Appliances
ANSI Z21.80/CSA 6.22	(2019) Line Pressure Regulators
ANSI Z21.93/CSA 6.30	(2017) Excess Flow Valves for Natural Gas and Propane Gas with Pressures up to 5 psig

AMERICAN PETROLEUM INSTITUTE (API)

API 570	(2016; Addendum 1 2017; Addendum 2 2018; ERTA 1 2018) Piping Inspection Code: In-Service Inspection, Rating, Repair, and Alteration of Piping Systems
API MPMS 2.2A	(1995; R 2017) Manual of Petroleum Measurement Standards Chapter 2-Tank Calibration Section 2A-Measurement and Calibration of Upright Cylindrical Tanks by the Manual Tank Strapping Method
API MPMS 2.2E	(2004; Errata 2009; R 2009) Petroleum and Liquid Petroleum Products - Calibration of Horizontal Cylindrical Tanks - Part 1: Manual Methods
API RP 1110	(2013; R 2018) Recommended Practice for the Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids, or Carbon Dioxide
API RP 2003	(2015; 8th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API RP 2009	(2002; R 2007; 7th Ed) Safe Welding, Cutting, and Hot Work Practices in Refineries, Gasoline Plants, and Petrochemical Plants
API Spec 5CT	(2018) Casing and Tubing
API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves
API Spec 15LR	(2001; R 2018) Specification for Low Pressure Fiberglass Line Pipe
API Std 598	(2009) Valve Inspecting and Testing
API Std 607	(2016) Fire Test for Quarter-turn Valves

and Valves Equipped with Non-metallic Seats

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25-16	(2016) Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems
ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.33	(2012; R 2017) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psi, (Sizes NPS 1/2 - NPS 2)
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.8	(2018; Supplement 2018) Gas Transmission and Distribution Piping Systems
ASME B31.9	(2020) Building Services Piping
ASME B36.10M	(2022) Welded and Seamless Wrought Steel Pipe

ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS WHB-2.9	(2004) Welding Handbook; Volume 2, Welding Processes, Part 1

ASTM INTERNATIONAL (ASTM)

ASTM 01.01	(2019) Steel - Piping, Tubing, Fittings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A513/A513M	(2020a) Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
ASTM A666	(2015) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B210/B210M	(2019a) Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B241/B241M	(2016) Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube

ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM D2513	(2018a) Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
ASTM D2517	(2018) Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
ASTM F2015	(2000; R 2013) Standard Specification for Lap Joint Flange Pipe End Applications

CSA GROUP (CSA)

ANSI LC 1/CSA 6.26	(2019) Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST)
CGA 3.11-M88	(2015) Lever Operated Pressure Lubricated Plug Type Gas Shut-Off Valves
CGA 3.16-M88	(2015) Lever Operated Non-Lubricated Gas Shut-Off Valves
CGA 9.2-M88	(1988; R 2009) Manually Operated Shut-Off Valves for Gas Piping Systems

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
NFPA 58	(2020; TIA 20-1; TIA 20-2; TIA 20-3) Liquefied Petroleum Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders
UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

UNDERWRITERS LABORATORIES (UL)

UL 125	(2020) UL Standard for Safety Flow Control Valves for Anhydrous Ammonia and LP-Gas
UL 842	(2015; Reprint Oct 2017) UL Standard for Safety Valves for Flammable Fluids
UL 860	(2014) Pipe Unions for Flammable and Combustible Fluids and Fire-Protection Service
UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

1.3 SYSTEM DESCRIPTION

The gas piping system includes [natural gas] [and] [liquid petroleum] piping and appurtenances from point of connection with supply system, as indicated, to gas operated equipment within the facility. Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, in three separate packages. Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein. [Provide cathodically protected insulating joints connecting aboveground piping from the meter to the building, with [lightning arrestors] [zinc grounding cells] conforming to API RP 2003, installed where indicated.]

1.3.1 Gas Facility System and Equipment Operation

Include shop drawings showing piping layout, locations of system valves, gas line markers[and cathodic protection system]; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system drawings); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data package No. 4.

1.3.2 Gas Facility System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No.4.

1.3.3 Gas Facility Equipment Maintenance

Include identification of valves, shut-offs, disconnects, and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Gas Piping System; G[, [_____]]

SD-03 Product Data

Pipe and Fittings; G[, [_____]]

Gas Equipment Connectors; G[, [_____]]

LPG Containers and Accessories; G[, [_____]]

Gas Piping System; G[, [_____]]

Pipe Coating Materials; G[, [_____]]

Pressure Regulators; G[, [_____]]

Risers; G[, [_____]]

Transition Fittings; G[, [_____]]

Valves; G[, [_____]]

Warning and Identification Tape; G[, [_____]]

SD-06 Test Reports

Testing; G[, [_____]]

Pressure Tests; G[, [_____]]

Pressure Tests for Liquified Petroleum Gas; G[, [_____]]

Test with Gas; G[, [_____]]

SD-07 Certificates

Welders Procedures and Qualifications; G[, [_____]]

Assigned Number, Letter, or Symbol; G[, [_____]]

SD-08 Manufacturer's Instructions

PE Pipe and Fittings; G[, [_____]]

Pipe Coating Materials; G[, [_____]]

SD-10 Operation and Maintenance Data

Gas Facility System and Equipment Operation; G[, [_____]]

Gas Facility System Maintenance; G[, [_____]]

Gas Facility Equipment Maintenance; G[, [_____]]

1.5 QUALITY ASSURANCE

Submit manufacturer's descriptive data and installation instructions for approval for compression-type mechanical joints used in joining dissimilar materials and for insulating joints. Mark all valves, flanges and fittings in accordance with MSS SP-25.

1.5.1 Welding Qualifications

a. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators in accordance with API RP 2009, ASME BPVC SEC IX, and ASME B31.9. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.9. Notify the Contracting Officer at least 24 hours in advance of tests, and perform at the work site if practicable.

b. Submit a certified copy of welders procedures and qualifications metal and PE in conformance with ASME B31.9 for each welder and welding operator. Submit the assigned number, letter, or symbol that will be used in identifying the work of each welder to the Contracting Officer.[Weld all structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING, and in conformance with AWS A5.8/A5.8M, and AWS WHB-2.9.]

1.5.2 Jointing Thermoplastic and Fiberglass Piping

Perform all jointing of piping using qualified joiners and qualified procedures in accordance with AGA XR0603. Furnish the Contracting Officer with a copy of qualified procedures and list of and identification symbols of qualified joiners. Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart, including all PE pipe and fittings.

1.5.3 Shop Drawings

Submit drawings for complete Gas Piping System, within [30] [_____] days of contract award, showing location, size and all branches of pipeline; location of all required shutoff valves; and instructions necessary for the installation of gas equipment connectors and supports. Include LP storage tank, pad, and mounting details.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Plastic Pipe

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap pipe and fittings ends during transportation or storage to minimize dirt and moisture entry. Do not subject piping to abrasion or concentrated external loads. Discard PE pipe sections and fittings that have been damaged.

1.6.2 CSST Tubing

Handle, transport and store CSST tubing on the wooden spool or shipping container provided by the manufacturer. Insure tubing ends are capped during transportation and storage to minimize dirt and moisture entry. Discard any tubing segment and fitting that has been damaged.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Submit catalog data and installation instructions for pipe, valves, all related system components, pipe coating materials and application procedures. Conform to NFPA 54NFPA 58 and with requirements specified herein. Provide supply piping to appliances or equipment at least as large as the inlets thereof.

2.2 GAS PIPING SYSTEM AND FITTINGS

[2.2.1 Steel Pipe, Joints, and Fittings

a. Pipe: Black carbon steel in accordance with ASTM A53/A53M, Schedule [40] [80], threaded ends for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.

b. Threaded Fittings: ASME B16.3, black malleable iron.

c. Socket-Welding Fittings: ASME B16.11, forged steel.

d. Butt-Welding Fittings: ASME B16.9, with backing rings of compatible material.

e. Unions: ASME B16.39, black malleable iron.

f. Flanges and Flanged Fittings: ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1, with flange faces having integral grooves of rectangular cross sections which afford containment for self-energizing gasket material.

Provide steel pipe conforming to ASME B36.10M; and malleable-iron threaded fittings conforming to ASME B16.1 and ASME B16.3. Provide steel pipe flanges and flanged fittings, including bolts, nuts, and bolt pattern in accordance with ASME B16.5 and ASTM A105/A105M. Provide wrought steel buttwelding fittings conforming to ASME B16.9. Provide socket welding and threaded forged steel fittings conforming to ASME B16.11[and ASTM A181/A181M, Class 60].

][2.2.2 Aluminum Alloy Pipe and Tubing, Joints, and Fittings

Provide aluminum alloy pipe conforming to ASTM B241/B241M, except that alloy 5456 is not allowed. Mark the ends of each length of pipe indicating it conforms to NFPA 54 NFPA 58. Thread, flange, braze, or weld pipe joints. Provide aluminum alloy tubing conforming toASTM B210/B210M, Type A or B, or ASTM B241/B241M, Type A or equivalent, with joints made up with gas tubing fittings recommended by the tubing manufacturer.

][2.2.3 Copper Tubing, Joints and Fittings

Provide copper tubing conforming to ASTM B88, Type K or L, or ASTM B280, with tubing joints made up with tubing fittings recommended by the tubing manufacturer. Provide copper and copper alloy press fittings, with sealing elements of Hydrogenated Nitrile Butadiene Rubber (HNBR), factory installed, or an alternative supplied by the fitting manufacturer. Press fittings are not a permitted connection fitting for natural and LP gas on Army and Navy projects.

][2.2.4 Steel Tubing, Joints and Fittings

Provide steel tubing conforming to ASTM 01.01, and ASTM A513/A513M, with tubing joints made up with gas tubing fittings recommended by the tubing manufacturer.

][2.2.5 Thermoplastic Pipe, Tubing, Joints, and Fittings

Provide thermoplastic pipe, tubing,casing and joints and fittings conforming to ASTM D2513 and API Spec 5CT.

][2.2.6 Fiberglass Pipe, Joints, and Fittings

Provide fiberglass piping systems conforming to ASTM D2517 and API Spec 15LR.

][2.2.7 Corrugated Stainless Steel Tubing, Fittings and Accessories

Provide corrugated stainless steel tubing conforming to ANSI LC 1/CSA 6.26 (austenitic stainless steel of series 300) with tubing joints made with special mechanical fittings as supplied by the tubing manufacturer.

2.2.7.1 Tubing

Austenitic stainless alloy of series 300 with polyethylene jacket/coating in accordance with ANSI LC 1/CSA 6.26 for sizes 3/8-inch through 2-inch

2.2.7.2 Mechanical Fittings

Copper alloy with one end matched to the corrugated tubing and one end with

NPT threads in accordance with ASME B1.20.1

2.2.7.3 Striker Plates

Hardened steel designed to protect tubing from mechanical damage in accordance with ANSI LC 1/CSA 6.26

2.2.7.4 Manifolds

Malleable iron, steel or copper alloy with threaded connections/ports in accordance with ASME B1.20.1

][2.2.8 Sealants for Steel Pipe Threaded Joints

Provide joint sealing compound as listed in UL FLAMMABLE & COMBUSTIBLE, Class 20 or less. For taping, use tetrafluoroethylene tape conforming to UL FLAMMABLE & COMBUSTIBLE.

]2.2.9 Warning and Identification

Provide pipe flow markings, warning and identification tape, and metal tags as required.

2.2.10 Flange Gaskets

Provide gaskets of nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type, containing aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR) suitable for a maximum 600 degree F service, to be used for hydrocarbon service.

2.2.11 Pipe Threads

Provide pipe threads conforming to ASME B1.20.1.

2.2.12 Escutcheons

Provide chromium-plated steel or chromium-plated brass escutcheons, either one piece or split pattern, held in place by internal spring tension or set screw.

2.2.13 Gas Transition Fittings

[a. Provide steel to plastic (PE) designed for steel-to-plastic with tapping tee or sleeve conforming to AGA XR0603 requirements for transitions fittings.. Coat or wrap exposed steel pipe with heavy plastic coating.]

[b. Plastic to Plastic: [Manufacturer's standard bolt-on (PVC to PE) plastic tapping saddle tee, UL listed for gas service, rated for 100 psig, and O-ring seals.] [Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support conforming to ASTM A666, O-ring seals, and rated for 150 psig gas service.] [Manufacturer's standard fused tapping (PE-to-PE) tee assembly with shut-off feature.]]

[c.[Provide lever operated pressure lubricated plug type gas shut-off valve conforming to CGA 3.11-M88.][Provide lever operated non-lubricated gas shut-off valves conforming to CGA 3.16-M88][

Provide manually operated shut-off valve conforming to CGA 9.2-M88]]

2.2.14 Insulating Pipe Joints

2.2.14.1 Insulating Joint Material

Provide insulating joint material between flanged or threaded metallic pipe systems where shown to control galvanic or electrical action.

2.2.14.2 Threaded Pipe Joints

Provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

2.2.14.3 Flanged Pipe Joints

Provide joints for flanged pipe consisting of full face sandwich-type flange insulating gasket of the dielectric type, insulating sleeves for flange bolts, and insulating washers for flange nuts. [Provide lap joint flange pipe ends conforming to ASTM F2015.]

2.2.15 Flexible Connectors

a. Provide flexible connectors for connecting gas utilization equipment to building gas piping conforming to ANSI Z21.24/CSA 6.10 or ANSI Z21.41/CSA 6.9 for quick disconnect devices, and flexible connectors for movable food service equipment conforming to ANSI Z21.69/CSA 6.16.[Provide combination gas controls for gas appliances conforming to ANSI Z21.78/CSA 6.20.]

b. Do not install the flexible connector through the appliance cabinet face. Provide rigid metallic pipe and fittings to extend the final connection beyond the cabinet, except when appliance is provided with an external connection point.

2.3 VALVES

Provide lockable shutoff or service isolation valves [as indicated in the drawings]conforming to the following:

2.3.1 Valves 2 Inches and Smaller

Provide valves 2 inches and smaller conforming to ASME B16.33 of materials and manufacture compatible with system materials used.[Provide manually operated household cooking gas appliance valves conforming to ANSI Z21.1/CSA 1.1 and ANSI Z21.15/CSA 9.1.]

[2.3.2 Valves 2-1/2 Inches and Larger

Provide valves 2-1/2 inches and larger of carbon steel conforming to API Spec 6D, Class 150.

][2.3.3 Valve Support on PE Piping

Provide valve support assembly in accordance with the PE piping maufacturer's requirements at valve terminations points.

]2.4 RISERS

Provide manufacturer's standard riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide [remote bolt-on or bracket][or][wall-mounted] riser supports [as indicated].

2.5 PIPE HANGERS AND SUPPORTS

Provide pipe hangers and supports conforming to MSS SP-58.

[2.6 LINE AND APPLIANCE REGULATORS AND SHUTOFF VALVES

Provide regulators conforming to [ANSI Z21.18/CSA 6.3 for appliances] [ANSI Z21.78/CSA 6.20 for combination gas controls for gas appliances] [, and ANSI Z21.80/CSA 6.22 for line pressure regulators]. Provide shutoff valves conforming to [ANSI Z21.15/CSA 9.1 for manually controlled gas shutoff valves] [and] [ANSI Z21.21/CSA 6.5 for automatic shutoff valves for gas appliances].

][2.7 NATURAL GAS SERVICE

2.7.1 Service Regulators

a. Provide ferrous bodied pressure regulators for individual service lines, capable of reducing distribution line pressure to pressures required for users. Provide service regulators conforming to AGA ANSI B109.4 CGA-6.18-M95 with full capacity internal relief [and overpressure shutoff]. Set pressure relief at a lower pressure than would cause unsafe operation of any connected user.

b. Adjust regulators for liquified petroleum gas to 2.5 to 3 kPa 10 to 12 inches of water column, with pressure relief set at 4 kPa 16 inches of water column.

c. Provide regulator(s) having a single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas flow rate at the regulator inlet pressure. Provide regulator valve vent of resilient materials designed to withstand flow conditions when pressed against the valve port, capable of regulating downstream pressure within limits of accuracy and limiting the buildup of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Provide a self-contained service regulator, and pipe not exceeding exceed 2 inch size.

2.7.2 Gas Meter

[AGA ANSI B109.1][AGA ANSI B109.2][AGA ANSI B109.3] [pipe][pedestal] mounted, [diaphragm] or [bellow][style], [cast-iron][enamel-coated steel][aluminum] case. [Provided with a strainer immediately upstream]. Provide [diaphragm-type meter conforming to AGA ANSI B109.1 for required flow rates less than 500 cfh, or AGA ANSI B109.2, for flow rates 500 cfh and above] [rotary-type displacement meter conforming to AGA ANSI B109.3] as required by local gas utility supplier. Provide combined [odometer-type] register totalizer index, UV-resistant index cover, water escape hole in housing, and means for sealing against tampering. Provide temperature-compensated type meters sized for the required volumetric flow rate and suitable for accurately measuring and handling gas at pressures, temperatures, and flow rates indicated. Provide meters with over-pressure protection as specified in 49 CFR 192 and ASME B31.8. Provide meters that are tamper-proof [with] [frost protection] [fungus protection][seismic protection]. Provide meters with a pulse switch initiator capable of operating up to speeds of 500 maximum pulses per minute with no false pulses and requiring no field adjustments. Provide not less than one pulse per 100 cubic feet of gas. Minimum service life must be 30,000,000 cycles.

2.7.2.1 Utility Monitoring and Control System (UMCS) / Energy Monitoring and Control (EMCS) or Automatic Meter Reading Interfaces

Provide gas meters capable of interfacing the output signal, equivalent to volumetric flow rate, with the existing UMCS / EMCS for data gathering in units of cubic meters cubic feet. Provide meters that do not require power to function and deliver data. Output signal must be either a voltage or amperage signal that can be converted to volumetric flow by using an appropriate scaling factor.

2.7.2.2 Measurement Configuration

For buildings that already have a gas meter with a pulse output, ensure that the pulse output is connected to a data gathering device (i.e. electric meter). For buildings where a natural gas meter already exists but does not have a pulse output, add a pulse kit to the existing meter and tie the output to a data gathering device. If the existing gas meter will not accept a pulse kit or if no meter exists a new natural gas meter must be installed, also requiring a pulse output to a data gathering device. Ensure the pulse frequency and electronic characteristics are compatible with the existing data gathering device, if any.

][2.8 SEISMIC PROVISIONS

Provide earthquake automatic gas shutoff valve conforming to ASCE 25-16, SMACNA 1981 or excess flow valve (EFV) conforming with ANSI Z21.93/CSA 6.30 and UL listed or AGA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The earthquake valve may be either pendulum or ball construction with [remote [, pneumatic] [electronic] [or] [electric]] actuator. The EFV may be either a bypass (automatic reset) or a non-bypass type (manual reset).

]2.9 AUTOMATIC GAS SHUT-OFF

[Provide low pressure automatic gas shutoff or excess flow valve (EFV) downstream of the point of delivery after the [meter/regulator] [propane tank] conforming to ANSI Z21.93/CSA 6.30 and UL listed or CSA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The EFV may be either a bypass (automatic reset) or a non-bypass type (manual reset).][Provide low pressure automatic gas shutoff or excess flow valve (EFV) at each branch to an appliance.]

2.10 LIQUIFIED PETROLEUM GAS - (LPG), LPG CONTAINERS AND ACCESSORIES

Provide NFPA 58, [DOT] [or] [ASME] compliant containers with appurtenances, system working pressure, minimum design pressure, that is LPG vapor pressure at 100 degrees F, and water capacity as indicated. Provide containers with piping and fittings,[fuse plugs,][hose and flexible hose connectors,][gas-air mixer,][strainer,] and marking conforming to NFPA 58, and[API MPMS 2.2A for upright cylindrical tanks] [API MPMS 2.2E for horizontal cylindrical tanks] Provide valves conforming to UL 125 and UL 842. Provide pipe unions conforming to UL 860.

2.11 BOLTING (BOLTS AND NUTS)

Stainless steel bolting; ASTM A193/A193M, Grade B8M or B8MA, Type 316, for bolts; and ASTM A194/A194M, Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts must conform with ASME B18.2.1 and ASME B18.2.2 with coarse threads conforming to ASME B1.1, with Class 2A fit for bolts and studs and Class 2B fit for nuts. Bolts or bolt-studs must extend through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Bolts must have American Standard regular square or heavy hexagon heads; nuts must be American Standard heavy semifinished hexagonal.

2.12 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.13 IDENTIFICATION FOR ABOVEGROUND PIPING

MIL-STD-101 for legends and type and size of characters. For pipes 3/4 inch od and larger, provide printed legends to identify contents of pipes and arrows to show direction of flow. Color code label backgrounds to signify levels of hazard. Make labels of plastic sheet with pressure-sensitive adhesive suitable for the intended application. For pipes smaller than 3/4 inch od, provide brass identification tags 1 1/2 inches in diameter with legends in depressed black-filled characters.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy or areas of conflict before performing the work.

3.2 EXCAVATION AND BACKFILLING

Provide required excavation, backfilling, and compaction as specified in Section 31 00 00 EARTHWORK.

3.3 GAS PIPING SYSTEM

Provide a gas piping system from the point of delivery, defined as the outlet of the [meter set assembly] [service regulator] [shutoff valve], [as specified under "Gas Service" within this specification,][as specified in Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES,] to the connections to each gas utilization device that is in compliance with NFPA 54[NFPA 58]..

3.3.1 Protection and Cleaning of Materials and Components

Protect equipment, pipe, and tube openings by closing with caps or plugs during installation. At the completion of all work, thoroughly clean the entire system.

3.3.2 Workmanship and Defects

Piping, tubing and fittings must be clear and free of cutting burrs and defects in structure or threading and must be thoroughly brushed and chip-and scale-blown. Repair of defects in piping, tubing or fittings is not allowed; replace defective items when found.

3.4 PROTECTIVE COVERING

3.4.1 Underground Metallic Pipe

Protect buried metallic piping and tubing from corrosion by either: (1) applying protective coatings as specified in Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES; (2) encasement in a water tight plastic conduit; or (3) encasement in a protective system designed and listed by the manufacturer for this application. When dissimilar metals are joined underground, use gastight insulating fittings.

3.4.2 Aboveground Metallic Piping Systems

3.4.2.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer. Solvent clean surfaces that have not been shop primed . Mechanically clean surfaces that contain loose rust, loose mill scale and other foreign substances [by power wire brushing] [or] [commercial sand blasted conforming to SSPC SP 6/NACE No.3] and prime with [ferrous metal primer] [or] [vinyl type wash coat]. Finish primed surfaces with two coats of exterior [oil paint] [or] [vinyl paint].

3.4.2.2 Nonferrous Surfaces

Except for aluminum alloy pipe, do not paint nonferrous surfaces. Paint surfaces of aluminum alloy pipe and fittings to protect against external corrosion where they contact masonry, plaster, insulation, or are subject to repeated wettings by such liquids as water, detergents or sewage. Solvent-clean the surfaces and treat with vinyl type wash coat. Apply a first coat of aluminum paint and a second coat of alkyd gloss enamel or silicone alkyd copolymer enamel.

3.5 INSTALLATION

Install the gas system in conformance with the manufacturer's recommendations and applicable provisions of NFPA 54NFPA 58[and]AGA XR0603, and as indicated. Perform all pipe cutting without damage to the pipe, with an approved type of mechanical cutter, unless otherwise authorized. Use wheel cutters where practicable. On steel pipe 6 inches and larger, an approved gas cutting and beveling machine may be used. Cut thermoplastic and fiberglass pipe in accordance with AGA XR0603.

3.5.1 Metallic Piping Installation

Bury underground piping a minimum of 18 inches below grade. Make changes in direction of piping with fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either tees or forged branch outlet fittings. Provide branch outlet fittings which are forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Do not use aluminum alloy pipe in exterior locations or underground.

3.5.2 Metallic Tubing Installation

Install metallic tubing using gas tubing fittings approved by the tubing manufacturer. CSST gas piping systems must be installed by contractors who have completed the manufacturer's training program as indicated on a certification card. Make branch connections with tees. Prepare all tubing ends with tools designed for that purpose. Do not use aluminum alloy tubing in exterior locations or underground. Maintain electrical continuity of gas piping system in accordance with NFPA 54 [NFPA 58], paragraph entitled 'Electrical Bonding and Grounding'.

3.5.3 Thermoplastic and Fiberglass Piping, Tubing, and Fittings

Installation of thermoplastic and fiberglass piping, tubing, and fittings is permitted only outside and underground. Bury piping a minimum of 18 inches below grade. Install the piping to avoid excessive stresses due to thermal contraction, and use only where indicated. Installations must be made using qualified procedures, by qualified installers, and in compliance with AGA XR0603 and NFPA 54 [NFPA 58], and must be inspected by a qualified inspector.

3.5.4 Connections Between Metallic and Plastic Piping

Connections between metallic and plastic piping are only allowed outside, underground, and with approved transition fittings.

3.5.5 Piping and Tubing Buried Under Buildings

Run underground piping and tubing installed beneath buildings in a steel pipe casing protected from corrosion with protective coatings as specified in Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES or installed within a water tight plastic conduit or as part of a listed encasement system. Extend casing or encasement system at least 4 inches outside the building, and provide the pipe with spacers and end bushings to seal at both ends to prevent the entrance of water and/or the escape of gas. Extend a vent line from the annular space above grade outside to a point where gas will not be a hazard, and terminate in a rain/insect-resistant fitting.

3.5.6 Concealed Piping in Buildings

Do not use combinations of fittings (unions, tubing fittings, running threads, right- and left-hand couplings, bushings, and swing joints) to conceal piping within buildings.

3.5.6.1 Piping and Tubing in Partitions

Locate concealed piping and tubing in hollow, rather than solid, partitions. Protect tubing passing through walls or partitions against physical damage both during and after construction, and provide appropriate safety markings and labels. Provide protection of concealed pipe and tubing in accordance with ANSI LC 1/CSA 6.26.

3.5.6.2 Piping in Floors

Lay piping in solid floors [except where embedment in concrete is indicated] in channels suitably covered to permit access to the piping with minimum damage to the building. [Surround piping embedded in concrete by a minimum of 1-1/2 inches of concrete and do not allow physical contact with other metallic items such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quickset additives or cinder aggregate.]

3.5.7 Aboveground Piping

Run aboveground piping as straight as practicable along the alignment and elevation indicated, with a minimum of joints, and separately supported from other piping system and equipment. Install exposed horizontal piping no farther than 6 inches from nearest parallel wall and at an elevation which prevents standing, sitting, or placement of objects on the piping.

3.5.8 Final Gas Connections

Unless otherwise specified, make final connections with rigid metallic pipe and fittings. [Make final connections to kitchen ranges using flexible connectors not less than 40 inch long[, to afford access to coupling] [and][to permit movement of equipment for cleaning].][Flexible connectors may be used for final connections to residential dryers.] [Flexible connectors may be used for final connections to gas utilization equipment.] [In addition to cautions listed in instructions required by ANSI standards for flexible connectors, insure that flexible connectors do not pass through equipment cabinet.] Provide accessible gas shutoff valve and coupling for each gas equipment item.

3.5.9 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads in conformance with ASCE 25-16[and][as specified in UFC 3-301-01, and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC][as indicated]. CSST tubing and fittings that are seismically qualified in accordance with the FM APP GUIDE: Flexible Piping Systems for Flammable Gases must meet the seismic requirements in accordance with the manufacturer's installation instructions.

3.6 PIPE JOINTS

Design and install pipe joints to effectively sustain the longitudinal pull-out forces caused by contraction of the piping or superimposed loads.

3.6.1 Threaded Metallic Joints

Provide threaded joints in metallic pipe with tapered threads evenly cut and made with UL approved graphite joint sealing compound for gas service or tetrafluoroethylene tape applied to the male threads only. Threaded joints up to 1-1/2 inches in diameter may be made with approved tetrafluoroethylene tape. Threaded joints up to 2 inches in diameter may be made with approved joint sealing compound. After cutting and before threading, ream pipe and remove all burrs. Caulking of threaded joints to stop or prevent leaks is not permitted.

3.6.2 Welded Metallic Joints

Conform beveling, alignment, heat treatment, and inspection of welds to NFPA 54. Remove weld defects and make repairs to the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect and store so that its characteristics or welding properties are not affected adversely. Do not use electrodes that have been wetted or have lost any of their coating.

3.6.3 Thermoplastic and Fiberglass Joints

3.6.3.1 Thermoplastic and Fiberglass

Conform jointing procedures to AGA XR0603. Do not make joints with solvent cement or heat of fusion between different kinds of plastics.

3.6.3.2 PE Fusion Welding Inspection

Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect, in conformance with API 570, 100 percent of all joints and re-inspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

3.6.4 Flared Metallic Tubing Joints

Make flared joints in metallic tubing with special tools recommended by the tubing manufacturer. Use flared joints only in systems constructed from nonferrous pipe and tubing, when experience or tests have demonstrated that the joint is suitable for the conditions, and when adequate provisions are made in the design to prevent separation of the joints. Do not use metallic ball sleeve compression-type tubing fittings for tubing joints.

3.6.5 Solder or Brazed Joints

Make all joints in metallic tubing and fittings with materials and procedures recommended by the tubing supplier. Braze joints with material having a melting point above 1000 degrees F, containing no phosphorous.

3.6.6 Joining Thermoplastic or Fiberglass to Metallic Piping or Tubing

When compression type mechanical joints are used, provide gasket material in the fittings compatible with the plastic piping and with the gas in the system. Use an internal tubular rigid stiffener in conjunction with the fitting, flush with end of the pipe or tubing, extending at least to the outside end of the compression fitting when installed. Remove all rough or sharp edges from stiffener. Do not force fit stiffener in the plastic. Split tubular stiffeners are not allowed.

3.6.7 Press Connections

Make press connections in accordance with manufacturer's installation instructions using tools approved by the manufacturer. Fully insert the tubing into the fitting and then mark at the shoulder of the fitting. Check the fitting alignment against the mark on the tubing to assure the tubing is fully inserted before the joint is pressed.

3.7 PIPE SLEEVES

Provide pipes passing through concrete or masonry walls or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Do not install sleeves in structural members except where indicated or approved. Make all rectangular and square openings as detailed. Extend each sleeve through its respective wall, floor or roof, and cut flush with each surface, except in mechanical room floors not located on grade where clamping flanges or riser pipe clamps are used. Extend sleeves in mechanical room floors above grade at least 4 inches above finish floor. Unless otherwise indicated, use sleeves large enough to provide a minimum clearance of 1/4 inch all around the pipe. Provide steel pipe for sleeves in bearing walls, waterproofing membrane floors, and wet areas . Provide sleeves in nonbearing walls, floors, or ceilings of steel pipe, galvanized sheet metal with lock-type longitudinal seam, or moisture-resistant fiber or plastic. For penetrations of fire walls, fire partitions and floors which are not on grade, seal the annular space between the pipe and sleeve with fire-stopping material and sealant that meet the requirement of Section 07 84 00 FIRESTOPPINGG.

3.8 PIPES PENETRATING WATERPROOFING MEMBRANES

Install pipes penetrating waterproofing membranes as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.9 FIRE SEAL

Fire seal all penetrations of fire rated partitions, walls and floors in accordance with Section 07 84 00 FIRESTOPPING.

3.10 ESCUTCHEONS

Provide escutcheons for all finished surfaces where gas piping passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms.

3.11 SPECIAL REQUIREMENTS

Provide drips, grading of the lines, freeze protection, and branch outlet locations as shown and conforming to the requirements of NFPA 54NFPA 58.

3.12 BUILDING STRUCTURE

Do not weaken any building structure by the installation of any gas piping. Do not cut or notch beams, joists or columns. Attach piping supports to metal decking. Do not attach supports to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.13 PIPING SYSTEM SUPPORTS

Support gas piping systems in buildings with pipe hooks, metal pipe straps, bands or hangers suitable for the size of piping or tubing. Do not support any gas piping system by other piping. Conform spacing of supports in gas piping and tubing installations to the requirements of NFPA 54NFPA 58. Conform the selection and application of supports in gas piping and tubing installations to the requirements of MSS SP-58. In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members is not to exceed the hanger and support spacing required for any of the individual pipes in the multiple pipe run. Rigidly connect the clips or clamps to the common base member. Provide a clearance of 1/8 inch between the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

3.14 ELECTRICAL BONDING AND GROUNDING

Provide a gas piping system within the building that is electrically continuous and bonded to a grounding electrode as required by NFPA 54, NFPA 58, and NFPA 70.

3.15 SHUTOFF VALVE

Install the main gas shutoff valve controlling the gas piping system to be easily accessible for operation, as indicated, protected from physical damage, and marked with a metal tag to clearly identify the piping system controlled. Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally.[Provide PE piping manufacturer bracket support assembly securely fastened to structure for valve connections to resist operating torque applied to PE pipes.] Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

3.16 LINE AND APPLIANCE PRESSURE REGULATORS

Install line pressure regulators and appliance regulators in accordance with the manufacturer's requirements and in accordance with NFPA 54[NFPA 58]. Install each regulator in an accessible location and install shutoff valves ahead of each line and appliance regulator to allow for maintenance. Where vent limiting devices are not included in the regulators, install a vent pipe to the exterior of the building. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

3.17 GAS SERVICE INSTALLATION

[Gas service line, service regulator and gas company meter must be installed in accordance with Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES.] Installations must be in accordance with 49 CFR 192 and ASME B31.8. Contractor must submit and use only tested and approved work procedures. Contractor must use only welders and jointers who have been recently qualified by training and test for joining and installing the gas pipe material used on this job. The finished product must be inspected by a person qualified to inspect joints made by the particular procedures used to make joints.

[3.17.1 Service Line

Install service line, branch connection to the main, and riser in accordance with 49 CFR 192 and ASME B31.8. Provide a minimum of 18 inches cover or encase the service line so that it is protected. Install service line so that no undue stress is applied to the pipe, connection, or riser. Install approved riser and terminate with an approved isolation valve, EFV and automatic shutoff device. After laying of pipe and testing, backfill the trench in accordance with Section 31 00 00 EARTHWORK.

Were steel pipe is used as service line, install corrosion prevention coating and cathodic protect for the steel service line. Where connected to an existing cathodically protected steel pipe, ensure electrical continuity from the riser to the branch connection to the main. Install a dielectric fitting on the riser to prevent electrical continuity to the above ground piping.

Where plastic pipe is used as the service line, make joints in accordance with procedures qualified by test. Personnel joining plastic pipe must be qualified by making a satisfactory specimen joint that passes the required inspection and test listed in 49 CFR 192.285. Inspection must be made by inspectors qualified in evaluating joints made under the specific joining procedure, as required by 49 CFR 192.287.

3.17.2 Service Regulator

Install service regulator in accordance with 49 CFR 192 and ASME B31.8 and this specification ensuring that the customer's piping is protected from over pressurization should the service regulator fail. A 3/8 inch tapped fitting equipped with a plug must be provided on both sides of the service regulator for installation of pressure gauges for adjusting the regulator. For inside installations, route the regulator vent pipe through the exterior wall to the atmosphere, and seal building penetrations for service line and vent. Terminate the regulator vent so that it is protected from precipitation and insect intrusion, so that it is not submerged during floods, and so that gas escaping will not create a hazard or enter the building through openings.

3.17.3 Gas Meter

Install shutoff valve, meter set assembly, and service regulator on the service line [outside the building] [inside the building, a minimum of 3 feet from any potential ignition source], 18 inches above the [ground] [finished floor] on the riser. An insulating joint (dielectric connection) must be installed on the inlet side of the meter set assembly and service regulator and must be constructed to prevent flow of electrical current.

][3.18 CATHODIC PROTECTION

Provide cathodic protection for underground ferrous gas piping as specified in [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM] [and] [Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM].

]3.19 TESTING

Submit test procedures and reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Test entire gas piping system to ensure that it is gastight prior to putting into service. Prior to testing, purge the system, clean, and clear all foreign material. Test each joint with an approved gas detector, soap and water, or an equivalent nonflammable solution. Inspect and test each valve in conformance with API Std 598 and API Std 607. Complete testing before any work is covered, enclosed, or concealed, and perform with due regard for the safety of employees and the public during the test. Install bulkheads, anchorage and bracing suitably designed to resist test pressures if necessary, and as directed and or approved by the Contracting Officer. Do not use oxygen as a testing medium.

3.19.1 Pressure Tests

Submit test procedures and reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Before appliances are connected, test by filling the piping systems with air or an inert gas to withstand a minimum pressure of 3 pounds gauge for a period of not less than 10 minutes as specified in NFPA 54as specified in NFPA 58 without showing any drop in pressure. Do not use Oxygen for test. Measure pressure with a mercury manometer, slope gauge, or an equivalent device calibrated to be read in increments of not greater than 0.1 pound. Isolate the source of pressure before the pressure tests are made.

3.19.2 Pressure Tests for Liquified Petroleum Gas

Pressure test system as described above. When appliances are connected to the piping system, use fuel gas for testing appliances to withstand a pressure of not less than 10.0 inches nor more than 14.0 inches water column (0.36 nor more than 0.51 pounds per square inch) for a period of not less than 10 minutes without showing any drop in pressure. Measure pressure with a water manometer or an equivalent device calibrated to be read in increments of not greater than 0.1 inch water column. Isolate the source of pressure before the pressure tests are made.

3.19.3 Test With Gas

Before turning on gas under pressure into any piping, close all openings from which gas can escape. Immediately after turning on the gas, check the piping system for leakage by using a laboratory-certified gas meter, an appliance orifice, a manometer, or equivalent device. Conform all testing to the requirements of NFPA 54NFPA 58. If leakage is recorded, shut off the gas supply, repair the leak , and repeat the tests until all leaks have been stopped.

3.19.4 Purging

After testing is completed, and before connecting any appliances, fully purge all gas piping. LPG piping tested using fuel gas with appliances connected does not require purging. Conform testing procedures to API RP 1110. Do not purge piping into the combustion chamber of an appliance. Do not purge the open end of piping systems into confined spaces or areas where there are ignition sources unless the safety precautions recommended in NFPA 54NFPA 58 are followed.

3.19.5 Labor, Materials and Equipment

Furnish all labor, materials and equipment necessary for conducting the testing and purging.

3.20 PIPE COLOR CODE MARKING

Provide color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS, conforming to ASME A13.1.

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SECTION 23 23 00

REFRIGERANT PIPING
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 710 I-P	(2009) Performance Rating of Liquid-Line Driers
AHRI 720	(2002) Refrigerant Access Valves and Hose Connectors
AHRI 750 I-P	(2016) Performance Rating of Thermostatic Refrigerant Expansion Valves
AHRI 760 I-P	(2014) Performance Rating of Solenoid Valves for Use with Volatile Refrigerants
AHRI 1370 I-P	(2017) Performance Rating of Electronic Expansion Valves

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15 & 34	(2013) ASHRAE Standard 34-2016 Safety Standard for Refrigeration Systems/ASHRAE Standard 34-2016 Designation and Safety Classification of Refrigerants-ASHRAE Standard 34-2016
ASHRAE 17	(2015) Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves
ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-6 2021; Addenda AS-BF 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B31.1	(2020) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B31.9	(2020) Building Services Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS A5.31/A5.31M	(2012) Specification for Fluxes for Brazing and Braze Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications

ASTM A334/A334M	(2004a; R 2021) Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Refrigerant Piping System; G[, [_____]]

SD-03 Product Data

Refrigerant Piping System

Spare Parts

Qualifications

Refrigerant Piping Tests

Verification of Dimensions

SD-06 Test Reports

Refrigerant Piping Tests

SD-07 Certificates

Service Organization

SD-10 Operation and Maintenance Data

Maintenance; G[, [_____]]

Operation and Maintenance Manuals; G[, [_____]]

Demonstrations; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

Submit [_____] copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations.[Weld piping in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders must be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests to be performed at the work site, if practical. The welder or welding operator must apply the personally assigned symbol near each weld made, as a permanent record. Weld structural members in accordance with Section [05 05 23.16 STRUCTURAL WELDING][05 12 00 STRUCTURAL STEEL].][Welding and nondestructive testing procedures are specified in Section [40 05 13.96 WELDING PROCESS PIPING][40 17 26.00 20 WELDING PROCESS PIPING].]

1.3.2 Contract Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation is the Contractor's responsibility. Replace any materials found to be damaged at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

1.5 MAINTENANCE

1.5.1 General

Submit Data Package 2 plus operation and maintenance data complying with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

1.5.2 Extra Materials

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than [_____] months prior to the date of beneficial occupancy. Include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis in the data.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

b. The 2 year use must include applications of equipment and materials under similar circumstances and of similar size. The 2 years' experience must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown.

c. Products must be supported by a service organization. System components must be environmentally suitable for the indicated locations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations must be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

d. Exposed equipment moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

e. Provide the manufacturer's standard catalog data, at least [5 weeks] [_____] prior to the purchase or installation of a particular component. Highlight the data to show information such as, but not limited to, material, size, options, performance charts, and curves in adequate detail to demonstrate compliance with contract requirements. Include the manufacturer's recommended installation instructions and procedures in the data provided. Provide data for the following components as a minimum:

   (1) Piping and Fittings
   (2) Valves
   (3) Piping Accessories
   (4) Pipe Hangers, Inserts, and Supports

2.2 ELECTRICAL WORK

[Electrical equipment and wiring must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Field wiring must be in accordance with manufacturer's instructions.] [Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, must be provided.]

2.3 REFRIGERANT PIPING SYSTEM

Provide refrigerant piping, valves, fittings, and accessories in accordance with ASHRAE 15 & 34 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories must be compatible with the fluids used and capable of withstanding the pressures and temperatures of the service. Refrigerant piping, valves, and accessories used for refrigerant service must be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant. Submit drawings, at least [5] [_____] weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings must consist of:

a. Piping layouts which identify all valves and fittings.

b. Plans and elevations which identify clearances required for maintenance and operation.

2.4 PIPE, FITTINGS AND END CONNECTIONS (JOINTS)

2.4.1 Steel Pipe

Steel pipe for refrigerant service must conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B. Do not use Type F pipe.

2.4.1.1 Welded Fittings and Connections

Butt-welded fittings must conform to ASME B16.9. Socket-welded fittings must conform to ASME B16.11. Identify welded fittings with the appropriate grade and marking symbol. Welded valves and pipe connections (both butt-welds and socket-welds types) must conform to ASME B31.9.

2.4.1.2 Threaded Fittings and Connections

Threaded fitting must conform to ASME B16.3. Threaded valves and pipe connections must conform to ASME B1.20.1.

2.4.1.3 Flanged Fittings and Connections

Flanges must conform to ASME B16.5, Class 150. Gaskets must be non-asbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type. Gaskets must contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Bolts, nuts, and bolt patterns must conform to ASME B16.5. Bolts must be high or intermediate strength material conforming to ASTM A193/A193M.

2.4.2 Steel Tubing

Tubing must be cold-rolled, electric-forged, welded-steel in accordance with ASTM A334/A334M, Grade 1. Joints and fittings must be socket type provided by the steel tubing manufacturer.

2.4.3 Copper Tubing

Provide copper tubing conforming to ASTM B280 annealed or hard drawn as required. Copper tubing must bear the product identification markings in accordance with ASTM B280, "ACR" must be present on copper tubing. Copper tubing must be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing must not be used in sizes larger than 1-3/8 inches. Joints must be brazed except that joints on lines 7/8 inchand smaller may be flared. Cast copper alloy fittings for flared copper tube must conform to ASME B16.26 and ASTM B62. Wrought copper and bronze solder-joint pressure fittings must conform to ASME B16.22 and ASTM B75/B75M. Joints and fittings for brazed joint must be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings are not allowed for brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

2.4.4 Solder

Solder must conform to ASTM B32, grade Sb5, tin-antimony alloy for service pressures up to 150 psig. Solder flux must be liquid or paste form, non-corrosive and conform to ASTM B813.

2.4.5 Brazing Filler Metal

Filler metal must conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type FB3-A or Type FB3-C flux, except Type BCuP-3, BCuP-4, or BCuP-5 may be used for brazing copper-to-copper joints. BAlSi-4 with AWS Type FB1-A flux may be used when joining copper piping to aluminum components.

2.4.6 Brazing Flux

Brazing flux must conform to AWS A5.31/A5.31M, Type FB3-A or Type FB3-C when using Type BAg-5 filler metal. Type FB1-A is to be used with Type BAlSi-4 filler metal.

2.4.7 Press Fittings

Press fittings are not acceptable for use in refrigerant piping systems.

2.5 VALVES

Valves must be designed, manufactured, and tested specifically for refrigerant service. The valve material and all internal components must be compatible with the specific refrigerant and lubricant used. Valve bodies must be of brass, bronze, steel, or ductile iron construction. Valves 1 inch and smaller must have brazed or socket welded connections. Valves larger than 1 inch must have [tongue-and-groove flanged] [butt welded] end connections. Do not use threaded end connections, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts must be removable for inspection or replacement without applying heat or breaking pipe connections. Valve stems exposed to the atmosphere must be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow must be legibly and permanently indicated on the valve body. Control valve inlets must be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Purge, charge and receiver valves must be of manufacturer's standard configuration.

2.5.1 Refrigerant Stop Valves

Valve must be the globe or full-port ball type with a back-seating stem especially packed for refrigerant service. Valve packing must be replaceable under line pressure. Provide valve with a [handwheel] [or] [wrench] operator and a seal cap. Valve must be the straight or angle pattern design as indicated.

2.5.2 Check Valves

Valve must be the swing or lift type as required to provide positive shutoff at the differential pressure indicated. Valve must be provided with resilient seat.

2.5.3 Liquid Solenoid Valves

Provide valves that comply with AHRI 760 I-P and are suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves must be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions must be furnished. Provide solenoid coils that are moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves must have safe working pressure of 610 psi and a maximum operating pressure differential of at least 200 psi at 85 percent rated voltage. Valves must have an operating pressure differential suitable for the refrigerant used.

2.5.4 Expansion Valves

Provide valve conforming to AHRI 750 I-P and ASHRAE 17. Valve must be the diaphragm and spring-loaded type with internal or external equalizers, and bulb and capillary tubing. Provide valve with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 2 degrees F of saturated suction temperature at evaporator conditions. Bulb charge must be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Do not use gas limited liquid charged valves and other valve devices for limiting evaporator pressure without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves must have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. Provide an isolatable pressure gauge in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicted or for constant evaporator loads.

2.5.5 Electronic Expansion Valves

Valve must conform to AHRI 1370 I-P and ASHRAE 17. The valve must prevent the return of liquid to the compressor in the event of power loss or low superheat.

2.5.6 Safety Relief Valves

Valve must be the two-way type, unless indicated otherwise. Valve must bear the ASME code symbol. Valve capacity must be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve must be of an automatically reseating design after activation.

2.5.7 Evaporator Pressure Regulators, Direct-Acting

Valve must include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve must maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load must not exceed the pressure difference corresponding to a 2 degrees F change in saturated refrigerant temperature at evaporator operating suction temperature. Spring must be selected for indicated maximum allowable suction pressure range.

2.5.8 Refrigerant Access Valves

Provide refrigerant access valves and hose connections in accordance with AHRI 720.

2.6 PIPING ACCESSORIES

2.6.1 Filter Driers

Driers must conform to AHRI 710 I-P. Sizes 5/8 inch and larger must be the full flow, replaceable core type. Sizes 1/2 inch and smaller must be the sealed type. Cores must be of suitable desiccant that will not plug, cake, dust, channel, or break down, and must remove water, acid, and foreign material from the refrigerant. Constructfilter driers so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure must be 1,500 psi.

2.6.2 Sight Glass and Liquid Level Indicator

2.6.2.1 Assembly and Components

Assembly must be pressure- and temperature-rated and constructed of materials suitable for the service. Glass must be borosilicate type. Ferrous components subject to condensation must be electro-galvanized.

2.6.2.2 Gauge Glass

Gauge glass must include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

2.6.2.3 Bull's-Eye and Inline Sight Glass Reflex Lens

Provide bull's-eye and inline sight glass reflex lens for dead-end liquid service. For pipe line mounting, provide two plain lenses in one body suitable for backlighted viewing.

2.6.2.4 Moisture Indicator

Indicator must be a self-reversible action, moisture reactive, color changing media. Indicator must be furnished with full-color-printing tag containing color, moisture, and temperature criteria. Unless otherwise indicated, the moisture indicator must be an integral part of each corresponding sight glass.

2.6.3 Vibration Dampeners

Dampeners must be of the all-metallic bellows and woven-wire type.

2.6.4 Flexible Pipe Connectors

Connector must be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly must be constructed with a safety factor of not less than 4 at300 degrees F. Unless otherwise indicated, the length of a flexible connector must be as recommended by the manufacturer for the service intended.

2.6.5 Strainers

Strainers used in refrigerant service must have brass or cast-iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens must be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.6.6 Pressure and Vacuum Gauges

Provide gauges conforming to ASME B40.100 with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge must be a minimum of 3-1/2 inches in diameter with a range from 0 psig to approximately 1.5 times the maximum system working pressure. Select each gauge range so that at normal operating pressure, the needle is within the middle-third of the range.

2.6.7 Temperature Gauges

Provide industrial duty type temperature gauges for the required temperature range. Gauges must have Fahrenheit scale in 2 degrees graduations scale (black numbers) on a white face. The pointer must be adjustable. Provide rigid stem type temperature gauges in thermowells located within 5 feet of the finished floor. Provide universal adjustable angle type or remote element type temperature gauges in thermowells located 5 to 7 feet above the finished floor. Provide remote element type temperature gauges in thermowells located 7 feet above the finished floor.

2.6.7.1 Stem Cased-Glass

Provide stem cased-glass case composed of polished stainless steel or cast aluminum, 9 inches long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.6.7.2 Bimetallic Dial

Provide bimetallic dial type case that is greater than 3-1/2 inches, stainless steel, and hermetically sealed with clear acrylic lens. Bimetallic element must be silicone dampened and unit fitted with external calibrator adjustment. Accuracy must be one percent of dial range.

2.6.7.3 Liquid-, Solid-, and Vapor-Filled Dial

Provide liquid-, solid-, and vapor-filled dial type cases that are greater than 3-1/2 inches, stainless steel or cast aluminum with clear acrylic lens. Fill must be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing must be double-braided bronze.

2.6.7.4 Thermowell

Thermowell must be identical size, 1/2 or 3/4 inch NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 1/2 inch NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury must not be used in thermometers. Extended neck thermowells must be of sufficient length to clear insulation thickness by 1 inch.

2.6.8 Pipe Hangers, Inserts, and Supports

Provide pipe hangers, inserts, guides, and supports conforming to MSS SP-58.

2.6.9 Escutcheons

Escutcheons must be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand [125] [500] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.7.2 Factory Applied Insulation

Factory installed insulation must be in accordance with ASHRAE 90.1 - IP. [Refrigerant suction lines between the cooler and each compressor [and cold gas inlet connections to gas cooled motors]] [Refrigerant pumps and exposed chilled water lines on absorption chillers] must be insulated with not less than 1/2 inch thick unicellular plastic foam. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by ASTM E84. Test insulation in the same density and installed thickness as the material to be used in the actual construction. Test material supplied by a manufacturer with a jacket as a composite material. Provide jackets, facings, and adhesives that have a flame spread index less than 25 and a smoke developed index less than 50 when tested in accordance with ASTM E84.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform a verification of dimensions in the field. Submit a letter, at least [2] [_____] weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found before performing any work.

3.2 INSTALLATION

Pipe and fitting installation must conform to the requirements of ASME B31.1. Cut pipe accurately to measurements established at the jobsite, and work into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation is not permitted without written approval. Cut pipe or tubing square, remove by reaming, and permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.2.1 Directional Changes

Make changes in direction with fittings, except that bending of pipe 4 inches and smaller is permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees is not permitted. The centerline radius of bends must not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.2.2 Functional Requirements

Install piping 1/2 inch/10 feet of pipe in the direction of flow to ensure adequate oil drainage. Properly cap or plug open ends of refrigerant lines or equipment during installation to keep moisture, dirt, or other foreign material out of the system. Piping must remain capped until installation. Equipment piping must be in accordance with the equipment manufacturer's recommendations and the contract drawings. Equipment and piping arrangements must fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

3.2.3 Fittings and End Connections

3.2.3.1 Threaded Connections

Make threaded connections with tapered threads and make tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Do not show more than three threads after the joint is made.

3.2.3.2 Brazed Connections

Perform brazing in accordance with AWS BRH, except as modified herein. During brazing, fill the pipe and fittings with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, clean both the outside of the tube and the inside of the fitting with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux on copper-to-copper connections. Remove surplus brazing material at all joints. Make steel tubing joints in accordance with the manufacturer's recommendations. Paint joints in steel tubing with the same material as the baked-on coating within 8 hours after joints are made. Protect tubing against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Support piping prior to brazing and do not spring or force.

3.2.3.3 Welded Connections

Fusion-weld joints in steel refrigerant piping. Make branch connections with welding tees or forged welding branch outlets. Thoroughly clean pipe of all scale and foreign matter before the piping is assembled. During welding, fill the pipe and fittings with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld must conform to ASME B31.1. Remove and reweld weld defects at no additional cost to the Government. Store and dry electrodes in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Do not use electrodes that have been wetted or that have lost any of their coating

3.2.3.4 Flared Connections

When flared connections are used, use a suitable lubricant between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.2.3.5 Flanged Connections

When steel refrigerant piping is used, provide union or flange joints in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, chillers, control valves, and other similar items. Flanged joints must be assembled square end tight with matched flanges, gaskets, and bolts. Provide gaskets that are suitable for use with the refrigerants to be handled.

3.2.4 Valves

3.2.4.1 General

Install refrigerant stop valves on each side of each piece of equipment such as compressors condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Install stop valves with stems horizontal unless otherwise indicated. Install ball valves must be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches must be external to thermal insulation. Safety switches must not be fitted with isolation valves. Filter dryers having access ports may be considered a point of isolation. Purge valves must be provided at all points of systems where accumulated non-condensable gases would prevent proper system operation. Valves must be furnished to match line size, unless otherwise indicated or approved.

3.2.4.2 Expansion Valves

Install expansion valves with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 2-1/8 inches in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 2-1/8 inches. Fasten the bulb securely with two clamps. Insulate ehe bulb . Install the bulb in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing must be facing up.

3.2.4.3 Valve Identification

Tag each system valve, including those which are part of a factory assembly. Tags must be in alphanumeric sequence, progressing in direction of fluid flow. Tags must be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 1-3/8 inch diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Attach tags with nonferrous, heavy duty, bead or link chain, 14 gauge annealed wire, nylon cable bands or as approved. Reference tag numbers in Operation and Maintenance Manuals and system diagrams.

3.2.5 Vibration Dampers

Provide vibration damper in the suction and discharge lines on spring mounted compressors. Install vibration dampers parallel with the shaft of the compressor and anchor firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.2.6 Strainers

Provide strainers immediately ahead of solenoid valves and expansion devices. Strainers may be an integral part of an expansion valve.

3.2.7 Filter Dryer

Provide a liquid line filter dryer on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. Size dryers in accordance with the manufacturer's recommendations for the system in which it is installed. Install dryers such that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Install dryers in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.2.8 Sight Glass

Install a moisture indicating sight glass in all refrigerant circuits down stream of all filter dryers and where indicated. Provide full line size sight glasses.

3.2.9 Discharge Line Oil Separator

Provide discharge line oil separator in the discharge line from each compressor. Connect the oil return line to the compressor as recommended by the compressor manufacturer.

3.2.10 Accumulator

Provide accumulators in the suction line to each compressor.

3.2.11 Flexible Pipe Connectors

Install connectors perpendicular to line of motion being isolated. Fit piping for equipment with bidirectional motion with two flexible connectors, in perpendicular planes. Install reinforced elastomer flexible connectors in accordance with manufacturer's instructions. Provide piping guides and restraints related to flexible connectors as required.

3.2.12 Temperature Gauges

Locate temperature gauges specifically on, but not limited to the following: [the sensing element of each automatic temperature control device where a thermometer is not an integral part thereof] [the liquid line leaving a receiver] [and] [the suction line at each evaporator or liquid cooler]. Thermowells for insertion thermometers and thermostats must extend beyond thermal insulation surface not less than 1 inch.

3.2.13 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports must conform to MSS SP-58, except as modified herein. Do not use pipe hanger types 5, 12, and 26. Fabricate hangers used to support piping 2 inches and larger to permit adequate adjustment after erection while still supporting the load. Support piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, by variable spring hangers and supports or by constant support hangers.

3.2.13.1 Hangers

Do not use Type 3 on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.2.13.2 Inserts

Secure Type 18 inserts to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.2.13.3 C-Clamps

Torque Type 19 and 23 C-clamps in accordance with MSS SP-58 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.2.13.4 Angle Attachments

Furnish Type 20 attachments used on angles and channels with an added malleable-iron heel plate or adapter.

3.2.13.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, must be used on all pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Use Type 40 shields on all piping less than 4 inches and all piping 4 inches and larger carrying medium less than 60 degrees F. Use a high-density insulation insert of cellular glass under the Type 40 shield for piping 2 inches and larger.

3.2.13.6 Horizontal Pipe Supports

Space horizontal pipe supports as specified in MSS SP-58 and install a support no more than 1 foot from the pipe fitting joint at each change in direction of the piping. Space pipe supports no more than 5 feet apart at valves. [Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 50 pounds must have the excess hanger loads suspended from panel points.]

3.2.13.7 Vertical Pipe Supports

Support vertical pipe at each floor, except at slab-on-grade, and at intervals of not more than 15 feet not more than 8 feet from end of risers, and at vent terminations.

3.2.13.8 Pipe Guides

Provide Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides where required to allow longitudinal pipe movement. Provide lateral restraints as required. Provide slide materials that are suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.2.13.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger, usea Type 39 saddle. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.2.13.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide must include a pipe cradle, welded to the guide structure and strapped securely to the pipe. Separate the pipe from the slide material by at least 4 inches, or by an amount adequate for the insulation, whichever is greater.

3.2.13.11 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members must not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.2.13.12 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads as specified under UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and [23 05 48.19 [SEISMIC] BRACING FOR HVAC] [22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL] [as shown on the drawings]. Provide structural steel required for reinforcement to properly support piping, headers, and equipment but not shown under this section. Specify material used for support under Section 05 12 00 STRUCTURAL STEEL.

3.2.13.13 Structural Attachments

Attachment to building structure concrete and masonry must be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors must be applied with a safety factor not less than 5. Do not attach supports to metal decking. Construct masonry anchors for overhead applications of ferrous materials only. Provide structural steel brackets required to support piping, headers, and equipment, but not shown, under this section. Specify material used for support under Section 05 12 00 STRUCTURAL STEEL.

3.2.14 Pipe Alignment Guides

Provide pipe alignment guides where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 5 feet on each side of each expansion joint, and in lines 4 inches or smaller not more than 2 feet on each side of the joint.

3.2.15 Pipe Anchors

Provide anchors wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Provide anchors consisting of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Install anchor braces in the most effective manner to secure the desired results using turnbuckles where required. Do not attach supports, anchors, or stays where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, immediately anchor these items adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Submit detailed drawings of pipe anchors for approval before installation.

3.2.16 Building Surface Penetrations

Do not install sleeves in structural members except where indicated or approved. Provide galvanized sheet metal sleeves in non-load bearing surfaces conforming to ASTM A653/A653M, Coating Class G-90, 20 gauge. Provide uncoated carbon steel pipe sleeves in load bearing surfaces conforming to ASTM A53/A53M, [Schedule 30] [Schedule 20] [Standard weight]. Apply sealants to moisture and oil-free surfaces and elastomers to not less than 1/2 inch depth. Do not install sleeves in structural members.

3.2.16.1 Refrigerated Space

Fit refrigerated space building surface penetrations with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Construct sleeves with integral collar or fit cold side with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, fill voids with latex mixed mortar cast to shape of sleeve and assemble flange/external collar type sleeve with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Flash integral cast-in collar type sleeve [as indicated.] [with not less than 4 inches of cold side vapor barrier overlap of sleeve surface.] Normally seal noninsulated penetrating round surfaces to sleeve bore with mechanically expandable seals in vapor tight manner and insulate remaining warm and cold side sleeve depth with not less than [4] [_____] inches of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Apply vapor barrier sealant to finish warm side insulation surface. Insulate warm side of penetrating surface beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Seal wires in refrigerated space surface penetrating conduit with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.2.16.2 General Service Areas

Extend each sleeve through its respective wall, floor, or roof, and cut flush with each surface. Provide pipes passing through concrete or masonry wall or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Provide sleeves that allow a minimum of 1/4 inch all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, seal the annular space between pipe and sleeve or between jacket over-insulation and sleeve in accordance with Section 07 92 00 JOINT SEALANTS.

3.2.16.3 Waterproof Penetrations

Install pipes passing through roof or floor waterproofing membrane through a 17 ounce copper sleeve, or a 0.032 inch thick aluminum sleeve, each within an integral skirt or flange. Form flashing sleeve, and extend skirt or flange greater than 8 inches from the pipe and set over the roof or floor membrane in a troweled coating of bituminous cement. Extend the flashing sleeve up the pipe a minimum of 2 inches above the roof or floor penetration. Seal the annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation as indicated. Seal penetrations by either one of the following methods.

3.2.16.3.1 Waterproofing Clamping Flange

Pipes up to and including 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Clamp waterproofing membrane into place and place sealant in the caulking recess.

3.2.16.3.2 Modular Mechanical Type Sealing Assembly

In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Provide seals consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Loosely assemble links with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tighten the bolt to cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Size each seal assembly as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals must provide sleeves of the proper diameters.

3.2.16.4 Fire-Rated Penetrations

Seal penetration of fire-rated walls, partitions, and floors as specified in Section 07 84 00 FIRESTOPPING.

3.2.16.5 Escutcheons

Provide escutcheons for finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Where sleeves project slightly from floors, use special deep-type escutcheons. Secure escutcheon to pipe or pipe covering.

3.2.17 Access Panels

Provide access panels for all concealed valves, vents, controls, and items requiring inspection or maintenance. Provide access panels of sufficient size and locate so that the concealed items may be serviced and maintained or completely removed and replaced. Provide access panels as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.2.18 Field Applied Insulation

Field installed insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.19 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.19.1 Color Coding

Color coding for piping identification is specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.19.2 Color Coding Scheme

Provide a color coding scheme for locating hidden piping in accordance with

[Section 22 00 00 PLUMBING, GENERAL PURPOSE][Section 22 00 70 PLUMBING, HEALTHCARE FACILITIES].

3.2.20 Identification Tags

Provide identification tags made of brass, engraved laminated plastic or engraved anodized aluminum indicating service and item number on all valves and dampers. Tags must be 1-3/8 inch minimum diameter and marking must be stamped or engraved. Indentations must be black for reading clarity. Attach tags to valves with No. 12 AWG copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.3 CLEANING AND ADJUSTING

Clean uncontaminated system(s) by evacuation and purging procedures currently recommended by refrigerant and refrigerant equipment manufacturers, and as specified herein, to remove small amounts of air and moisture. Systems containing moderate amounts of air, moisture, contaminated refrigerant, or any foreign matter are considered contaminated systems. Restore contaminated systems to clean condition including disassembly, component replacement, evacuation, flushing, purging, and re-charging, using currently approved refrigerant and refrigeration manufacturer's procedures. Restore contaminated systems at no additional cost to the Government as determined by the Contracting Officer. Do not use water in any procedure or test.

3.4 TRAINING COURSE

a. Submit a schedule, at least [2] [_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training. Conduct a training course for [_____] members of the operating staff as designated by the Contracting Officer. The training period must consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.

b. Cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations in the field posted instructions..

c. Submit [6] [_____] complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least [4] [_____] weeks prior to the first training course. Include the manufacturer's name, model number, and parts list in the booklets. Include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features in the manuals.

d. Submit [6] [_____] complete copies of maintenance manual in bound 8 1/2 x 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. Include piping layouts and simplified wiring and control diagrams of the system as installed in the manuals.

3.5 REFRIGERANT PIPING TESTS

After all components of the refrigerant system have been installed and connected, subject the entire refrigeration system to pneumatic, evacuation, and startup tests as described herein. Submit a schedule, at least [2] [_____] weeks prior to the start of related testing, for each test. Identify the proposed date, time, and location for each test. Conduct tests in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test. Provide the services of a qualified technician, as required, to perform all tests and procedures indicated herein. Coordinate field tests with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Submit [6] [_____] copies of the tests report in bound 8 1/2 by 11 inch booklets documenting all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results in the report.

3.5.1 Preliminary Procedures

Prior to pneumatic testing, isolate equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, from the test pressure, or remove from the system. Remove safety relief valves and rupture discs that are not part of factory sealed systems, and cap or plug openings.

3.5.2 Pneumatic Test

Provide pressure control and excess pressure protection at the source of test pressure. Valves must be wide open, except those leading to the atmosphere. Test gas must be dry nitrogen, with minus 70 degree F dewpoint and less than 5 ppm oil. Apply test pressure in two stages before any refrigerant pipe is insulated or covered. In accordance with ASME B31.5, a preliminary test not to exceed 25 psi must be applied as a means of locating major leaks. Every joint being tested must be coated with a thick soap or color indicating solution. The second stage test pressure must be at least 110 percent of the design pressure, but cannot exceed 130 percent of the design pressure of any component in the system. For large systems that are not completely visible, the pressure in the system must be gradually increased to one-half of the test pressure after which the pressure must be increased in steps of one-tenth of the test pressure, until the required test pressure has been reached. The test pressure must be continuously maintained for at leas 24 hours, after which it can be reduced to the leak test pressure. A correction factor of 0.3 psi will be allowed for each degree F change between test space initial and final ambient temperature, plus for increase and minus for a decrease. The leak test pressure must be the design pressure, or a pressure specified in the engineering design. To repair leaks, the joint must be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, re-melting, or back-welding/brazing are not acceptable. Following repair, the entire system must be retested using the pneumatic tests described above. Reassemble the entire system once the pneumatic tests are satisfactorily completed.

3.5.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, relieve the pressure and evacuate the entire system to an absolute pressure of 300 micrometers. During evacuation of the system, the ambient temperature must be higher than 35 degrees F. Do not evacuate no more than one system at one time by one vacuum pump. Once the desired vacuum has been reached, close the vacuum line and allow the system to stand for 1 hour. If the pressure rises over 500 micrometers after the 1 hour period, evacuate the system again down to 300 micrometers and let set for another 1 hour period. Do not charge the system until a vacuum of at least 500 micrometers is maintained for a period of 1 hour without the assistance of a vacuum line. If during the testing the pressure rises above 500 micrometers, continue to repeat the evacuation procedures until all residual moisture has been removed. During evacuation, record pressures by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

3.5.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, charge the system with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system must operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. Test the entire system tested for leaks. Test fluorocarbon systems with halide torch or electronic leak detectors.

3.5.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must be immediatelyisolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. The refrigerant must not be discharged into the atmosphere.

3.5.6 Contractor's Responsibility

At all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps must include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time will the allowable leak rate exceed the leak rates allowed in Section 608 of the Clean Air Act: 30 percent of the full charge per year for industrial refrigeration, 20 percent of the full charge per year for commercial refrigeration, and 10 percent of the full charge per year for comfort cooling. Any system leaks within the first year must be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

-- End of Section --

SECTION 23 25 00

CHEMICAL TREATMENT OF WATER FOR MECHANICAL SYSTEMS
05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D1384	(2005; R 2019) Corrosion Test for Engine Coolants in Glassware
ASTM D2688	(2015; E 2016) Standard Test Method for Corrosivity of Water in the Absence of Heat Transfer (Weight Loss Methods)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 200-1-13	(2016) Environmental Quality -- Minimizing the Risk of Legionellosis Associated with Building Water Systems on Army Installation
PWTB 420-49-5	(1998) Industrial Water Treatment Procedures

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-430-08N	(2004) Central Heating Plants

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will

review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Water Treatment System; G[, [_____]]

Water Analysis; G[, [_____]]

Spare Parts

Field Instructions

Tests; G[, [_____]]

Training Course; G[, [_____]]

SD-06 Test Reports

Condenser Water QA Tests

Steam Boiler Water QA Tests

SD-10 Operation and Maintenance Data

Water Treatment System

1.3 MAINTENANCE MATERIAL SUBMITTALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings, not later than [_____] months prior to the date of beneficial occupancy. Include a complete list of parts and supplies, with source of supply, with the data.

1.4 QUALITY CONTROL

1.4.1 Safety

Ensure exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel are insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Provide [catwalk,] [ladder,] [and guardrail] where indicated and in accordance with Section [05 50 13 MISCELLANEOUS METAL FABRICATIONS] [05 51 33 METAL LADDERS].

1.4.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Summary

This section covers the provisions and installation procedures necessary for a complete and totally functional water system(s) chemical treatment. Provide and install the system with all necessary System Components, Accessories, Piping Components, and Supplemental Components/Services. Minimize to risk of Legionellosis by following the guidance in EM 200-1-13.

2.1.2 Standard Products

a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for two years' prior to bid opening.

b. Include in the two-year use all applications of equipment and materials under similar circumstances and of similar size. Ensure the two years' experience has been satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a two-year field service record are acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown.

c. All products are required to be supported by a service organization. Submit a certified list of qualified permanent service organizations for support of the equipment, including their addresses and qualifications. These service organizations are required to be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

d. The selected service organization provides the chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company provides all chemicals required for the [condenser] [condenser and chilled] water systems and fills the systems with chemicals to the levels specified. The chemical is required to meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and cooling tower. Acid treatment chemicals are not allowed to be used.

2.1.3 Water Analysis

Conditions of make-up water to be supplied to the boilers, cooling towers and chilled water systems reported in accordance with ASTM D596 are as follows:

Date of Sample	[_____]
Temperature	[_____] degrees C

Silica (SiO 2)	[_____] ppm (mg/L)
Insoluble	[_____] ppm (mg/L)
Iron, total (Fe)	[_____] ppm (mg/L)
Aluminum (Al)	[_____] ppm (mg/L)
Calcium (Ca)	[_____] ppm (mg/L)
Magnesium (Mg)	[_____] ppm (mg/L)
Carbonate (HCO 3)	[_____] ppm (mg/L)
Sulfate (SO 4)	[_____] ppm (mg/L)
Chloride (Cl)	[_____] ppm (mg/L)
Nitrate (NO 3)	[_____] ppm (mg/L)
Turbidity	[_____] ntu
pH	[_____]
Residual Chlorine	[_____] ppm (mg/L)
Total Alkalinity	[_____] ppm (mg/L)
Non-Carbonate Hardness	[_____] ppm (mg/L)
Total Hardness	[_____] ppm (mg/L)
Dissolved Solids	[_____] ppm (mg/L)
Conductivity	[_____] Micromho/cm

2.2 EQUIPMENT

2.2.1 Nameplates

Provide a nameplate for each major component of equipment that includes the manufacturer's name, address, type or style, and catalog or serial number securely attached to the item of equipment. Provide nameplates for:

a. Pump(s)

b. Pump Motor(s)

c. Water Treatment Controller(s)

2.2.2 Electrical Work

Ensure all electrical equipment, motors, motor efficiencies, and wiring complies with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment specified complete with motors, motor starters, and controls. Provide electrical characteristics and enclosure types as shown, and unless otherwise indicated, provide all motors of 1 horsepower and above with open, drip-proof, or totally enclosed fan cooled enclosures, high efficiency type. Perform field wiring in accordance with manufacturer's instructions. Each motor is required to conform to NEMA MG 1 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Provide continuous duty motors with the enclosure specified. Provide motor starters complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Furnish motors with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Furnish motor starters with [NEMA 1] [NEMA 3R] [NEMA [_____]] enclosures. Provide manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown.

2.2.3 Gauges

Provide gauges that conform to ASME B40.100, Class 1, 2, or 3, Style X, Type I or III as required, 4-1/2 inches in diameter with phenolic or metal case.

2.3 COMPONENTS

2.3.1 Condenser Water Treatment Systems

The use of chemical-treatment products containing hexavalent chromium (Cr) is prohibited. Treat the water to be used in the condenser water systems to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals are required to meet all required federal, state, and local environmental regulations for the treatment of condenser-side heat exchangers, cooling towers and direct discharge to the sanitary sewer.

Provisions should be made to effectively dose, monitor and control a water treatment program to include (1) inhibitor and biocide injection (2) water sampling, (3) corrosion coupon sampling, and (4) effective bleed and control points.

2.3.1.1 Condenser Water Limits

Meet the following condenser water limits, unless dictated differently by the cooling tower or chiller manufacturer's recommendations:

Treatment type	Phosphonate/Polymer
Puckorius Index	4 minimum
Langelier Index	4 maximum
Total Dissolved Solids	5000 ppm maximum
Calcium Hardness	1200 ppm maximum
Silica	150 ppm maximum
pH	7.5 - 8.5

For treated condenser/cooling tower water, minimize blowdown until the first of one of the top 5 limits is reached. Specific requirements for treatment chemicals and levels are listed below in paragraphs dealing with small and large systems.

2.3.1.2 Glycol Solution

Coordinate minimum glycol concentration with manufacturer to avoid corrosion inhibitor degradation. Test the glycol in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. Provide glycol that contains corrosion inhibitors. Silicate based inhibitors are not acceptable. Ensure the solution is compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.3.1.3 Chemical Treatment for Small Systems

For cooling systems with a capacity of 50 tons or less, provide the following chemical treatment. For corrosion control provide 15 to 20 pounds polyphosphate in nylon mesh bag in cooling tower sump. If biocide is needed, use either 1-bromo-3-chloro-5.5-dimethylhydantoin or gluteraldehyde as recommended by manufacturer.

2.3.1.4 Chemical Treatment for Large Systems

For cooling systems with capacities greater than 50 tons provide one of the three following chemical treatments with the limits indicated. The zinc and molybdate in the last two treatments help to meet the maximum corrosion requirements in waters that tend to be more corrosive. Maintain biocides to control bacteria below 10,000 colony forming units per milliliter.

a. Phosphonate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
TT	1-2 ppm
Biocides	as required

b. Zinc-Phosphonate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
Zinc	1-2 ppm
TT	1-2 ppm
Biocides	as required

c. Zinc-Molybdate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
Molybdate	10-15 ppm
Zinc	2-3 ppm
TT	1-2 ppm
Biocides	as required

2.3.1.4.1 General Requirements

Provide a water treatment system capable of automatically feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. Submit [6] [_____] complete copies, at least 5 weeks prior to the purchase of the water treatment system, of the proposed water treatment plan including a layout; control scheme; a list of existing make-up water chemistry, including the items listed in paragraph Water Analysis; a list of treatment chemicals to be added; the proportion of chemicals to be added; the final treated water control levels; and a description of health, safety and environmental concerns for handling the chemicals plus any special ventilation requirements. Automatic chemical feed systems automatically feed chemicals into the condenser water based on makeup water rate. Use electrical signals from a water meter on the makeup water line to control the output of chemical feed pumps. Set the system initially manually based on the water analysis of the make-up water. Submit [6] [_____] complete copies of operating and maintenance manuals for the step-by-step water treatment procedures. Include in the manuals all testing procedures used in determining water quality.

2.3.1.4.2 Chemical Feed Pumps and Tanks

a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. Furnish chemical feed pumps of the positive displacement diaphragm type. Furnish all pump cylinders, plungers, ball check valves, and check valve bodies made of corrosion resistant materials suitable for the chemicals being pumped. Ensure the cylinders of the provided pumps are replaceable for increased or reduced pressure or capacity ranges.

b. Provide pumps with a flow rate adjustable from 0 to 100 percent while in operation. The volumetric accuracy of the pumps is required to be within one percent over the range indicated. Ensure pump capacities are adjustable by positioning crank pin with micrometer setscrews. Divide stroke length scale in percentage graduations engraved on scale. Ensure the discharge pressure of pumps is not less than 1.5 times the line pressure at the point of connection. Provide the pumps with a pressure relief valve and a check valve mounted in the pump discharge. Control the pump by an external controller/timer receiving signals from the makeup water meter.

c. Provide drive motors rated at 110 volt, single phase with drip-proof enclosures. Provide two chemical tanks constructed of [materials compatible with the chemicals to be stored in the tank] [high density polyethylene] [stainless steel] [fiber reinforced plastic] with a hinged cover and mounted on legs. Ensure tanks have filling and drain connections and gauge glasses. Furnish each tank with one pump, mounted and piped with pipe materials and fittings suitable for working pressure and compatible with the chemicals in the tank it is in contact with, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Provide a tank bottom that is dished concave to a radius equal to the diameter of the tank. Provide motor-driven agitator. Size the tanks to have sufficient capacity to require recharging only once per [7] [14] [21] [_____] days during normal operation.

2.3.1.4.3 Chemical Injection Assembly

Provide an injection assembly at each chemical feed point. Locate the injection assembly downstream of recirculating pumps and upstream of the condenser. Construct the injection assemblies of stainless steel. Locate the discharge of the assemblies in the condenser water piping as recommended by the manufacturer. Include with each assembly a shutoff valve and check valve at the point of entrance into the condenser water line.

2.3.1.4.4 Water Meter

Provide water meters with an electric contacting register and remote accumulative counter. Install the meter within the make-up water line, as indicated.

2.3.1.4.5 Timers

Provide timers which are of the automatic reset, adjustable type, and are electrically operated. Ensure the timers are designed to work with the contacting head water meters. Include the water meter cable with the timer. Ensure timers control operation of the chemical feed pumps and are suitable for a 120 volt current. Locate the timers within the water treatment control panel.

2.3.1.4.6 Bleed (Blowdown) Line

Control the flow through the bleed line by a conductivity meter and probe installed to measure the conductivity of the condenser water. Provide a high and low set point on the conductivity meter above which the meter opens a solenoid valve on the bleed line. Locate the bleed line attachment to the condenser water piping downstream of the recirculating pumps and upstream of the chemical injection point. Extend the bleed line to the nearest drain for continuous discharge.

2.3.1.4.7 Control Panel

Provide a NEMA 12 control panel enclosure suitable for surface mounting. Construct the panel of [stainless steel] [coated steel] with a hinged door and lock. Include a laminated plastic nameplate identifying each of the following functions:

(1) Main power switch and indicating light
(2) MAN-OFF-AUTO selector switch
(3) Indicating lamp for bleed-off valve
(4) Indicating lamp for each chemical feed pump
(5) Set point reading for each timer

2.3.1.4.8 Chemical Piping

Construct the piping and fittings of [schedule 80 PVC] [stainless steel] suitable for the water treatment chemicals.

2.3.1.4.9 Sequence of Operation

Add chemicals based upon sensing the make-up water flow rate and activating appropriate timers. Provide a separate timer for each chemical. Control the blow down based upon the conductivity of the condenser water. Control the injection of the chemical required for biological control manually set for proper chemical feed. The water treatment company is required to determine and set a timer set points, blow down rates, and chemical pump flow rates.

2.3.1.4.10 Test Kits

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals.

2.3.2 Chilled Water System

Provide a [2] [5] [_____] gallon shot feeder on the chilled water piping as indicated. Furnish the feeder with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.3.2.1 Requirements for Glycol Solution

Coordinate minimum [ethylene][propylene] glycol concentration with manufacturer to avoid corrosion inhibitor degradation. Test the glycol in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. Ensure the glycol contains corrosion inhibitors. Silicate based inhibitors are not acceptable. Ensure the solution is compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.3.2.2 Chilled Water Treatment

Treat chilled water with either a borax/nitrite type treatment or a molybdate type treatment. Both types of treatment are acceptable for use with glycol. Maintain borax/nitrite treatment at the limits of [ ] ppm nitrite, [ ] ppm copper corrosion inhibitor (TT or MBT), and pH of 8.5 to 9.5. Maintain molybdate treatment at the limits of [ ] ppm molybdate, [ ] ppm copper corrosion inhibitor (TT or MBT), and pH of 8.0 to 9.0.

2.3.2.3 Dual Temperature Systems

Dual hot/chilled water systems that are treated with borax/nitrite are also to be treated with a biocide.

2.3.2.4 Chilled Water Test Kits

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals (e.g. pH and nitrite or molybdate).

2.3.3 Low and Medium Temperature Hot Water Boilers and Heat Exchangers

Low and medium temperature hot water boilers are defined as those operating below 350 degrees F, (250 degrees F for Low Temperature).

2.3.3.1 Chemical Feeder

Provide a [2] [5] [_____] gallon shot feeder on the hot water piping as indicated. Base the size and capacity of feeder upon local requirements and water analysis. Furnish the feeder with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.3.3.2 Water Softening System

Provide a water softening system as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.3.3.3 Low and Medium Temperature Hot Water Treatment

Treat hot water with either a borax/nitrite type treatment or a molybdate type treatment. Both types of treatment are acceptable to use with glycol. Maintain borax/nitrite treatment at the limits of 600 to 1000 ppm nitrite, 40 - 50 ppm copper corrosion inhibitor (TT or MBT) and pH of 8.5 to 9.5. Maintain molybdate treatment at the limits of 100 to 125 ppm molybdate, 40 - 50 ppm copper corrosion inhibitor (TT or MBT) and pH of 8.0 to 9.0.

2.3.3.4 Dual Temperature Systems

Dual hot/chilled water systems treated with borax/nitrite are required to also be treated with a biocide.

2.3.3.5 Test Kit Requirements

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals (e.g. pH and nitrite or molybdate).

2.3.4 High Temperature Hot Water Boilers

2.3.4.1 Chemical Feeder Unit

Provide a feeder unit for each boiler. Ensure chemical feeder provided is automatic proportioning, shot type, or pump type. Provide all appurtenances necessary to ensure the system performs in compliance with the requirements outlined herein. Base the size and capacity of feeder upon local requirements and water analysis.

2.3.4.2 Pumps and Tanks

a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. The chemical feed pumps are required to be positive displacement diaphragm type. Furnish the pump cylinders, plungers, ball check valves, and check valve bodies fabricated from corrosion resistant materials suitable for the chemicals being pumped. Ensure cylinders used are replaceable for increased or reduced pressure or capacity ranges.

b. Provide for a flow rate of the pumps that is adjustable from 0 to 100 percent while in operation. Ensure volumetric accuracy of the pumps is within one percent over the range indicated. Ensure pump capacities are adjustable by positioning crank pin with micrometer setscrews. Divide stroke length scale in percentage graduations engraved on scale. Ensure the discharge pressure of pumps is not less than 1.5 times the line pressure at the point of connection. Design the pumps to feed the chemical solutions into the HTW return line to the system circulating pumps with a capacity to feed a maximum of [5] [_____] gph. Provide the pumps with a pressure relief valve and a check valve mounted in the pump discharge. Control the pumps by an external controller/timer receiving signals from the makeup water meter.

c. Provide drive motors that are 110 volt, single phase and have drip-proof enclosures. Provide the tanks constructed of [materials compatible with the chemicals to be stored in the tank] [high density polyethylene] [stainless steel] [fiber reinforced plastic] with a hinged cover and mounted on legs. Ensure tanks have both filling and drain connections and gauge glass. Furnish each tank with one pump, mounted and piped with black iron pipe and fittings suitable for working pressures and compatible with the chemicals in the tank it is in contact with, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Provide tank with a dished concave bottom to a radius equal to the diameter of the tank. Provide units suitable for phosphate, caustic feed and sulfite feeding. Provide sulfite tank with a floating cover to completely cover the surface of the solution. Include a motor-driven agitator. Size tanks to have sufficient capacity to require recharging only once per [7] [14] [21] [_____] days during normal operation.

d. For auto proportioning systems, provide controllers designed to be used with selected system specifically for the purpose of injecting chemicals into boiler systems.

e. Mount system components on metal buses or supports instead of mounting directly to the floor.

2.3.4.3 Water Softening System

Provide water softening system as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.3.4.4 Treated Water Limits

Consult with the boiler manufacturer for the determination of the boiler water chemical composition limits. Provide for the following recirculating hot water chemical limits unless dictated differently by the boiler manufacturer's recommendations:

pH	9.3-9.9
Sulfite	30-60 ppm
Hardness	Less than 2.0 ppm

2.3.5 Test Kit

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals (e.g. pH, hardness and sulfite).

2.3.6 Steam Boiler Water Treatment

Provide a water treatment system capable of feeding chemicals and blowdown of the system to prevent corrosion and scale within the boiler and piping distribution system. Treat the water to maintain the conditions recommended by the boiler manufacturer or UFC 3-430-08N (Central Heating Plants) and PWTB 420-49-5 (Industrial Water Treatment Procedures). Provide chemicals that meet all required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. Engage the services of a company regularly engaged in the treatment of boilers to determine the correct concentrations required for water treatment. The company is required to maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Do not use filming amines, hydrazine and chelants. Ensure the water treatment chemicals remain stable throughout the operating temperature range of the system and are compatible with pump seals and other elements of the system.

2.3.6.1 Boiler Water Limits

Provide for boiler water limits as follows unless dictated differently by the boiler manufacturer's recommendations:

Causticity (OH)	20-200 ppm
Total Alkalinity (CaCO3)	200-800 ppm
Phosphate (PO4)	30-60 ppm
Polymer (dispersant) or Tannin	5-10 ppm or medium color, respectively
Dissolved Solids (water tube boilers)	3000-3500 ppm
Dissolved Solids (fire tube boilers)	3500-5000 ppm
Suspended Solids	15 ppm Maximum
Sodium Sulfite	20-40 ppm
Silica	Less than 200 ppm
Dissolved Oxygen	Less than 7 ppb
Iron	Less than 10 ppm
pH (Condensate)	7.5 - 8
Conductivity (Condensate)	Less than 35 micromhos
Hardness (Condensate and makeup)	Less than 2 ppm

The above limits apply to boilers operating above 15 psi up 300 psi. Above 300 psi these limits decrease. Use ABMA or chemical vendor recommended limits above 300 psi.

2.3.6.2 Water Softening System

Provide the water softening system as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.3.6.3 Boiler Water Treatment System

Provide water treatment system capable of automatically feeding chemicals to prevent corrosion and scale within the boiler and condensate system. Ensure automatic chemical feed systems feed chemicals into the boiler based on makeup water rate. Use electrical signals from a water meter on the makeup water line to control the output of chemical feed pumps.

2.3.6.4 Steam Boiler Chemical Feed Pumps and Tanks

a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. Use chemical feed pumps that are positive displacement diaphragm type. Ensure the pump cylinders, plungers, ball check valves, and check valve bodies are fabricated of corrosion resistant materials suitable for the chemicals being pumped. Ensure cylinders are replaceable for increased or reduced pressure or capacity ranges. Ensure the flow rate of the pumps is adjustable from 0 to 100 percent while in operation. Ensure volumetric accuracy of the pumps is within one percent over the range indicated. Pump capacities are required to be adjustable by positioning crank pin with micrometer setscrews. Divide stroke length scale in percentage graduations engraved on scale.

b. Ensure the discharge pressure of pumps is not less than 1.5 times the line pressure at the point of connection. Provide pumps with a pressure relief valve and a check valve mounted in the pump discharge. Control the pumps by an external controller/timer receiving signals from the makeup water meter.

c. Provide drive motors rated for 110 volt, single phase and are equipped with drip-proof enclosures. Provide tanks constructed of [materials compatible with the chemicals to be stored in the tank] [high density polyethylene] [stainless steel] [fiber reinforced plastic] with a hinged cover and mounted on legs. Ensure tanks have filling and drain connections and gauge glass. Furnish each tank with one pump, mounted and piped with pipe and fittings suitable for working pressures and compatible with the chemicals in the tank it is in contact with, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Shape tank bottom to be dished concave to a radius equal to the diameter of the tank. Ensure the tank for sodium sulfite is equipped with a floating cover to minimize contact with air. Provide a motor-driven agitator. Size the tanks to have sufficient capacity to require recharging only once per [7] [14] [21] [_____] days during normal operation.

2.3.6.5 Steam Boiler Chemical Injection Assemblies

Provide an injection assembly at each chemical injection point located along the boiler piping as indicated. Provide injection assemblies that are constructed of stainless steel. Extend the discharge of the assemblies to the centerline of the piping. Include a shutoff valve and check valve with each assembly at the point of entrance into the water line.

2.3.6.6 Steam Boiler Water Meter

Provide the water meter with an electric contacting register and remote accumulative counter. Install the meter within the makeup water line, as indicated.

2.3.6.7 Steam Boiler Timers

Provide timers that are automatic reset, adjustable type, and electrically operated. Design timers to work with the contacting head water meters. Include the water meter cable with the timer. Ensure timers control operation of the chemical feed pumps. Ensure timers are suitable for a 120 volt current. Use timers to control the electrical signals from the water meters to the chemical feed pumps.

2.3.6.8 Steam Boiler Control Panel

Provide control panel constructed of a NEMA 12, single door, wall-mounted box conforming with NEMA 250. Ensure the panel is constructed of [coated steel] [stainless steel] with a hinged door and lock. Ensure the panel contains, as a minimum, the following functions identified with a laminated plastic nameplate:

a. Main power switch and indicating light
b. MAN-OFF-AUTO selector switch
c. Indicating lamp for each chemical feed pump
d. Indicating lamp for the water softener

2.3.6.9 Boiler Blowdown

Provide the boiler with [continuous blowdown] [automatic blowdown based upon conductivity or boiler load]. Provide a bottom blowdown connection and valve to allow removal of solids and water from the bottom of the boiler.

2.3.6.10 Boiler Chemical Piping

Fabricate the piping and fittings of [steel] [stainless steel].

2.3.6.11 Boiler Test Kits

Provide one test kit of each type required to determine the water quality as outlined in paragraph Boiler Water Limits above and within the operation and maintenance manuals.

2.3.7 Supplemental Components/Services

Ensure drain and makeup water piping complies with the requirements of Section 22 00 00 PLUMBING, GENERAL PURPOSE. Connect drains to sanitary sewer systems by means of an indirect waste connection.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy, before performing any work.

3.2 INSTALLATION

Provide all chemicals, equipment and labor necessary to bring all system waters in conformance with the specified requirements. Perform all work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements.

3.2.1 Piping

Fabricate all connections between dissimilar metals using dielectric unions.

3.3 FIELD QUALITY CONTROL

3.3.1 Tests

If the waters of the mechanical systems are not in conformance with the specified requirements or in accordance with manufacturer's recommendations, the contractor is required to direct the water treatment company to take corrective action to achieve compliance. Perform daily operational tests in the directed frequencies to maintain required control to prevent corrosion, scaling and damage to equipment during operation. Submit test schedules, at least 2 weeks prior to the start of related testing, for the condenser/chilled/boiler/condensate/feedwater water quality tests. Identify the date, time, frequency and collection location for each test within the schedules.

3.3.2 Condenser Water Quality Tests

3.3.2.1 Small Systems (weekly)

Once a week, for cooling systems with a capacity of 50 tons or less, ensuring the following items are recorded.

pH	[_____]
Total Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm

3.3.2.2 Tests for Large Systems (daily)

Daily, for cooling systems with a capacity larger than 50 tons, ensuring the following items are recorded.

pH	[_____]
Total Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Phosphate	[_____] ppm (mg/L)
Zinc, if used (Zn)	[_____] ppm (mg/L)
Molybdate, if used (Mo)	[_____] ppm (mg/L)

3.3.3 Chilled Water Testing (monthly)

Perform the following tests on chilled water on a monthly basis.

pH	[_____]
Nitrite or Molybdate	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm

3.3.4 Hot Water Boiler Water Quality Testing

3.3.4.1 Low and Medium Temperature Systems (monthly)

Complete and record monthly testing for the following parameters.

pH	[_____]
Nitrite or Molybdate	[_____] ppm (mg/L)

3.3.4.2 High Temperature Hot Water Systems (daily)

Complete and record daily testing for the following parameters.

pH	[_____]
Sulfite	[_____] ppm (mg/L)
Hardness	[_____] ppm (mg/L)

3.3.5 Steam Boiler Water Testing

3.3.5.1 Small Steam Systems

The type of treatment required for small steam systems (below 25 hp) varies greatly depending on local water and system conditions. Base the determination of the type of treatment and frequency of testing on the recommendations of by the water treatment chemical vendor.

3.3.5.2 Medium Steam Systems (twice weekly)

Record the following items twice a week for steam boiler systems operating between 25 hp and 100 hp and utilize data for operation purposes.

pH	[_____]
P Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphate (PO4)	[_____] ppm (mg/L)

Sulfite (NaSO3)	[_____] ppm (mg/L)

3.3.5.3 Large Steam Systems (daily)

Record the following items daily for steam boiler systems operating above 15 psi and 100 hp and utilize data for operational purposes.

Sulfite (NaSO3)	[_____] ppm (mg/L)
P Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Neutralized Conductivity	[_____] micromho/cm
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphate (PO4)	[_____] ppm (mg/L)
Condensate pH	[_____]
Condensate Conductivity	[_____] micromho/cm
Condensate Hardness (as CaCO3)	[_____] ppm (mg/L)
Makeup Water Hardness (as CaCO3)	[_____] ppm (mg/L)

3.3.6 Quality Assurance Testing

Conduct QA testing periodically by an independent water treatment lab/consultant to verify to managers that the mechanical and water treatment systems are being maintained properly. Provide the QA evaluation reports to the government COR.

3.3.6.1 Condenser Water QA Tests

Submit test reports in bound 8-1/2 by 11 inch booklets. Within the reports, identify the chemical composition of the condenser water. Also include in the reports a comparison of the manufacturer's or chemical vendor's recommended operating conditions for the cooling tower and condenser in relation to the actual condition of the condenser water. Document any required corrective actions undertaken within the report.

a. For cooling systems with a capacity of 50 ton or less, the perform following tests

Presence of scale/corrosion	[_____]
Polyphosphate	[_____] ppm (mg/L)
Biocide	[_____] ppm (mg/L)

pH	[_____]
Total Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Calcium Hardness (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Written evaluation summary	

b. For cooling systems with capacities greater than 50 ton), analyze the condenser water a minimum of once a month for a period of one year by the water treatment company. Ensure the analysis includes the following information recorded in accordance with ASTM D596.

Date of Sample	[_____]
Temperatures (before & after condenser)	[_____] & [_____] degrees C
pH	[_____]
Silica (SiO2)	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Copper (Cu)	[_____] ppm (mg/L)
Calcium Hardness(CaCO3)	[_____] ppm (mg/L)
Total Hardness (as CaCO3)	[_____] ppm (mg/L)
Chloride (Cl)	[_____] ppm (mg/L)
Total Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphonate (as PO4)	[_____] ppm (mg/L)
Zinc (if used) (Zn)	[_____] ppm (mg/L)
Molybdate (if used) (Mo)	[_____] ppm (mg/L)
Tolyltriazole (TT)	[_____] ppm (mg/L)
Biocide	[_____] ppm (mg/L)
Bacteria colony count	[_____] colonies/mL
Makeup water pH	[_____] ppm (mg/L)
Makeup water Iron	[_____] ppm (mg/L)

Makeup water Silica	[_____] ppm (mg/L)
Makeup water Calcium Hardness	[_____] ppm (mg/L)
Makeup water Total Hardness	[_____] ppm (mg/L)
Makeup water Total Alkalinity	[_____] ppm (mg/L)
Makeup water Chloride (Cl)	[_____] ppm (mg/L)
Makeup water Conductivity	[_____] micromho/cm
Written evaluation summary	

3.3.6.2 Chilled Water Quality Assurance Testing (quarterly)

Perform the following tests quarterly on chilled water.

pH	[_____]
Nitrite or Molybdate	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Written evaluation summary	

3.3.6.3 Hot Water Boiler Water Quality Assurance Testing

a. Complete quarterly testing of Low and Medium Temperature Systems and record the following parameters.

pH	[_____]
Nitrite or Molybdate	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Written evaluation summary	

b. Have an independent consultant analyze the hot water boiler water once a month for a period of 1 year. Include the following information recorded in accordance with ASTM D596 in the monthly report.

pH	[_____]
Sulfite (Na2SO3)	[_____] ppm (mg/L)

Hardness(as CaCO3)	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Written evaluation summary	

3.3.6.4 Steam Boiler Water QA Tests

Submit the water quality test report identifying the chemical composition of the boiler, feedwater and condensate water. Include in the report a comparison of the condition of the boiler water with the manufacturer's or chemical vendor's recommended conditions. Document any required corrective action within the report.

a. Small and Medium Steam Boiler Systems (quarterly)are systems operating between 25 hp and 100 hp. Perform the following tests quarterly.

pH	[_____]
Sulfite, if used, (NaSO3)	[_____] ppm (mg/L)
P Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphate, if used, (PO4)	[_____] ppm (mg/L)
Polymer, if used	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Condensate pH	[_____]
Condensate Conductivity	[_____] micromho/cm
Condensate Hardness (as CaCO3)	[_____] ppm (mg/L)
Condensate Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Makeup Water Hardness (as CaCO3)	[_____] ppm (mg/L)
Written evaluation summary	

b. Large steam boilers are those operating above 15 psi and 100 hp. Retain an independent consultant to analyze the boiler water a minimum of once a month for a period of 1 year. Include the following information recorded in accordance with ASTM D596 in the monthly report.

Date of Sample	[_____]
pH	[_____]

Sulfite (NaSO3)	[_____] ppm (mg/L)
P Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Neutralized Conductivity	[_____] micromho/cm
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphate (PO4)	[_____] ppm (mg/L)
Polymer, if used	[_____] ppm (mg/L)
Silica (SiO2)	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Condensate pH	[_____]
Condensate Conductivity	[_____] micromho/cm
Condensate Hardness (as CaCO3)	[_____] ppm (mg/L)
Condensate Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Makeup Water Hardness (as CaCO3)	[_____] ppm (mg/L)
Written evaluation summary	

3.3.7 Corrosion Testers

Install corrosion coupon and rack systems to verify corrosion control in the systems. Install testers or coupons in flowing system water through a sidestream or rack system. Test both mild steel and copper metal samples in the corrosion testers in accordance with ASTM D2688. Replace and analyze samples every 3 months. Rates of corrosion less than 3 mpy for steel and 0.2 mpy for copper are acceptable. Install corrosion testers on the piping systems of the following systems.

Condenser loop
Chilled water system
Hot water loop
Condensate

3.4 CLOSEOUT ACTIVITIES

3.4.1 Training Course

Submit a schedule, at least 2 weeks prior to the date of the proposed training course that identifies the date, time, and location for the training. Conduct a training course for the operating staff as designated by the Contracting Officer. Conduct the training to include a total of [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. Submit field instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. Include within the condensed operation instructions all preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. Frame the posted instructions under glass or laminated plastic and post where indicated by the Contracting Officer. Ensure the field instructions cover all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.5 INSPECTIONS

3.5.1 Inspection General Requirements

Thirty days after project completion, inspect the cooling tower and condenser for problems due to corrosion, scale, and biological growth. If the cooling tower and condenser are found not to conform to the manufacturer's recommended conditions, and the water treatment company recommendations have been followed; instruct the water treatment company to provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

3.5.2 Boiler/Piping Test

Thirty days after project completion, inspect the boiler and condensate piping for problems due to corrosion and scale. If the boiler is found not to conform to the manufacturer's recommendations, and the water treatment company recommendations have been followed, instruct the water treatment company to provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations. If corrosion is found within the condensate piping, proper repairs are required to be made by the water treatment company at no additional cost.

-- End of Section --

SECTION 23 30 00

HVAC AIR DISTRIBUTION
05/20, CHG 1: 02/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.51 (2012; R 2017) American National Standard Acoustics - Determination of Sound Power Levels and Sound Energy Levels of Noise Sources using Sound Pressure - Precision Methods for Reverberation Test Rooms

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)

ACCA Manual 4 (2001) Installation Techniques for Perimeter Heating and Cooling; 11th Edition

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 201 (2002; R 2011) Fans and Systems

AMCA 210 (2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

AMCA 220 (2005;R 2012) Test Methods for Air Curtain Units

AMCA 300 (2014) Reverberant Room Method for Sound Testing of Fans

AMCA 301 (2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data

AMCA 500-D (2018) Laboratory Methods of Testing Dampers for Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 260 I-P (2012) Sound Rating of Ducted Air Moving and Conditioning Equipment

AHRI 350 (2015) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment

AHRI 410 (2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils

AHRI 430 (2009) Central-Station Air-Handling Units

AHRI 440	(2008) Performance Rating of Room Fan-Coils
AHRI 880 I-P	(2011) Performance Rating of Air Terminals
AHRI 885	(2008; Addendum 2011) Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
AHRI DCAACP	(Online) Directory of Certified Applied Air-Conditioning Products
AHRI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15 & 34	(2013) ASHRAE Standard 34-2016 Safety Standard for Refrigeration Systems/ASHRAE Standard 34-2016 Designation and Safety Classification of Refrigerants-ASHRAE Standard 34-2016
ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2019) Ventilation for Acceptable Indoor Air Quality
ASHRAE 68	(1997) Laboratory Method of Testing to Determine the Sound Power In a Duct
ASHRAE 70	(2006; R 2021) Method of Testing the Performance of Air Outlets and Inlets
ASHRAE 84	(2020; Errata 2021) Method of Testing Air-to-Air Heat/Energy Exchangers
ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-6 2021; Addenda AS-BF 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A924/A924M	(2022) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B766	(1986; R 2015) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3359	(2017) Standard Test Methods for Rating Adhesion by Tape Test
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E2016	(2022) Standard Specification for Industrial Woven Wire Cloth

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

GERMAN INSTITUTE FOR STANDARDIZATION (DIN)

DIN EN 14037	(2016) Free Hanging Heating and Cooling Surfaces for Water with a Temperature Below 120 Degrees C - Part 1: Pre-Fabricated Ceiling Mounted Radiant Panels for Space Heating
DIN EN 14240	(2004) Ventilation for Buildings

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)

IEST RP-CC-001	(2016; Rev 6) HEPA and ULPA Filters

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase

	Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 96	(2021) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
NFPA 701	(2019) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1403	(2008) Accepted Industry Practice for Industrial Duct Construction, 2nd Edition
SMACNA 1819	(2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition
SMACNA 1884	(2003) Fibrous Glass Duct Construction Standards, 7th Edition
SMACNA 1966	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition
SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders

U.S. DEPARTMENT OF ENERGY FEDERAL ENERGY MANAGEMENT PROGRAM (FEMP)

PL-109-58	(1992; R 2005) Energy Efiicient Procument

	Requirements

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82	Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 94	(2013; Reprint Apr 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 555S	(2014; Reprint Oct 2020) UL Standard for Safety Smoke Dampers
UL 586	(2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 705	(2017; Reprint Aug 2021) UL Standard for Safety Power Ventilators
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 900	(2015) Standard for Air Filter Units
UL 1995	(2015) UL Standard for Safety Heating and Cooling Equipment
UL 2021	(2015; Reprint Dec 2016) UL Standard for Safety Fixed and Location-Dedicated Electric Room Heaters
UL Bld Mat Dir	(updated continuously online) Building Materials Directory
UL Electrical Construction	(2012) Electrical Construction Equipment Directory
UL Fire Resistance	(2014) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation. Coordinate the work of the different trades to avoid interference between piping, equipment, structural, and electrical work. Provide complete, in place, all necessary offsets in piping and ductwork, and all fittings, and other components, required to install the work as indicated and specified.

1.2.1 Mechanical Equipment Identification

The number of charts and diagrams must be equal to or greater than the number of mechanical equipment rooms. Where more than one chart or diagram per space is required, mount these in edge pivoted, swinging leaf, extruded aluminum frame holders which open to 170 degrees.

1.2.1.1 Charts

Provide chart listing of equipment by designation numbers and capacities such as flow rates, pressure and temperature differences, heating and cooling capacities, horsepower, pipe sizes, and voltage and current characteristics.

[1.2.1.2 Diagrams

Submit proposed diagrams, at least 2 weeks prior to start of related testing. provide neat mechanical drawings provided with extruded aluminum frame under 1/8-inch glass or laminated plastic, system diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system. After approval, post these items where directed.

]1.2.2 Service Labeling

Label equipment, including fans, air handlers, terminal units, etc. with labels made of self-sticking, plastic film designed for permanent installation. Provide labels in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Air handling unit Number	AHU - [_____]
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF - [_____]
VAV Box Number	VAV - [_____]
Fan Coil Unit Number	FC - [_____]
Terminal Box Number	TB - [_____]
Unit Ventilator Number	UV - [_____]

Identify similar services with different temperatures or pressures. Where pressures could exceed 125 pounds per square inch, gage, include the maximum system pressure in the label. Label and arrow piping in accordance with the following:

a. Each point of entry and exit of pipe passing through walls.

b. Each change in direction, i.e., elbows, tees.

c. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.

d. In long straight runs, locate labels at distances within eyesight of each other not to exceed 75 feet. All labels must be visible and legible from the primary service and operating area.

For Bare or Insulated Pipes	
for Outside Diameters of	Lettering
1/2 thru 1-3/8 inch	1/2 inch
1-1/2 thru 2-3/8 inch	3/4 inch
2-1/2 inch and larger	1-1/4 inch

1.2.3 Color Coding

Color coding of all piping systems must be in accordance with [ASME A13.1] [MIL-STD-101].

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G[, [_____]]

SD-03 Product Data

Metallic Flexible Duct

Insulated Nonmetallic Flexible Duct Runouts

Duct Connectors

Duct Access Doors; G[, [_____]]

Fire Dampers

Manual Balancing Dampers; G[, [_____]]

Automatic Smoke-Fire Dampers

Automatic Smoke Dampers

Sound Attenuation Equipment

Acoustical Duct Liner

Diffusers

Registers and Grilles

Louvers

Air Vents, Penthouses, and Goosenecks

Centrifugal Fans

In-Line Centrifugal Fans

Axial Flow Fans

Panel Type Power Wall Ventilators

Centrifugal Type Power Wall Ventilators

Centrifugal Type Power Roof Ventilators

Propeller Type Power Roof Ventilators

Air-Curtain Fans

Ceiling Exhaust Fans

PL-109-58 label for ceiling exhaust fan product; S

Air Handling Units; G[, [_____]]

Room Fan-Coil Units; G[, [_____]]

Coil Induction Units; G[, [_____]]

Constant Volume, Single Duct Terminal Units; G[, [_____]]

Variable Volume, Single Duct Terminal Units; G[, [_____]]

Variable Volume, Single Duct, Fan-Powered Terminal Units; G[, [_____]]

Dual Duct Terminal Units; G[, [_____]]

Ceiling Induction Terminal Units; G[, [_____]]

Reheat Units; G[, [_____]]

Unit Ventilators

Energy Recovery Devices; G[, [_____]]

Hydronic Modular Panels; G[, [_____]]

Prefabricated Radiant-Heating Electric Panels; G[, [_____]]

Test Procedures

Diagrams; G[, [_____]]

Indoor Air Quality for Duct Sealants; S

SD-06 Test Reports

Performance Tests; G[, [_____]]

Damper Acceptance Test; G[, [_____]]

SD-07 Certificates

Bolts

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions

Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

Fire Dampers; G[, [_____]]

Manual Balancing Dampers; G[, [_____]]

Automatic Smoke-Fire Dampers; G[, [_____]]

Automatic Smoke Dampers; G[, [_____]]

Centrifugal Fans; G[, [_____]]

In-Line Centrifugal Fans; G[, [_____]]

Axial Flow Fans; G[, [_____]]

Panel Type Power Wall Ventilators; G[, [_____]]

Centrifugal Type Power Wall Ventilators; G[, [_____]]

Centrifugal Type Power Roof Ventilators; G[, [_____]]

Propeller Type Power Roof Ventilators; G[, [_____]]

Air-Curtain Fans; G[, [_____]]

Ceiling Exhaust Fans; G[, [_____]]

Air Handling Units; G[, [_____]]

Room Fan-Coil Units; G[, [_____]]

Coil Induction Units; G[, [_____]]

Constant Volume, Single Duct Terminal Units; G[, [_____]]

Variable Volume, Single Duct Terminal Units; G[, [_____]]

Variable Volume, Single Duct, Fan-Powered Terminal Units; G[, [_____]]

Dual Duct Terminal Units; G[, [_____]]

Ceiling Induction Terminal Units; G[, [_____]]

Reheat Units; G[, [_____]]

Unit Ventilators; G[, [_____]]

Energy Recovery Devices; G[, [_____]]

Hydronic Modular Panels; G[, [_____]]

Prefabricated Radiant-Heating Electric Panels; G[, [_____]]

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.4 QUALITY ASSURANCE

Except as otherwise specified, approval of materials and equipment is based on manufacturer's published data.

a. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in UL Bld Mat Dir, and UL 6 is acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Outline methods of testing used by the specified agencies.

b. Where materials or equipment are specified to be constructed or tested, or both, in accordance with the standards of the ASTM International (ASTM), the ASME International (ASME), or other standards, a manufacturer's certificate of compliance of each item is acceptable as proof of compliance.

c. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.

d. Where products are specified to meet or exceed the specified energy efficiency requirement of FEMP-designated or ENERGY STAR covered product categories, equipment selected must have as a minimum the efficiency rating identified under "Energy-Efficient Products" at http://femp.energy.gov/procurement.[Equipment having a lower efficiency may be specified if the designer determines such equipment to be more life-cycle cost effective.]

1.4.1 Prevention of Corrosion

Protect metallic materials against corrosion. Provide rust-inhibiting treatment and standard finish for the equipment enclosures. Do not use aluminum in contact with earth, and where connected to dissimilar metal. Protect aluminum by approved fittings, barrier material, or treatment. Provide hot-dip galvanized ferrous parts such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials in accordance with ASTM A123/A123M for exterior locations and cadmium-plated in conformance with ASTM B766 for interior locations.[Provide written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. Include illustrations of product markings, and the number of each type of bolt to be furnished in the certification.]

1.4.2 Asbestos Prohibition

Do not use asbestos and asbestos-containing products.

1.4.3 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4.4 Detail Drawings

Submit detail drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submit drawings showing bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Submit function designation of the equipment and any other requirements specified throughout this Section with the shop drawings.

1.4.5 Test Procedures

Conduct performance tests as required in Section 23 05 93 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control for HVAC.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. "Standard products" is defined as being in satisfactory commercial or industrial use for 2 years before bid opening, including applications of components and equipment under similar circumstances and of similar size, satisfactorily completed by a product that is sold on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record are acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Provide equipment items that are supported by a service organization. In product categories covered by ENERGY STAR or the Federal Energy Management Program, provide equipment that is listed on the ENERGY STAR Qualified Products List or that meets or exceeds the FEMP-designated Efficiency Requirements.

2.2 STANDARD PRODUCTS

Except for the fabricated duct, plenums and casings specified in paragraphs "Metal Ductwork" and "Plenums and Casings for Field-Fabricated Units", provide components and equipment that are standard products of manufacturers regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. This requirement applies to all equipment, including diffusers, registers, fire dampers, and balancing dampers.

a. Standard products are defined as components and equipment that have been in satisfactory commercial or industrial use in similar applications of similar size for at least two years before bid opening.

b. Prior to this two year period, these standard products must have been sold on the commercial market using advertisements in manufacturers' catalogs or brochures. These manufacturers' catalogs, or brochures must have been copyrighted documents or have been identified with a manufacturer's document number.

c. Provide equipment items that are supported by a service organization. In product categories covered by ENERGY STAR or the Federal Energy Management Program, provide equipment that is listed on the ENERGY STAR Qualified Products List or that meets or exceeds the FEMP-designated Efficiency Requirements.

2.3 IDENTIFICATION PLATES

In addition to standard manufacturer's identification plates, provide engraved laminated phenolic identification plates for each piece of mechanical equipment. Identification plates are to designate the function of the equipment. Submit designation with the shop drawings. Provide identification plates that are layers, black-white-black, engraved to show white letters on black background. Letters must be upper case. Identification plates that are 1-1/2-inches high and smaller must be 1/16-inch thick, with engraved lettering 1/8-inch high; identification plates larger than 1-1/2-inches high must be 1/8-inch thick, with engraved lettering of suitable height. Identification plates 1-1/2-inches high and larger must have beveled edges. Install identification plates using a compatible adhesive.

2.4 EQUIPMENT GUARDS AND ACCESS

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Properly guard or cover with insulation of a type specified, high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard. The requirements for catwalks, operating platforms, ladders, and guardrails are specified in Section 08 31 00 ACCESS DOORS AND PANELS.

2.5 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown. For packaged equipment, include manufacturer provided controllers with the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Provide premium efficiency type integral size motors in accordance with NEMA MG 1.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system , and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered interval between start and stop. Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.

e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.6 ANCHOR BOLTS

Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts must not degrade the surrounding concrete.

2.7 SEISMIC ANCHORAGE

Anchor equipment in accordance with applicable seismic criteria for the area and as defined in SMACNA 1981

2.8 PAINTING

Paint equipment units in accordance with approved equipment manufacturer's standards unless specified otherwise. Field retouch only if approved. Otherwise, return equipment to the factory for refinishing. Paint in accordance with Section 09 96 00 HIGH-PEFORMANCE COATINGS.

2.9 INDOOR AIR QUALITY

Provide equipment and components that comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.10 DUCT SYSTEMS

2.10.1 Metal Ductwork

Provide metal ductwork construction, including all fittings and components, that complies with SMACNA 1966, as supplemented and modified by this specification .

a. Construct ductwork meeting the requirements for the duct system static pressure specified in APPENDIX D of Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

b. Provide radius type elbows with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes are allowed.

c. Provide ductwork that meets the requirements of Seal Class [A][C]. Provide ductwork in VAV systems upstream of the VAV boxes that meets the requirements of Seal Class A.

d. Provide ductwork that meets the requirements of Seal Class A. Provide ductwork in VAV systems upstream of the VAV boxes that meets the requirements of Seal Class A.

e. Provide sealants that conform to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS and are suitable for the range of air distribution and ambient temperatures to which it is exposed. Do not use pressure sensitive tape as a sealant. Provide duct sealant products that meet either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants are classified as "Other" within the SCAQMD Rule 1168 sealants table). Provide validation of indoor air quality for duct sealants.

f. Make spiral lock seam duct, and flat oval with duct sealant and lock with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA 1966. Apply the sealant to the exposed male part of the fitting collar so that the sealer is on the inside of the joint and fully protected by the metal of the duct fitting. Apply one brush coat of the sealant over the outside of the joint to at least 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar are not acceptable.

g. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.10.1.1 Metallic Flexible Duct

a. Provide duct that conforms to UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Provide duct assembly that does not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 2 inches water gauge positive and 1.5 inches water gauge negative. Provide flexible round duct length that does not exceed 5 feet. Secure connections by applying adhesive for 2 inches over rigid duct, apply flexible duct 2 inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

b. Inner duct core: Provide interlocking spiral or helically corrugated flexible core constructed of zinc-coated steel, aluminum, or stainless steel; or constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.

c. Insulation: Provide inner duct core that is insulated with mineral fiber blanket type flexible insulation, minimum of 1 inch thick. Provide insulation covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.10.1.2 Insulated Nonmetallic Flexible Duct Runouts

Use flexible duct runouts only where indicated. Runout length is indicated on the drawings, and is not to exceed 5 feet. Provide runouts that are preinsulated, factory fabricated, and that comply with NFPA 90A and UL 181. Provide either field or factory applied vapor barrier. Provide not less than 20 ounce glass fabric duct connectors coated on both sides with neoprene. Where coil induction or high velocity units are supplied with vertical air inlets, use a streamlined, vaned and mitered elbow transition piece for connection to the flexible duct or hose. Provide a die-stamped elbow and not a flexible connector as the last elbow to these units other than the vertical air inlet type. Insulated flexible connectors are allowed as runouts. Provide insulated material and vapor barrier that conform to the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Do not expose the insulation material surface to the air stream.

2.10.1.3 General Service Duct Connectors

Provide a flexible duct connector approximately 6 inches in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars using normal duct construction methods. Provide a composite connector system that complies with NFPA 701 and is classified as "flame-retardent fabrics" in UL Bld Mat Dir.

2.10.1.4 High Temperature Service Duct Connections

Provide material that is approximately 3/32 inch thick, 35 to 40-ounce per square yard weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 1200 degrees F.

2.10.1.5 Aluminum Ducts

ASTM B209, alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.10.1.6 Copper Sheets

ASTM B152/B152M, light cold rolled temper.

2.10.1.7 Corrosion Resisting (Stainless) Steel Sheets

ASTM A167

2.10.2 Duct Access Doors

Provide hinged access doors conforming to SMACNA 1966 in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Provide doors that are a minimum 15 by 18 inches, unless otherwise shown. Where duct size does not accommodate this size door, make the doors as large as practicable. Equip doors 24 by 24 inches or larger with fasteners operable from inside and outside the duct. Use insulated type doors in insulated ducts.

2.10.3 Fire Dampers

Use 1.5 hour rated fire dampers unless otherwise indicated. Provide fire dampers that conform to the requirements of NFPA 90A and UL 555. Perform the fire damper test as outlined in NFPA 90A. Provide a pressure relief door upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then provide a factory installed pressure relief damper. Provide automatic operating fire dampers with a dynamic rating suitable for the maximum air velocity and pressure differential to which it is subjected. Provide fire dampers approved for the specific application, and install according to their listing. Equip fire dampers with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, does not impair the operation of the damper. Equip sleeves or frames with perimeter mounting angles attached on both sides of the wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies in conformance with UL Fire Resistance. Provide [curtain type with damper blades] [in the air stream] [out of the air stream][or][single blade type][or][multi-blade type] fire dampers. Install dampers that do not reduce the duct or the air transfer opening cross-sectional area. Install dampers so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, comply with the installation details given in SMACNA 1819 and in manufacturer's instructions for fire dampers. Perform acceptance testing of fire dampers according to paragraph Fire Damper Acceptance Test and NFPA 90A.

2.10.4 Manual Balancing Dampers

Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators. Install dampers that are 2 gauges heavier than the duct in which installed. Unless otherwise indicated, provide opposed blade type multileaf dampers with maximum blade width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews. Provide stand-off mounting brackets, bases, or adapters not less than the thickness of the insulation when the locking-type quadrant operators for dampers are installed on ducts to be thermally insulated, to provide clearance between the duct surface and the operator. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.10.5 Manual Balancing Dampers

a. Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators.

b. Unless otherwise indicated, provide opposed blade type multileaf dampers with maximum blade width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews. Provide access doors or panels in hard ceilings, partitions and walls for access to all concealed damper operators and damper locking setscrews. Coordinate location of doors or panels with other affected contractors.

c. Provide stand-off mounting brackets, bases, or adapters not less than the thickness of the insulation when the locking-type quadrant operators for dampers are installed on ducts to be thermally insulated, to provide clearance between the duct surface and the operator. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.10.5.1 Square or Rectangular Dampers

2.10.5.1.1 Duct Height 12 inches and Less

2.10.5.1.1.1 Frames

Width	Height	Galvanized Steel Thickness	Length
Maximum 19 inches	Maximum 12 inches	Minimum 20 gauge	Minimum 3 inches
More than 19 inches	Maximum 12 inches	Minimum 16 gauge	Minimum 3 inches

2.10.5.1.1.2 Single Leaf Blades

Width	Height	Galvanized Steel Thickness	Length
Maximum 19 inches	Maximum 12 inches	Minimum 20 gauge	Minimum 3 inches

Width	Height	Galvanized Steel Thickness	Length
More than 19 inches	Maximum 12 inches	Minimum 16 gauge	Minimum 3 inches

2.10.5.1.1.3 Blade Axles

To support the blades of round dampers, provide galvanized steel shafts supporting the blade the entire duct diameter frame-to-frame. Provide axle shafts that extend through standoff bracket and hand quadrant.

Width	Height	Material	Square Shaft
Maximum 19 inches	Maximum 12 inches	Galvanized Steel	Minimum 3/8 inch
More than 19 inches	Maximum 12 inches	Galvanized Steel	Minimum 1/2 inch

2.10.5.1.1.4 Axle Bearings

Support the shaft on each end at the frames with shaft bearings. Press fit shaft bearings configuration to provide a tight joint between blade shaft and damper frame.

Width	Height	Material
Maximum 19 inches	Maximum 12 inches	solid nylon, or equivalent solid plastic, or oil-impregnated bronze
More than 19 inches	Maximum 12 inches	oil-impregnated bronze

2.10.5.1.1.5 Control Shaft/Hand Quadrant

Provide dampers with accessible locking-type control shaft/hand quadrant operators.

Provide stand-off mounting brackets, bases, or adapters for the locking-type quadrant operators on dampers installed on ducts to be thermally insulated. Provide a minimum stand-off distance of 2 inches off the metal duct surface. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.10.5.1.1.6 Finish

Mill Galvanized

2.10.5.1.2 Duct Height Greater than 12 inches

2.10.5.1.2.1 Dampers

Provide dampers with multi-leaf opposed-type blades.

2.10.5.1.2.2 Frames

Maximum 48 inches in height; maximum 48 inches in width; minimum of 16 gauge galvanized steel,
minimum of 5 inches long.

2.10.5.1.2.3 Blades

Minimum of 16 gauge galvanized steel; 6 inch nominal width.

2.10.5.1.2.4 Blade Axles

To support the blades of round dampers, provide galvanized square steel shafts supporting the blade the entire duct diameter frame-to-frame. Provide axle shafts that extend through standoff bracket and hand quadrant.

2.10.5.1.2.5 Axle Bearings

Support the shaft on each end at the frames with shaft bearings constructed of oil-impregnated bronze, or solid nylon, or a solid plastic equivalent to nylon. Press fit shaft bearings configuration to provide a tight joint between blade shaft and damper frame.

2.10.5.1.2.6 Blade Actuator

Minimum 1/2 inch diameter galvanized steel.

2.10.5.1.2.7 Blade Actuator Linkage

Mill Galvanized steel bar and crank plate with stainless steel pivots.

2.10.5.1.2.8 Control Shaft/Hand Quadrant

Provide dampers with accessible locking-type control shaft/hand quadrant operators.

Provide stand-off mounting brackets, bases, or adapters for the locking-type quadrant operators on dampers installed on ducts to be thermally insulated. Provide a minimum stand-off distance of 2 inches off the metal duct surface. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.10.5.1.2.9 Finish

Mill Galvanized

2.10.5.2 Round Dampers

2.10.5.2.1 Frames

Size	Galvanized Steel Thickness	Length
4 to 20 inches	Minimum 20 gauge	Minimum 6 inches

Size	Galvanized Steel Thickness	Length
22 to 30 inches	Minimum 20 gauge	Minimum 6 inches
32 to 40 inches	Minimum 16 gauge	Minimum 6 inches

2.10.5.2.2 Blades

Size	Galvanized Steel Thickness
4 to 20 inches	Minimum 20 gauge
22 to 30 inches	Minimum 16 gauge
32 to 40 inches	Minimum 10 gauge

2.10.5.2.3 Blade Axles

To support the blades of round dampers, provide galvanized steel shafts supporting the blade the entire duct diameter frame-to-frame. Provide axle shafts that extend through standoff bracket and hand quadrant.

Size	Shaft Size and Shape
4 to 20 inches	Minimum 3/8 inch square
22 to 30 inches	Minimum 1/2 inch square
32 to 40 inches	Minimum 3/4 inch square

2.10.5.2.4 Axle Bearings

Support the shaft on each end at the frames with shaft bearings constructed of oil-impregnated bronze, nylon, or a solid plastic equivalent to nylon. Axle bearings intended for low leakage at the damper frame must be neoprene, nitrile, or equivalent of 60 or greater durometer to reduce damper blade vibration. Press fit shaft bearings configuration to provide a tight joint between blade shaft and damper frame.

Size	Material
4 to 20 inches	solid nylon, or equivalent solid plastic, or oil-impregnated bronze
22 to 30 inches	solid nylon, or equivalent solid plastic, or oil-impregnated bronze

Size	Material
32 to 40 inches	oil-impregnated bronze, or stainless steel sleeve bearing

2.10.5.2.5 Control Shaft/Hand Quadrant

Provide dampers with accessible locking-type control shaft/hand quadrant operators.

Provide stand-off mounting brackets, bases, or adapters for the locking-type quadrant operators on dampers installed on ducts to be thermally insulated. Provide a minimum stand-off distance of 2 inches off the metal duct surface. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.10.5.2.6 Finish

Mill Galvanized

2.10.6 Automatic Balancing Dampers

Provide dampers as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

2.10.7 Automatic Smoke-Fire Dampers

Multiple blade type, 180 degrees F fusible fire damper link; smoke damper assembly to include [pneumatically powered][electric] damper operator. UL 555 as a 1.5 hour rated fire damper; further qualified under UL 555S as a leakage rated damper. Provide a leakage rating under UL 555S that is no higher than Class [II][or][III] at an elevated temperature Category B (250 degrees F for 30 minutes). Ensure that pressure drop in the damper open position does not exceed 0.1 inch water gauge with average duct velocities of 2500 fpm.

2.10.8 Automatic Smoke Dampers

UL listed multiple blade type, supplied by smoke damper manufacturer, with pneumatic electric damper operator as part of assembly. Qualified under UL 555S with a leakage rating no higher than Class II or III at an elevated temperature Category B (250 degrees F for 30 minutes). Ensure that pressure drop in the damper open position does not exceed 0.1 inch water gauge with average duct velocities of 2500 fpm.

2.10.9 Air Supply And Exhaust Air Dampers

Provide outdoor air supply and exhaust air dampers that have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - IP, including maximum Damper Leakage for:

a. Climate Zones 1,2,6,7,8 the maximum damper leakage at 1.0 inch w.g. for motorized dampers is 4 cfm per square foot of damper area and non-motorized dampers are not allowed.

b. All other Climate Zones the maximum damper leakage at 1.0 inch w.g. is 10 cfm per square foot and for non-motorized dampers is 20 cfm per square foot of damper area.

Dampers smaller than 24 inches in either direction may have leakage of 40 cfm per square foot.

2.10.10 Air Deflectors (Volume Extractors) and Branch Connections

Provide air deflectors (volume extractors) at all duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections are allowed in lieu of deflectors for branch connections. Furnish all air deflectors (volume extractors), except those installed in 90 degree elbows, with an approved means of adjustment. Provide easily accessible means for adjustment inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, provide external adjustments with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Provide factory-fabricated air deflectors consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Provide factory or field assembled air deflectors (volume extractors). Make adjustment from the face of the diffuser or by position adjustment and lock external to the duct. Provide stand-off brackets on insulated ducts as described herein. Provide fixed air deflectors (volume extractors), also called turning vanes, in 90 degree elbows.

2.10.11 Plenums and Casings for Field-Fabricated Units

2.10.11.1 Plenum and Casings

Fabricate and erect plenums and casings as shown in SMACNA 1966, as applicable. Construct system casing of not less than 16 gauge galvanized sheet steel. Furnish cooling coil drain pans with 1 inch threaded outlet to collect condensation from the cooling coils. Fabricate drain pans from not lighter than 16 gauge steel, galvanized after fabrication or of 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304, welded and stiffened. Thermally insulate drain pans exposed to the atmosphere to prevent condensation. Coat insulation with a flame resistant waterproofing material. Provide separate drain pans for each vertical coil section, and a separate drain line for each pan. Size pans to ensure capture of entrained moisture on the downstream-air side of the coil. Seal openings in the casing, such as for piping connections, to prevent air leakage. Size the water seal for the drain to maintain a pressure of at least 2 inch water gauge greater than the maximum negative pressure in the coil space.

2.10.11.2 Casing

Terminate casings at the curb line and bolt each to the curb using galvanized angle, as indicated in SMACNA 1966.

2.10.11.3 Access Doors

Provide access doors in each section of the casing. Weld doorframes in place, gasket each door with neoprene, hinge with minimum of two brass hinges, and fasten with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, make doors 36 by 18 inches and locate them 18 inches above the floor. Where the space available does not accommodate doors of this size, use doors as large as the space accommodates. Swing doors so that fan suction or pressure holds doors in closed position, airtight. Provide a push-button station, located inside the casing, to stop the supply.

2.10.11.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components are allowed for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Provide panels of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Seal and insulate panel joints. Provide and gasket access doors to prevent air leakage. Provide panel construction that is not less than 20 gauge galvanized sheet steel, assembled with fasteners treated against corrosion. Provide standard length panels that deflect not more than 1/2 inch under operation. Construct details, including joint sealing, not specifically covered, as indicated in SMACNA 1966. Construct the plenums and casings to withstand the specified internal pressure of the air systems.

2.10.11.5 Duct Liner

Unless otherwise specified, duct liner is not permitted.

2.10.12 Sound Attenuation Equipment

2.10.12.1 Systems with total pressure above 4 Inches Water Gauge

Provide sound attenuators on the discharge duct of each fan operating at a total pressure above 4 inch water gauge, and, when indicated, at the intake of each fan system. Provide sound attenuators elsewhere as indicated. Provide factory fabricated sound attenuators, tested by an independent laboratory for sound and performance characteristics. Provide a net sound reduction as indicated. Maximum permissible pressure drop is not to exceed 0.63 inch water gauge. Construct traps to be airtight when operating under an internal static pressure of 10 inch water gauge. Provide air-side surface capable of withstanding air velocity of 10,000 fpm. Certify that the equipment can obtain the sound reduction values specified after the equipment is installed in the system and coordinated with the sound information of the system fan to be provided. Provide sound absorbing material conforming to ASTM C1071, Type I or II. Provide sound absorbing material that meets the fire hazard rating requirements for insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. For connection to ductwork, provide a duct transition section. Factory fabricated double-walled internally insulated spiral lock seam and round duct and fittings designed for high pressure air system can be provided if complying with requirements specified for factory fabricated sound attenuators, in lieu of factory fabricated sound attenuators. Construct the double-walled duct and fittings from an outer metal pressure shell of zinc-coated steel sheet, 1 inch thick acoustical blanket insulation, and an internal perforated zinc-coated metal liner. Provide a sufficient length of run to obtain the noise reduction coefficient specified. Certify that the sound reduction value specified can be obtained within the length of duct run provided. Provide welded or spiral lock seams on the outer sheet metal of the double-walled duct to prevent water vapor penetration. Provide duct and fittings with an outer sheet that conforms to the metal thickness of high-pressure spiral and round ducts and fittings shown in SMACNA 1966. Provide acoustical insulation with a thermal conductivity "k" of not more than 0.27 Btu/inch/square foot/hour/degree F at 75 degrees F mean temperature. Provide an internal perforated zinc-coated metal liner that is not less than 24 gauge with perforations not larger than 1/4 inch in diameter providing a net open area not less than 10 percent of the surface.

2.10.12.2 System with total pressure of 4 Inch Water Gauge and Lower

Use sound attenuators only where indicated. Provide factory fabricated sound attenuators that are constructed of galvanized steel sheets. Provide attenuator with outer casing that is not less than 22 gauge. Provide fibrous glass acoustical fill. Provide net sound reduction indicated. Obtain values on a test unit not less than 24 by 24 inches outside dimensions made by a certified nationally recognized independent acoustical laboratory. Provide air flow capacity as indicated or required. Provide pressure drop through the attenuator that does not exceed the value indicated, or that is not in excess of 15 percent of the total external static pressure of the air handling system, whichever is less. Acoustically test attenuators with metal duct inlet and outlet sections while under the rated air flow conditions. Include with the noise reduction data the effects of flanking paths and vibration transmission. Construct sound attenuators to be airtight when operating at the internal static pressure indicated or specified for the duct system, but in no case less than 2 inch water gauge.

2.10.12.3 Acoustical Duct Liner

Use fibrous glass designed or flexible elastomeric duct liner for lining ductwork and conforming to the requirements of ASTM C1071, Type I and II. Provide uniform density, graduated density, or dual density liner composition, as standard with the manufacturer. Provide not less than 1 inch thick coated lining. Where acoustical duct liner is used, provide the thermal equivalent of the insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS for liner or combination of liner and insulation applied to the exterior of the ductwork. Increase duct sizes shown to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, provide acoustically equivalent lengths of fibrous glass duct, elastomeric duct liner or factory fabricated double-walled internally insulated duct with perforated liner.

2.10.13 Diffusers, Registers, and Grilles

Provide factory-fabricated units of [steel][corrosion-resistant steel][or][aluminum] that distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Provide outlets for diffusion, spread, throw, and noise level as required for specified performance. Certify performance according to ASHRAE 70. Provide sound rated and certified inlets and outlets according to ASHRAE 70. Provide sound power level as indicated. Provide diffusers and registers with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device is acceptable. Provide opposed blade type volume dampers for all diffusers and registers, except linear slot diffusers. Provide linear slot diffusers with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 7 feet above the floor, protect them by a grille or screen according to NFPA 90A.

2.10.13.1 Diffusers

Provide diffuser types indicated. Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Provide air handling troffers or combination light and ceiling diffusers conforming to the requirements of UL Electrical Construction for the interchangeable use as cooled or heated air supply diffusers or return air units. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets between ceiling and surface mounted diffusers for air leakage control. Provide suitable trim for flush mounted diffusers. For connecting the duct to diffuser, provide duct collar that is airtight and does not interfere with volume controller. Provide return or exhaust units that are similar to supply diffusers.

2.10.13.2 Perforated Plate Diffusers

Provide adjustable [one-way,] [two-way,] [three-way,][or][four-way] air pattern controls as indicated. Provide diffuser faceplates that do not sag or deflect when operating under design conditions.

2.10.13.3 Linear Diffusers

Make joints between diffuser sections that appear as hairline cracks. Provide alignment slots for insertion of key strips or other concealed means to align exposed butt edges of diffusers.[Equip with plaster frames when mounted in plaster ceiling.] Do not use screws and bolts in exposed face of frames or flanges. Metal-fill and ground smooth frames and flanges exposed below ceiling. Furnish separate pivoted or hinged adjustable air-volume-damper and separate air-deflection blades.

2.10.13.4 Security Ceiling Diffusers

Provide diffusers that are steel with faceplate, fixed diffusion louvers, with flat surface margin, and an opposed blade damper. Provide faceplate that is 14 gage minimum with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.10.13.5 Registers and Grilles

Provide units that are four-way directional-control type, except provide return and exhaust registers that are fixed horizontal or vertical louver type similar in appearance to the supply register face. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Install wall supply registers at least 6 inches below the ceiling unless otherwise indicated. Locate return and exhaust registers 6 inches above the floor unless otherwise indicated. Achieve four-way directional control by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Provide grilles as specified for registers, without volume control damper.

2.10.13.6 Registers

Double-deflection supply registers.[Provide manufacturer-furnished volume dampers. Provide volume dampers of the group-operated, opposed-blade type and key adjustable by inserting key through face of register. Operating mechanism must not project through any part of the register face. Automatic volume control devices are acceptable.][Provide exhaust and return registers as specified for supply registers, except provide exhaust and return registers that have a single set of nondirectional face bars or vanes having the same appearance as the supply registers.][Set face bars or vanes at [_____] degrees.]

2.10.13.7 Security Supply Air Registers Except in Cells

Provide supply air registers, except in prisoner cells and prisoner holding cells, that are steel with individually adjustable horizontal and vertical vanes, perforated faceplate, flat surface margin and opposed blade damper. Put vertical vanes in front; with 3/4 inch o.c. vane spacing. Provide a 14 gage (minimum) perforated faceplate with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.10.13.8 Security Return and Other Air Registers Except in Cells

Provide return, exhaust, transfer and relief air registers, except in prisoner cells and prisoner holding cells, that are steel with perforated faceplate, flat surface margin, opposed blade damper, and duct mounting sleeve. Provide 14 gage (minimum) faceplate with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.10.13.9 Security Supply Air Registers in Cells

Provide supply air registers in prisoner cells and prisoner holding cells that are steel with perforated faceplate, flat surface margin, extension sleeve, opposed blade damper, and back mounting flanges. Provide a 14 gage (minimum) faceplate with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent. Provide a 14 gage (minimum) wall sleeve.

2.10.13.10 Security Return and Other Type Air Registers in Cells

Provide steel return, exhaust, transfer and relief air registers in prisoner cells and prisoner holding cells with perforated faceplate, flat surface margin, wall sleeve, opposed blade damper, and back mounting flanges. Provide 14 gage (minimum) faceplate with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent. Provide a 14 gage (minimum)wall sleeve.

2.10.14 Louvers

Provide louvers for installation in exterior walls that are associated with the air supply and distribution system as specified in Section [07 60 00 FLASHING AND SHEET METAL] [08 91 00 METAL [WALL][AND][DOOR] LOUVERS].

2.10.15 Air Vents, Penthouses, and Goosenecks

Fabricate air vents, penthouses, and goosenecks from galvanized steel [or aluminum] sheets with galvanized[or aluminum] structural shapes. Provide sheet metal thickness, reinforcement, and fabrication that conform to SMACNA 1966. Accurately fit and secure louver blades to frames. Fold or bead edges of louver blades for rigidity and baffle these edges to exclude driving rain. Provide air vents, penthouses, and goosenecks with bird screen.

2.10.16 Bird Screens and Frames

Provide bird screens that conform to ASTM E2016, No. 2 mesh, aluminum or stainless steel. Provide "medium-light" rated aluminum screens. Provide "light" rated stainless steel screens. Provide removable type frames fabricated from either stainless steel or extruded aluminum.

2.10.17 Radon Exhaust Ductwork

Fabricate radon exhaust ductwork installed in or beneath slabs from Schedule 40 PVC pipe that conforms to ASTM D1785. Provide fittings that conform to ASTM D2466. Use solvent cement conforming to ASTM D2564 to make joints. Otherwise provide metal radon exhaust ductwork as specified herein.

2.11 AIR SYSTEMS EQUIPMENT

2.11.1 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans must not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives designed for not less than [150] [140] [120] percent of the connected driving capacity. Provide variable pitch motor sheaves for 15 hp and below, and fixed pitch as defined by AHRI Guideline D (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated. Provide power ventilators that conform to UL 705 and have a UL label.

2.11.1.1 Centrifugal Fans

Provide fully enclosed, single-width single-inlet, or double-width double-inlet centrifugal fans, with AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Provide impeller wheels that are rigidly constructed and accurately balanced both statically and dynamically. [Provide forward curved or backward-inclined airfoil design fan blades in wheel sizes up to 30 inches. Provide backward-inclined airfoil design fan blades for wheels over 30 inches in diameter]. [Provide open-wheel radial type booster fans for exhaust dryer systems, and fans suitable for conveying lint and the temperatures encountered. Equip the fan shaft with a heat slinger to dissipate heat buildup along the shaft. Install an access (service) door to facilitate maintenance to these fans.] Provide fan wheels over 36 inches in diameter with overhung pulleys and a bearing on each side of the wheel. Provide fan wheels 36 inches or less in diameter that have one or more extra long bearings between the fan wheel and the drive. Provide sleeve type, self-aligning and self-oiling bearings with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Connect grease fittings to tubing for serviceability from a single accessible point. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide steel, accurately finished fan shafts, with key seats and keys for impeller hubs and fan pulleys. Provide fan outlets of ample proportions, designed for the attachment of angles and bolts for attaching flexible connections. Provide[[manually] [automatically] operated inlet vanes on suction inlets. Provide [manually] [automatically] operated outlet dampers.] Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have [open] [dripproof] [totally enclosed] [explosion-proof] enclosures. [Provide [manual] [magnetic] [across-the-line] [reduced-voltage-start] type motor starters with [general-purpose] [weather-resistant] [watertight] enclosure.] [Provide remote manual switch with pilot indicating light where indicated.]

2.11.1.2 In-Line Centrifugal Fans

Provide in-line fans with centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Mount fans in a welded tubular casing. Provide a fan that axially flows the air in and out. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts from the air stream. Provide precision, self aligning ball or roller type fan bearings that are sealed against dust and dirt and are permanently lubricated. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11.[Provide motors with [open][dripproof][totally enclosed] [explosion-proof] enclosure.] [Provide [manual] [magnetic] motor starters across-the-line with [general-purpose] [weather-resistant] [explosion-proof] enclosures.][Provide remote manual switch with pilot indicating light where indicated.]

2.11.1.3 Axial Flow Fans

Provide axial flow fans complete with drive components and belt guard, with steel housing, cast fan wheel, cast or welded steel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. Provide fan wheels that are dynamically balanced and keyed to the fan shaft, with radially projecting blades of airfoil cross-section. Enclose and isolate fan bearings and drive shafts from the air stream. Permanently lubricate fan bearings or provide them with accessible grease fittings. Provide precision self-aligning ball or roller type fan bearings that are sealed against dust and dirt. Provide fan bearings that have a L50 rated bearing life at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Provide fan inlets with an aerodynamically shaped bell and an inlet cone. Install diffuser or straightening vanes at the fan discharge to minimize turbulence and provide smooth discharge air flow. Furnish fan unit with [inlet and outlet flanges,] [inlet screen,] [duct equalizer section,] and [manual] [automatic] operation adjustable inlet vanes. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have [open] [dripproof] [totally enclosed] [explosion-proof] enclosure. [Provide [manual] [magnetic] motor starters across-the-line with [general-purpose] [weather-resistant] [explosion-proof] enclosure.] [Provide remote manual switch with pilot indicating light where indicated.]

2.11.1.4 Panel Type Power Wall Ventilators

Provide propeller type fans, assembled on a reinforced metal panel with venturi opening spun into panel. Provide direct or V-belt driven fans with wheels less than 24 inches in diameter and provide V-belt driven fans with wheels 24 inches in diameter and larger. Provide fans with wall mounting collar. Provide lubricated bearings. Equip fans with wheel and motor side metal or wire guards which have a corrosion-resistant finish. Provide [dripproof][totally enclosed fan cooled][explosion-proof] type motor enclosure. Install [gravity][motor operated] backdraft dampers where indicated.

2.11.1.5 Centrifugal Type Power Wall Ventilators

Provide [direct][or][V-belt] driven centrifugal type fans with backward inclined, non-overloading wheel. Provide removable and weatherproof motor housing. Provide unit housing that is designed for sealing to building surface and for discharge and condensate drippage away from building surface. Construct housing of heavy gauge aluminum. Equip unit with an [aluminum or plated steel wire discharge bird screen,] [disconnect switch,] [[anodized aluminum][stainless steel] wall grille,] [manufacturer's standard [gravity][motor-operated] damper,] an airtight and liquid-tight metallic wall sleeve. Provide [totally enclosed fan cooled] [dripproof] [explosion-proof] type motor enclosure. Use only lubricated bearings.

2.11.1.6 Centrifugal Type Power Roof Ventilators

Provide [direct][or][V-belt] driven centrifugal type fans with backward inclined, non-overloading wheel. Provide hinged or removable and weatherproof motor compartment housing, constructed of heavy gauge aluminum. Provide fans with [birdscreen,] [disconnect switch,] [[gravity] [motorized] dampers,] [sound curb,] [roof curb,] and [extended base]. Provide [dripproof] [explosion-proof] type motor enclosure. Provide centrifugal type kitchen exhaust fans according to UL 705 and NFPA 96, fitted with V-belt drive, round hood, and windband upblast discharge configuration, integral residue trough and collection device, with motor and power transmission components located in outside positively air ventilated compartment. Use only lubricated bearings. If there is a conflict between NFPA 96 and UL 705 the most stringent wording must be adhered to.

2.11.1.7 Propeller Type Power Roof Ventilators

Provide [direct][or][V-belt] driven fans. Provide hinged or removable weathertight fan housing, fitted with framed rectangular base constructed of aluminum or galvanized steel. Provide [totally enclosed fan cooled] [explosion-proof] type motors. Furnish motors with nonfusible, horsepower rated, manual disconnect mount on unit. Furnish fans with [gravity] [motor operated] dampers, [birdscreen][sound curb][roof curb]. Use only lubricated bearings.

2.11.1.8 Air-Curtain Fans

Provide fans that conform to AMCA 220 with AMCA seal. Furnish air curtains with a weatherproof housing constructed of high impact plastic or minimum 18 gauge rigid welded steel. Provide backward curved, non-overloading, centrifugal type fan wheels, accurately balanced statically and dynamically. Provide motors with totally enclosed fan cooled enclosures. Provide remote manual type motor starters with weather-resistant enclosure actuated when the doorway served is open. Provide air curtains that attain the air velocities specified within 2 seconds following activation. Provide bird screens at air intake and discharge openings. Provide air curtain unit or a multiple unit installation that is at least as wide as the opening to be protected. Provide the air discharge openings to permit outward adjustment of the discharge air. Place installation and adjust according to the manufacturer's written recommendation. Furnish directional controls on air curtains for service windows for easy clean or convenient removal. Design air curtains to prevent the adjustment of the air velocities specified. Make the interior surfaces of the air curtain units accessible for cleaning. Provide certified test data indicating that the fan can provide the air velocities required when fan is mounted as indicated. Provide air curtains designed as fly fans unless otherwise indicated. [Provide air curtains designed for use in service entranceways that develop an air curtain not less than 3 inches thick at the discharge nozzle. Provide air velocity that is not less than 1600 fpm across the entire entryway when measured 3 feet above the floor.] [Provide air curtains designed for use on customer entranceways that develop an air curtain not less than 8 inches thick at the discharge opening. Provide velocity that is not less than 600 fpm across the entire entryway when measured 3 feet above the floor. Equip recirculating type air curtains with readily removable filters, or design the filters for in-position cleaning. Provide readily accessible and easily cleanable air capture compartment or design for in-position cleaning.] [Provide air curtains designed for use on service windows that develop an air curtain not less than 8 inches thick at the discharge opening. Provide air velocity that is not less than 600 fpm across the entire opening of the service window measured 3 feet below the air discharge opening.]

2.11.1.9 Ceiling Exhaust Fans

Provide centrifugal type, direct driven suspended cabinet-type ceiling exhaust fans. Provide fans with acoustically insulated housing. Provide chatter-proof backdraft damper. Provide egg-crate design or louver design integral face grille. Mount fan motors on vibration isolators. Furnish unit with mounting flange for hanging unit from above. Provide U.L. listed fans. Provide PL-109-58 labeled ceiling exhaust fan product. Provide proof of PL-109-58 label for ceiling exhaust fan product.

2.11.2 Coils

Provide fin-and-tube type coils constructed of seamless [copper][red brass] tubes and [aluminum][or][copper] fins mechanically bonded or soldered to the tubes.[Provide copper tube wall thickness that is a minimum of [0.016][0.020][0.024] inches].[Provide red brass tube wall thickness that is a minimum of [0.035] [0.049] inches]. [Provide aluminum fins that are [0.0055][0.0075] inch minimum thickness.][Provide copper fins that are 0.0045 inch minimum thickness.] Provide casing and tube support sheets that are not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Mount coils for counterflow service. Rate and certify coils to meet the requirements of AHRI 410.[Provide factory applied phenolic, vinyl or epoxy/electrodeposition coating.]

2.11.2.1 Direct-Expansion Coils

Provide suitable direct-expansion coils for the refrigerant involved. Provide refrigerant piping that conforms to ASTM B280 and clean, dehydrate and seal. Provide seamless copper tubing suction headers or seamless or resistance welded steel tube suction headers with copper connections. Provide supply headers that consist of a distributor which distributes the refrigerant through seamless copper tubing equally to all circuits in the coil. Provide circuited tubes to ensure minimum pressure drop and maximum heat transfer. Provide circuiting that permits refrigerant flow from inlet to suction outlet without causing oil slugging or restricting refrigerant flow in coil. Provide field installed coils which are completely dehydrated and sealed at the factory upon completion of pressure tests. Pressure test coils in accordance with UL 1995.

2.11.2.2 Water Coils

Install water coils with a pitch of not less than 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans. Pressure test coils in accordance with UL 1995.

2.11.2.3 Steam Heating Coils

Construct steam coils from cast semisteel, welded steel or copper headers, and [red brass][copper] tubes. Construct headers from cast iron, welded steel or copper. Provide fin tube and header section that float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide each coil with a field or factory installed vacuum breaker. Provide single-tube type coils with tubes not less than 1/2 inch outside diameter, except for steam preheat coils. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent. Pressure testcoils in accordance with UL 1995.

2.11.2.4 Steam Preheat (Nonfreeze) Coils

Provide steam-distribution-tube type steam (nonfreeze) coils with condensing tubes not less than 1 inch outside diameter for tube lengths 60 inches and over and 1/2 inch outside diameter for tube lengths under 60 inches. Construct headers from cast iron, welded steel, or copper. Provide distribution tubes that are not less than 5/8 inch outside diameter for tube lengths 60 inches and over and 3/8 inch outside diameter for tube lengths under 60 inches with orifices to discharge steam to condensing tubes. Install distribution tubes concentric inside of condensing tubes and hold securely in alignment. Limit maximum length of a single coil to 144 inches. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent. Pressure test coils in accordance with UL 1995.

2.11.2.5 Electric Heating Coil

Provide an electric duct heater coil in accordance with UL 1995 and NFPA 70. Provide duct- or unit-mounted coil. Provide [nickel chromium resistor, single stage, strip] [nickel chromium resistor, single stage, strip or stainless steel, fin tubular] type coil. Provide coil with a built-in or surface-mounted high-limit thermostat interlocked electrically so that the coil cannot be energized unless the fan is energized. Provide galvanized steel or aluminum coil casing and support brackets. Mount coil to eliminate noise from expansion and contraction and for complete accessibility for service.

2.11.2.6 Eliminators

Equip each cooling coil having an air velocity of over 400 fpm through the net face area with moisture eliminators, unless the coil manufacturer guarantees, over the signature of a responsible company official, that no moisture can be carried beyond the drip pans under actual conditions of operation. Construct of minimum 24 gage [zinc-coated steel] [copper] [copper nickel] [or] [stainless steel], removable through the nearest access door in the casing or ductwork. Provide eliminators that have not less than two bends at 45 degrees and are spaced not more than 2-1/2 inches center-to-center on face. Provide each bend with an integrally formed hook as indicated in the SMACNA 1884.

2.11.2.7 Sprayed Coil Dehumidifiers

Provide assembly with reinforced, braced, and externally insulated galvanized steel casing, vertical in-line spray pump, bronze self-cleaning spray nozzles, galvanized steel pipe spray headers, adjustable float valve with replaceable neoprene seat, manufacturer's standard cooling coil, and welded black steel drain tank. Provide overflow drain, make-up, and bleed connection.

2.11.2.8 Corrosion Protection for Coastal Installations

[_____]

2.11.3 Air Filters

List air filters according to requirements of UL 900, except list high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method under the Label Service to meet the requirements of UL 586.

2.11.3.1 Extended Surface Pleated Panel Filters

Provide 2 inch depth, sectional, disposable type filters of the size indicated with a MERV of 8 when tested according to ASHRAE 52.2. Provide initial resistance at 500 fpm that does not exceed 0.36 inches water gauge. Provide UL Class 2 filters, and nonwoven cotton and synthetic fiber mat media. Attach a wire support grid bonded to the media to a moisture resistant fiberboard frame. Bond all four edges of the filter media to the inside of the frame to prevent air bypass and increase rigidity.

2.11.3.2 Extended Surface Nonsupported Pocket Filters

Provide [30][_____] inch depth, sectional, replaceable dry media type filters of the size indicated with a MERV of 13 when tested according to ASHRAE 52.2. Provide initial resistance at [500][_____] fpm that does not exceed [0.45][_____] inches water gauge. Provide UL Class 1 filters. Provide fibrous glass media, supported in the air stream by a wire or non-woven synthetic backing and secured to a galvanized steel metal header. Provide pockets that do not sag or flap at anticipated air flows. Install each filter [with an extended surface pleated panel filter as a prefilter] in a factory preassembled, side access housing or a factory-made sectional frame bank, as indicated.

2.11.3.3 Cartridge Type Filters

Provide 12 inch depth, sectional, replaceable dry media type filters of the size indicated with a MERV of 13 when tested according to ASHRAE 52.2. Provide initial resistance at [500][_____] fpm that does not exceed

[0.56][_____] inches, water gauge. Provide UL class 1 filters, and pleated microglass paper media with corrugated aluminum separators, sealed inside the filter cell to form a totally rigid filter assembly. Fluctuations in filter face velocity or turbulent airflow have no effect on filter integrity or performance. Install each filter [with an extended surface pleated media panel filter as a prefilter] in a factory preassembled side access housing, or a factory-made sectional frame bank, as indicated.

2.11.3.4 Sectional Cleanable Filters

Provide [1][2] inch thick cleanable filters. Provide viscous adhesive in 5 gallon containers in sufficient quantity for 12 cleaning operations and not less than one quart for each filter section. Provide one washing and charging tank for every 100 filter sections or fraction thereof; with each washing and charging unit consisting of a tank and [single][double] drain rack mounted on legs and drain rack with dividers and partitions to properly support the filters in the draining position.

2.11.3.5 Replaceable Media Filters

Provide the [dry-media][viscous adhesive] type replaceable media filters, of the size required to suit the application. Provide filtering media that is not less than 2 inches thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Enclose pad in a holding frame of not less than 16 gauge galvanized steel, equipped with quick-opening mechanism for changing filter media. Base the air flow capacity of the filter on net filter face velocity not exceeding [300][_____] fpm, with initial resistance of [0.13][_____] inches water gauge. Provide MERV that is not less than [_____] when tested according to ASHRAE 52.2.

2.11.3.6 Automatic Renewable Media Filters

Provide the following:

a. Automatic, renewable media filters consisting of a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass supplied in convenient roll form, and filter that does not require water supply, sewer connections, adhesive reservoir, or sprinkler equipment as part of the operation and maintenance requirements.

b. Basic frame that is fabricated of not less than 14 gauge galvanized steel, and sectional design filters with each section of each filter fully factory assembled, requiring no field assembly other than setting in place next to any adjacent sections and the installation of media in roll form.

c. Each filter complete with initial loading of filter media drive motor adequate to handle the number of sections involved, and [painted steel] [stainless steel] control box containing a warning light to indicate media runout, a runout switch, and a Hand-Off-Auto selector switch.

d. Media feed across the filter face in [full-face increments] [increments] automatically controlled as determined by [filter pressure differential] [time interval control] [time interval control with pressure override] [photo electric control] to provide substantially constant operating resistance to airflow and varying not more than plus or minus 10 percent. Roll or enclose media in such a way that collected particulates can not re-entrain.

e. Rolls of clean media, no less than 65 feet long, rerolled on disposable spools in the rewind section of the filter after the media has accumulated its design dirt load. Equip rewind section with a compression panel to tightly rewind used media for ease of handling. Provide media made of continuous, bonded fibrous glass material, UL Class 2, that does not compress more than 1/4 inch when subjected to air flow at 500 fpm. Factory charge media with an odorless and flame retardant adhesive which does not flow while in storage nor when subjected to temperatures up to 175 degrees F. Support media on both the leaving and entering air faces. Clean media must have initial resistance that does not exceed 0.18 inch water gauge at its rated velocity of 500 fpm. Set control so that the resistance to air flow is between 0.40-and 0.50 inch water gauge unless otherwise indicated.

f. Dust holding capacity, of 80 percent average arrestance under these operating conditions, when operating at a steady state with an upper operating resistance of 0.50 inch water gauge, that is at least 592 (55) grams of ASHRAE Standard Test Dust per square foot of media area, when tested according to the dynamic testing provisions of ASHRAE 52.2.

g. The horizontal type automatic renewable media filters, when used in conjunction with factory fabricated air handling units, that are dimensionally compatible with the connecting air handling units, and horizontal type filter housings with all exposed surfaces factory insulated internally with 1 inch, 1-1/2 pound density neoprene coated fibrous glass with thermal conductivity not greater than 0.27 Btu/hour/degree F/square foot/inch of thickness.

h. Access doors for horizontal filters with double wall construction as specified for plenums and casings for field-fabricated units in paragraph DUCT SYSTEMS.

2.11.3.7 Electrostatic Filters

Provide the following:

a. The combination dry agglomerator/extended surface, nonsupported pocket electrostatic filters or the combination dry agglomerator/automatic renewable, media (roll) type electrostatic filters, as indicated (except as modified). Supply each dry agglomerator electrostatic air filter with the correct quantity of fully housed power packs and equip with silicon rectifiers, manual reset circuit breakers, low voltage safety cutout, relays for field wiring to remote indication of primary and secondary voltages, with lamps mounted in the cover to indicate these functions locally. Equip power pack enclosure with external mounting brackets, and low and high voltage terminals fully exposed with access cover removed for ease of installation. Furnish interlock safety switches for each access door and access panel that permits access to either side of the filter, so that the filter is de-energized in the event that a door or panel is opened.

b. Ozone generation within the filter that does not exceed five parts per one hundred million parts of air. Locate high voltage insulators in a serviceable location outside the moving air stream or on the clean air side of the unit. Fully expose ionizer wire supports and furnish ionizer wires precut to size and with formed loops at each end to facilitate ionizer wire replacement.

c. Agglomerator cell plates that allow proper air stream entrainment of agglomerates and prevent excessive residual dust build-up, with cells that are open at the top and bottom to prevent accumulation of agglomerates which settle by gravity. Where the dry agglomerator electrostatic filter is indicated to be the automatic renewable media type, provide a storage section that utilizes a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass for dry agglomerator storage section service supplied in 65 foot lengths in convenient roll form. Otherwise, provide section construction and roll media characteristics as specified for automatic renewable media filters. Also a dry agglomerator/renewable media combination with an initial air flow resistance, after installation of clean media, that does not exceed 0.25 inch water gauge at 500 fpm face velocity.

d. A MERV of the combination that is not less than 15 when tested according to ASHRAE 52.2 at an average operating resistance of 0.50 inch water gauge. Where the dry agglomerator electrostatic filter is indicated to be of the extended surface nonsupported pocket filter type, provide a storage section as specified for extended surface non-supported pocket filters, with sectional holding frames or side access housings as indicated.

e. A dry agglomerator/extended surface nonsupported pocket filter section combination with initial air flow resistance, after installation of clean filters, that does not exceed 0.65 inch water gauge at 500 fpm face velocity, with a MERV of the combination not less than 16 when tested according to ASHRAE 52.2. Furnish front access filters with full height air distribution baffles and upper and lower mounting tracks to permit the baffles to be moved for agglomerator cell inspection and service. When used in conjunction with factory fabricated air handling units, supply side access housings which have dimensional compatibility.

2.11.3.8 High-Efficiency Particulate Air (HEPA) Filters

Provide HEPA filters that meet the requirements of IEST RP-CC-001 and are individually tested and certified to have an efficiency of not less than [95] [99.97] percent, and an initial resistance at [_____] fpm that does not exceed [_____] inches water gauge. Provide filters that are constructed by pleating a continuous sheet of filter medium into closely spaced pleats separated by corrugated aluminum or mineral-fiber inserts, strips of filter medium, or by honeycomb construction of the pleated filter medium. Provide interlocking, dovetailed, molded neoprene rubber gaskets of 5-10 durometer that are cemented to the perimeter of the [upstream] [downstream] face of the filter cell sides. Provide self-extinguishing rubber-base type adhesive or other materials conforming to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Provide filter cell sides that are [3/4 inch thick exterior grade fire-retardant plywood] [cadmium plated steel] [galvanized steel] assembled in a rigid manner. Provide overall cell side dimensions that are correct to 1/16 inch, and squareness that is maintained to within 1/8 inch. Provide holding frames that use spring loaded fasteners or other devices to seal the filter tightly within it and that prevent any bypass leakage around the filter during its installed life. Provide air capacity and the nominal depth of the filter as indicated. Install each filter in a factory preassembled side access housing or a factory-made sectional supporting frame as indicated. Provide prefilters of the type, construction and efficiency indicated.

2.11.3.9 Holding Frames

Fabricate frames from not lighter than 16 gauge sheet steel with rust-inhibitor coating. Equip each holding frame with suitable filter holding devices. Provide gasketed holding frame seats. Make all joints airtight.

2.11.3.10 Filter Gauges

Provide dial type filter gauges, diaphragm actuated draft for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Provide gauges that are at least 3-7/8 inches in diameter, with white dials with black figures, and [graduations] [graduated in 0.01 inch of water,] with a minimum range of 1 inch of water beyond the specified final resistance for the filter bank on which each gauge is applied. Provide each gauge with a screw operated zero adjustment and two static pressure tips with integral compression fittings, two molded plastic vent valves, two 5 foot minimum lengths of 1/4 inch diameter [aluminum] [vinyl] tubing, and all hardware and accessories for gauge mounting.

2.12 AIR HANDLING UNITS

2.12.1 Field-Fabricated Air Handling Units

Provide built-up units as specified in paragraph DUCT SYSTEMS. Provide fans, coils spray-coil dehumidifiers, and air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types indicated.

2.12.2 Factory-Fabricated Air Handling Units

Provide [single-zone draw-through type][or][single-zone blow-through type][or][multizone blow-through type][blow-through double-deck type][blow-through triple deck type] units as indicated. Units must include fans, coils, airtight insulated casing, [prefilters,] [secondary filter sections,][and][diffuser sections where indicated,] [air blender] adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, [mixing box] [combination sectional filter-mixing box,] [[pan][drysteam][spray type] humidifier,] vibration-isolators, and appurtenances required for specified operation. Provide vibration isolators as indicated. Physical dimensions of each air handling unit must be suitable to fit space allotted to the unit with the capacity indicated. Provide air handling unit that is rated in accordance with AHRI 430 and AHRI certified for cooling.

2.12.2.1 Casings

Provide the following:

a. [Casing sections [[single] [2 inch double] wall type] [as indicated], constructed of a minimum 18 gauge galvanized steel, or 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304.][Inner casing of double-wall units that are a minimum 20 gauge solid galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304.] Design and construct casing with an integral insulated structural galvanized steel frame such that exterior panels are non-load bearing.

b. Individually removable exterior panels with standard tools. Removal must not affect the structural integrity of the unit. Furnish casings with access sections, according to paragraph AIR HANDLING UNITS, inspection doors, and access doors, all capable of opening a minimum of 90 degrees, as indicated.

c. Insulated, fully gasketed, double-wall type inspection and access doors, of a minimum 18 gauge outer and 20 gauge inner panels made of either galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Provide rigid doors with heavy duty hinges and latches. Inspection doors must be a minimum 12 inches wide by 12 inches high. Access doors must be a minimum 24 inches wide, the full height of the unit casing or a minimum of 6 foot, whichever is less. [Install a minimum 8 by 8 inches sealed glass window suitable for the intended application, in all access doors.]

d. Double-wall insulated type drain pan (thickness equal to exterior casing) constructed of 16 gauge [galvanized steel] [corrosion resisting sheet steel conforming to ASTM A167, Type 304], conforming to ASHRAE 62.1. Construct drain pans water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils must not flow across the face of lower coils. Provide intermediate drain pans or condensate collection channels and downspouts, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Construct drain pan to allow for easy visual inspection, including underneath the coil without removal of the coil and to allow complete and easy physical cleaning of the pan underneath the coil without removal of the coil. Provide coils that are individually removable from the casing.

e. Casing insulation that conforms to NFPA 90A. Insulate single-wall casing sections handling conditioned air with not less than 1 inch thick, 1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.23 Btu/hr-sf-F. Insulate double-wall casing sections handling conditioned air with not less than 2 inches of the same insulation specified for single-wall casings. Foil-faced insulation is not an acceptable substitute for use with double wall casing. Seal double wall insulation completely by inner and outer panels.

f. Factory applied fibrous glass insulation that conforms to ASTM C1071, except that the minimum thickness and density requirements do not apply, and that meets the requirements of NFPA 90A. Make air handling unit casing insulation uniform over the entire casing. Foil-faced insulation is not an acceptable substitute for use on double-wall access doors and inspections doors [and casing sections].

g. Duct liner material, coating, and adhesive that conforms to fire-hazard requirements specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Protect exposed insulation edges and joints where insulation panels are butted with a metal nosing strip or coat to meet erosion resistance requirements of ASTM C1071.

h. A latched and hinged inspection door, in the fan and coil sections. Plus additional inspection doors, access doors and access sections [_____][where indicated].

2.12.2.2 Heating and Cooling Coils

Provide coils as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.12.2.3 Air Filters

Provide air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.12.2.4 Fans

Provide the following:

a. Fans that are double-inlet, centrifugal type with each fan in a separate scroll. Dynamically balance fans and shafts prior to installation into air handling unit, then after it has been installed in the air handling unit, statically and dynamically balance the entire fan assembly. Mount fans on steel shafts, accurately ground and finished.

b. Fan bearings that are sealed against dust and dirt and are precision self-aligning ball or roller type, with L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide bearings that are permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit. Support bearings by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Do not fasten bearings directly to the unit sheet metal casing. Furnish fans and scrolls with coating indicated.

c. Fans that are driven by a unit-mounted, or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted motors. Furnish belt guards that are the three-sided enclosed type with solid or expanded metal face. Design belt drives for not less than a 1.3 service factor based on motor nameplate rating.

d. [Motor sheaves that are variable pitch for 25 hp and below and fixed pitch above 25 hp as defined by AHRI Guideline D.] Where fixed sheaves are required, the use of variable pitch sheaves is allowed during air balance, but replace them with an appropriate fixed sheave after air balance is completed. Select variable pitch sheaves to drive the fan at a speed that produces the specified capacity when set at the approximate midpoint of the sheave adjustment. Furnish motors for V-belt drives with adjustable bases, and with [open][splashproof][totally enclosed] enclosures.

e. Motor starters of [manual][magnetic][across-the-line][reduced-voltage-start] type with [general-purpose][weather-resistant][watertight] enclosure. Select unit fan or fans to produce the required capacity at the fan static pressure with sound power level as indicated. Obtain the sound power level values according to AMCA 300, ASHRAE 68, or AHRI 260 I-P.

2.12.2.5 Access Sections and Filter/Mixing Boxes

Provide access sections where indicated and furnish with access doors as shown. Construct access sections and filter/mixing boxes in a manner identical to the remainder of the unit casing and equip with access doors. Design mixing boxes to minimize air stratification and to promote thorough mixing of the air streams.

2.12.2.6 Diffuser Sections

Furnish diffuser sections between the discharge of all housed supply fans [and cooling coils of blow-through single zone units][and][filter sections of those units with high efficiency filters located immediately downstream of the air handling unit fan section]. Provide diffuser sections that are fabricated by the unit manufacturer in a manner identical to the remainder of the unit casing, designed to be airtight under positive static pressures up to [8][_____] inches water gauge and with an access door on each side for inspection purposes. Provide a diffuser section that contains a perforated diffusion plate, fabricated of galvanized steel, Type 316 stainless steel, aluminum, or steel treated for corrosion with manufacturer's standard corrosion-resisting finish, and designed to accomplish uniform air flow across the down-stream [coil][filters] while reducing the higher fan outlet velocity to within plus or minus 5 percent of the required face velocity of the downstream component.

2.13 TERMINAL UNITS

2.13.1 Room Fan-Coil Units

Provide base units that include galvanized coil casing, coil assembly drain pan [valve and piping package,] [outside air damper,] [wall intake box,] air filter, fans, motor, fan drive, motor switch, an enclosure for cabinet models and casing for concealed models, leveling devices integral with the unit for vertical type units, and sound power levels as indicated. Obtain sound power level data or values for these units according to test procedures based on AHRI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models are acceptable for concealed models without separate test provided there is no variation between models as to the coil configuration, blowers, motor speeds, or relative arrangement of parts. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Fasten each unit securely to the building structure. Provide units with capacity indicated. Provide room fan-coil units that are certified as complying with AHRI 440, and meet the requirements of UL 1995.

2.13.1.1 Enclosures

Fabricate enclosures from not lighter than 18 gauge steel, reinforced and braced. Provide enclosures with front panels that are removable and have 1/4 inch closed cell insulation or 1/2 inch thick dual density foil faced fibrous glass insulation. Make the exposed side of a high density, erosion-proof material suitable for use in air streams with velocities up to 4,500 fpm. Provide a discharge grille that is [adjustable] [fixed] and that is of such design as to properly distribute air throughout the conditioned space. Plastic discharge and return grilles are acceptable provided the plastic material is certified by the manufacturer to be classified as flame resistant according to UL 94 and the material complies with the heat deflection criteria specified in UL 1995. Provide galvanized or factory finished ferrous metal surfaces with corrosion resistant enamel, and access doors or removable panels for piping and control compartments, plus easy access for filter replacement. Provide duct discharge collar for concealed models.

2.13.1.2 Fans

Provide steel or aluminum, multiblade, centrifugal type fans. In lieu of metal, fans and scrolls could be of non-metallic materials of suitably reinforced compounds with smooth surfaces. Dynamically and statically balance the fans. Provide accessible assemblies for maintenance. Disassemble and re-assemble by means of mechanical fastening devices and not by epoxies or cements.

2.13.1.3 Coils

Fabricate coils from not less than 3/8 inch outside diameter seamless copper tubing, with copper or aluminum fins mechanically bonded or soldered to the tubes. Provide coils with not less than 1/2 inch outside diameter flare or sweat connectors, accessory piping package with thermal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 300 psi or under water at 250 psi air pressure. Provide coils suitable for 200 psi working pressure. Make provisions for coil removal.

2.13.1.4 Drain Pans

Size and locate drain and drip pans to collect all water condensed on and dripping from any item within the unit enclosure or casing. Provide condensate drain pans designed for self-drainage to preclude the buildup of microbial slime and thermally insulated to prevent condensation and constructed of not lighter than 21 gauge type 304 stainless steel or noncorrosive ABS plastic. Provide insulation with a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and of a waterproof type or coated with a waterproofing material. Design drain pans so as to allow no standing water and pitch to drain. Provide minimum 3/4 inch NPT or 5/8 inch OD drain connection in drain pan. Provide plastic or metal auxiliary drain pans to catch drips from control and piping packages, eliminating insulation of the packages; if metal, provide auxiliary pans that comply with the requirements specified above. Extend insulation at control and piping connections 1 inch minimum over the auxiliary drain pan.

2.13.1.5 Manually Operated Outside Air Dampers

Provide manually operated outside air dampers according to the arrangement indicated, and parallel airfoil type dampers of galvanized construction. Provide blades that rotate on stainless steel or nylon sleeve bearings.

2.13.1.6 Filters

Provide disposable type filter that complies with ASHRAE 52.2. Provide filters in each unit that are removable without the use of tools.

2.13.1.7 Motors

Provide motors of the permanent split-capacitor type with built-in thermal overload protection, directly connected to unit fans. Provide motor switch with two or three speeds and off, manually operated, and mounted on an identified plate [inside the unit below or behind an access door][or][adjacent to the room thermostat][as indicated]. In lieu of the above fan speed control, a solid-state variable-speed controller having a minimum speed reduction of 50 percent is allowed. Provide motors with permanently-lubricated or oilable sleeve-type or combination ball and sleeve-type bearings with vibration isolating mountings suitable for continuous duty. Provide a motor power consumption, shown in watts, at the fan operating speed selected to meet the specified capacity that does not exceed the following values:

Free Discharge Motors			
Unit Capacity (cfm)	Maximum Power Consumption (Watts)		
	115V	230V	277V
200	70	110	90
300	100	110	110
400	170	150	150
600	180	210	220
800	240	240	230
1000	310	250	270
1200	440	400	440

High Static Motors	
Unit Capacity (cfm)	Maximum Power Consumption (Watts)
200	145
300	145
400	210
600	320
800	320
1000	530
1200	530

2.13.2 Coil Induction Units

Provide base unit that includes air plenums, air-discharge nozzles, air discharge grilles, recirculation grilles, water coil assembly, valve and piping package, condensate drain pan, and adjustable air-balancing dampers, plus an enclosure for cabinet models and casing for concealed models. Make each unit capable of producing not less than the capacity indicated without exceeding the indicated static pressure. Provide a sound power level as indicated with power level data or values for these units based on tests conducted according to ASA S12.51. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles.

The values obtained for the standard cabinet models are acceptable for concealed models without separate tests, provided there is no variation between models as to coil configuration, air discharge nozzles, air balancing dampers, or relative arrangement of parts. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Secure each unit to the building structure. Provide units with capacity indicated.

2.13.2.1 Enclosures

Fabricate enclosures from not lighter than 18 gauge steel, reinforced and braced. Provide a removable front panel of enclosure and insulate when required acoustically and to prevent condensation. Provide discharge grilles that are [adjustable][integrally stamped] and properly distribute air throughout the conditioned space. Plastic discharge and return grilles are not acceptable. Provide access doors for all piping and control compartments.

2.13.2.2 Air Plenums

Fabricate plenums from galvanized steel with interior acoustically baffled and lined with sound absorbing material to attenuate the sound power from the primary air supply to the room. Provide heat-resistant nozzles that are integral with or attached airtight to the plenum. Where coil induction units are supplied with vertical runouts, furnish a streamlined, vaned, mitered elbow transition piece for connection between the unit and ductwork. Provide an adjustable air-balancing damper in each unit.

2.13.2.3 Coils

Fabricate coils from not less than 3/8 inch outside diameter seamless copper tubing, with copper or aluminum fins, mechanically bonded or soldered to the tubes. Furnish coil connections with not less than 1/2 inch outside diameter flare or sweat connectors, accessory piping package with terminal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 300 psi or under water at 250 psi air pressure and provide coils suitable for 200 psi working pressure.

2.13.2.4 Screens

Provide easily accessible lint screens or throwaway filters for each unit.

2.13.2.5 Drain Pan

Size and locate drain and drip pans to collect condensed water dripping from any item within the unit enclosure. Provide drain pans constructed of not lighter than 21 gauge steel, galvanized after fabrication, and thermally insulated to prevent condensation. Provide insulation that has a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and that is a waterproof type or coated with a waterproofing material. In lieu of the above, drain pans constructed of die-formed 22 gauge steel are allowed, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 21 gauge steel material or of die-formed 21 gauge type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Provide drain connection when a condensate drain system is indicated. Make connection a minimum 3/4 inch NPT or 5/8 inch OD.

2.13.3 Variable Air Volume (VAV) and Dual Duct Terminal Units

a. Provide VAV and dual duct terminal units that are the type, size, and capacity shown, mounted in the ceiling or wall cavity, plus units that are suitable for single or dual duct system applications. Provide actuators and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. For each VAV terminal unit, provide a temperature sensor in the unit discharge ductwork.

b. Provide unit enclosures that are constructed of galvanized steel not lighter than 22 gauge or aluminum sheet not lighter than 18 gauge. Provide single or multiple discharge outlets as required. Units with flow limiters are not acceptable. Provide unit air volume that is factory preset and readily field adjustable without special tools. [Provide reheat coils as indicated.]

c. Attach a flow chart to each unit. Base acoustic performance of the terminal units upon units tested according to AHRI 880 I-P with the calculations prepared in accordance with AHRI 885. Provide sound power level as indicated. Show discharge sound power for minimum and [1-1/2][_____] inches water gauge inlet static pressure. Provide acoustical lining according to NFPA 90A.

2.13.3.1 Constant Volume, Single Duct Terminal Units

Provide constant volume, single duct, terminal units that contain within the casing, a constant volume regulator. Provide volume regulators that control air delivery to within plus or minus 5 percent of specified air flow subjected to inlet pressure from 3/4 to 6 inch water gauge.

2.13.3.2 Variable Volume, Single Duct Terminal Units

Provide variable volume, single duct, terminal units with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Provide units that control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 3/4 to 6 inch water gauge. Provide units with an internal resistance not exceeding 0.4 inch water gauge at maximum flow range. Provide external differential pressure taps separate from the control pressure taps for air flow measurement with a 0 to 1 inch water gauge range.

2.13.3.3 Variable Volume, Single Duct, Fan-Powered Terminal Units

Provide variable volume, single duct, fan-powered terminal units with a calibrated air volume sensing device, air valve or damper, actuator, fan and motor, and accessory relays. Provide units that control primary air volume to within plus or minus 5 percent of each air set point as determined by the thermostat with variations in inlet pressure from 3/4 to 6 inch water gauge. Provide unit fan that is centrifugal, direct-driven, double-inlet type with forward curved blades. Provide either single speed with speed controller or three-speed, permanently lubricated, permanent split-capacitor type fan motor. Isolate fan/motor assembly from the casing to minimize vibration transmission. Provide factory furnished fan control that is wired into the unit control system. Provide a factory-mounted pressure switch to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

2.13.3.4 Dual Duct Terminal Units

Provide dual duct terminal units with hot and cold inlet valve or dampers that are controlled in unison by single or dual actuators. Provide actuator as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Provide unit that controls delivered air volumes within plus or minus 5 percent with inlet air variations from 1 to 8 inch water gauge in either duct. Include mixing baffles with the unit casing. Provide cabinet and closed duct leakage that does not exceed 2 percent of maximum rated air volume. Provide units with an internal resistance that does not exceed [_____] inch water gauge at maximum flow range.

2.13.3.5 Ceiling Induction Terminal Units

Provide ceiling induction unit with a calibrated primary air volume sensing device, primary air valve, induced air damper, and insulated induction tube. Arrange unit to induce air from the ceiling plenum to maintain a maximum total flow circulated to the conditioned space. Vary primary air upon demand of the room thermostat. Upon a demand for maximum cooling, provide a unit that delivers 100 percent primary air and, at minimum cooling, delivers [50] [25] percent primary air. Provide a terminal unit capable of closing to full shut off without additional actuators or linkage changes. Provide terminals that reset primary air volume within plus or minus 5 percent determined by the thermostat regardless of upstream changes in the static pressure. Provide a minimum inlet static pressure that does not exceed 1 inch water gauge, including a maximum of 0.3 inch water gauge downstream static pressure. Provide external differential pressure taps separate from control pressure taps for primary air flow measurement with 0 to 1 inch water gauge range. Make each unit normally [open] [closed] upon loss of pneumatic pressure. Factory pipe actuator and accuracy controls requiring only field installation of 20 psi pneumatic main air and room thermostat.

2.13.3.6 Series Fan Powered Variable Air Volume (VAV) Terminals

Provide units factory assembled, designed, tested, rated in accordance with AHRI 880 I-P, that are AHRI certified, listed in the AHRI DCAACP and that produce a supply air discharge mix by modulation of conditioned primary air and recirculating of return air. Provide units that include casing, centrifugal fan and motor, primary VAV damper or valve, electronic volume regulator, discharge air damper, primary air inlet cone with high and low pressure flow sensors, recirculating air filter frames, filter, and electrical disconnect. [Provide hot water heating coils integral to the terminal, or provide insulated hot water coil section attached to the discharge of the terminal.]

2.13.3.6.1 Casing

Provide removable full bottom access panels for servicing internal components without disturbing duct connections. Insulate inside of casing with manufacturer's standard insulation. Provide units that have recirculating air inlet equipped with filter frame, round primary damper or valve, and unit mounting brackets.

2.13.3.6.2 Fans and Motors

Provide centrifugal, forward curved, multiblade, fan wheels with direct-drive motors. Provide motors that are the high efficiency permanent-split capacitor type with thermal overload protection, permanently lubricated bearings, and have three speeds or are equipped with solid state speed controllers. Provide isolation between fan motor assembly and unit casing. Provide fan and motor that is removable through casing access panel.

2.13.3.6.3 Flow Sensor

Provide ring or cross type sensor with minimum of two pickup points which average the velocity across the inlet. Obtain flow measurement within plus or minus 5 percent of rated airflow with 1.5 diameters of straight duct upstream of unit and inlet static variation of 0.5 to 5.0 inches water gauge. Supply flow measuring taps and calibration flowchart with each unit for field balancing airflows.

2.13.3.6.4 Primary VAV Damper or Valve

Provide galvanized steel damper blade that closes against gasket inside unit. Connect damper to operating shaft with a positive mechanical connection. Provide nylon bearing for damper shaft. Cylindrical die cast aluminum valve inlet tapered to fit round flexible ducts with integral flow diffuser and beveled self-centering disc. Provide damper or valve leakage at shutoff that does not exceed 2 percent of capacity at 1 inch water gauge pressure.

2.13.3.6.5 Regulator

Provide electronic volume regulator. Electronic controls contained in NEMA ICS 6, Type 1 enclosure sealed from airflow. Provide unit with controls mounted on side or on air valve. System powered regulators are not permitted. Provide volume regulator that resets primary air volume as determined by thermostat, within upstream static pressure variation noted in paragraph titled "Flow Sensor." Provide volume regulators that are field adjustable, factory set and calibrated to indicated maximum and minimum primary airflows, direct acting and normally [open] [closed] upon loss of pneumatic pressure.

2.13.3.6.6 Electrical

Provide unit that incorporates single point electrical connection with electrical disconnect. Provide electrical components that are UL or ETL listed, installed in accordance with NFPA 70 and mounted in control box. Units UL or ETL listed as an assembly do not require airflow switch interlock with electric heating coil, when factory assembled.

2.13.3.6.7 Filters

Provide UL listed throwaway one inch thick fiberglass filters, standard dust-holding capacity.

2.13.3.7 Reheat Units

2.13.3.7.1 Hot Water Coils

Provide fin-and-tube type hot-water coils constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Provide headers that are constructed of cast iron, welded steel or copper. Provide casing and tube support sheets that are 16 gauge, galvanized steel, formed to provide structural strength. Provide tubes that are correctly circuited for proper water velocity without excessive pressure drop and are drainable where required or indicated. At the factory, test each coil at not less than 250 psi air pressure and provide coils suitable for 200 psi working pressure. Install drainable coils in the air handling units with a pitch of not less than 1/8 inch per foot of tube length toward the drain end. Coils must conform to the provisions of AHRI 410.

2.13.3.7.2 Steam Coils

Provide steam coils constructed of cast semisteel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered to the tubes. Roll and bush, braze or weld tubes into headers. Provide coil casings and tube support sheets, with collars of ample width, that are not lighter than 16 gauge galvanized steel formed to provide structural strength. When required, furnish multiple tube supports to prevent tube sag. Float the fin tube and header section within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide coils that are factory pressure tested and capable of withstanding 250 psi hydrostatic test pressure or 250 psi air pressure, and are for [100] [200] psi steam working pressure. Provide steam-distribution tube type preheat coils with condensing tubes having not less than 5/8 inch outside diameters. Provide distribution tubes that have not less than 3/8 inch outside diameter, with orifices to discharge steam to condensing tubes. Install distribution tubes concentric inside of condensing tubes held securely in alignment. Limit the maximum length of a single coil to 120 times the diameter of the outside tube. Other heating coils must be single tube type with an outside diameter not less than 1/2 inch. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Provide coils that conform to the provisions of AHRI 410.

2.13.3.7.3 Electric Resistance Heaters

Provide the duct-mounting type electric resistance heaters consisting of a nickel-chromium resistor mounted on refractory material and a steel or aluminum frame for attachment to ductwork. Provide electric duct heater that meets the requirement of Underwriters Laboratories and NFPA 70 and is provided with a built-in or surface-mounted high-limit thermostat. Interlock electric duct heaters electrically so that they cannot be energized unless the fan is running.

2.13.4 Unit Ventilators

Provide unit ventilators that include an enclosure, [galvanized casing,] [cold-rolled steel casing with corrosion resistant coating,] coil assembly, [resistance heating coil assembly,] [valve and piping package,] drain pan, air filters, fan assembly, fan drive, motor, motor controller, dampers, damper operators, and sound power level as indicated. Obtain sound power level data or values for these units according to test procedures based on AHRI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles, when handling standard flow for which the unit air capacity is rated. Secure each unit to the building structure. Provide the unit ventilators with capacity indicated. Provide the year-round classroom type unit ventilator with automatic controls arranged to properly heat, cool, and ventilate the room. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Make the sequence of control any one of the standard ANSI cycles specified in paragraph CONTROLS.

2.13.4.1 Enclosures

Fabricate enclosures from not lighter than 16 gauge galvanized steel, reinforced and braced, or all welded framework with panels to provide equivalent strength. Provide casing that is acoustically and thermally insulated internally with not less than 1/2 inch thick dual density fibrous glass insulation. Make the exposed side a high density, erosion-proof material suitable for use in air streams with velocities up to 4500 fpm. Fasten the insulation with waterproof, fire-resistant adhesive. Design front panel for easy removal by one person. Provide discharge grilles that [have adjustable grilles or grilles with adjustable vanes and] properly distribute air throughout the conditioned space. Provide return grilles that are removable where front panel does not provide access to interior components. Plastic discharge or return grilles are not acceptable. Furnish removable panels or access doors for all piping and control compartments. Provide fan switch that is key operated or accessible through a locked access panel. Install gaskets at the back and bottom of the unit for effective air seal, as required.

2.13.4.2 Electric Resistance Heating Elements

Provide electric resistance heating elements that are of the sheathed, finned, tubular type, or of the open resistance type designed for direct exposure to the air stream. Provide heating element electrical characteristics as indicated. Where fan motor or control voltage is lower than required for the electric-resistance heating element, install a fused factory mounted and wired transformer.

2.13.4.3 Fans

Provide fans that meet the requirements as specified in paragraph AIR SYSTEMS EQUIPMENT. Provide galvanized steel or aluminum, multiblade, centrifugal type fans, dynamically and statically balanced. Equip fan housings with resilient mounted, self-aligning permanently lubricated ball bearings, sleeve bearings, or combination ball and sleeve bearings, capable of not less than 2000 hours of operation on one oiling. Provide direct-connected fans.

2.13.4.4 Coils

Provide coils that are circuited for a maximum water velocity of 8 fps without excessive pressure drop and are otherwise as specified for hot water coils in paragraph TERMINAL UNITS.

2.13.4.5 Drain Pans

Size and locate drain and drip pans to collect all condensed water dripping from any item within the unit enclosure. Provide drain pans constructed of not lighter than 18 gauge steel, galvanized after fabrication, and thermally insulated to prevent condensation. Provide insulation that is coated with a fire-resistant waterproofing material. In lieu of the above, drain pans constructed of die-formed 20 gauge steel is allowed, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 18 gauge steel material, or of die-formed 18 gauge type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Furnish drain connection unless otherwise indicated. Make the minimum connection 3/4 inch NDT or 5/8 inch OD.

2.13.4.6 Filters

Disposable type rated in accordance with ASHRAE 52.2, installed upstream of coil.

2.13.4.7 Dampers

Provide an outside air proportioning damper on each unit. In addition, provide a vane to prevent excessive outside air from entering unit and to prevent blow-through of outside air through the return air grille under high wind pressures. Where outside air and recirculated air proportioning dampers are provided on the unit, an additional vane is not required. Provide face and bypass dampers for each unit to ensure constant air volume at all positions of the dampers. Furnish each unit with a factory installed control cam assembly, pneumatic motor, or electric motor to operate the face and bypass dampers and outside air damper or outside air and recirculated air dampers in the sequence as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

2.13.4.8 Motors

Provide permanent split-capacitor type motors with built-in thermal overload protection and automatic reset. Mount motor on a resilient mounting, isolated from the casing and suitable for operation on electric service available. Provide a manually operated motor switch that provides for 2 or 3 speeds and off, mounted on an identified plate [inside the unit below or behind an access door][or][adjacent to the room thermostat][as indicated]. In lieu of speed control, provide a solid state variable speed controller having minimum speed reduction of 50 percent.

2.13.4.9 Outside Air Intakes

Provide the manufacturer's standard design outside air intakes furnished with 1/2 inch mesh bird screen or louvers on 1/2 inch centers.

2.14 ENERGY RECOVERY DEVICES

2.14.1 Rotary Wheel

Provide unit that is a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream, with device performance according to ASHRAE 84 and that delivers an energy transfer effectiveness of not less than [70][85][_____] percent with cross-contamination not in excess of [0.1][1.0][_____] percent of exhaust airflow rate at system design differential pressure, including purging sector if provided with wheel. Provide exchange media that is chemically inert, moisture-resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Isolate exhaust and supply streams by seals which are static, field adjustable, and replaceable. Equip chain drive mechanisms with ratcheting torque limiter or slip-clutch protective device. Fabricate enclosure from galvanized steel and include provisions for maintenance access. Provide recovery control and rotation failure provisions as indicated.

2.14.2 Run-Around-Coil

Provide assembly that is factory fabricated and tested air-to-liquid-to-air energy recovery system for transfer of sensible heat from exhaust air to supply air stream and that delivers an energy transfer effectiveness not less than that indicated without cross-contamination with maximum energy recovery at minimum life cycle cost. Computer optimize components for capacity, effectiveness, number of coil fins per inch, number of coil rows, flow rate, heat transfer rate of [_____] percent by volume of [ethylene][propylene] glycol solution, and frost control. Provide coils that conform to paragraph AIR HANDLING UNITS. Provide related pumps, and piping specialties that conform to requirements of [Section 23 63 00.00 COLD STORAGE REFRIGERATION SYSTEMS][Section 23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS][23 69 00.00 20 REFRIGERATION EQUIPMENT FOR COLD STORAGE] [_____].

2.14.3 Heat Pipe

Provide a device that is a factory fabricated, assembled and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply streams and that delivers an energy transfer effectiveness not less than that indicated without cross-contamination. Provide heat exchanger tube core that is [1/2][5/8][1] inch nominal diameter, seamless aluminum or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Provide maximum fins per unit length and number of tube rows as indicated. Provide tubes that are fitted with internal capillary wick, filled with a refrigerant complying with ASHRAE 15 & 34, selected for system design temperature range, and hermetically sealed. Refrigerants containing chlorofluorocarbons (CFC) are prohibited. Provide heat exchanger frame that is constructed of not less than 16 gauge galvanized steel and fitted with intermediate tube supports, and flange connections. Provide tube end-covers and a partition of galvanized steel to separate exhaust and supply air streams without cross-contamination and in required area ratio.[Provide a drain pan constructed of welded Type 300 series stainless steel.] Provide heat recovery regulation by [system face and bypass dampers and related control system as indicated][interfacing with manufacturer's standard tilt-control mechanism for summer/winter operation, regulating the supply air temperature and frost prevention on weather face of exhaust side at temperature indicated]. Coil must be fitted with pleated flexible connectors.

2.14.4 Desiccant Wheel

Provide counterflow supply, regeneration airstreams, a rotary type dehumidifier designed for continuous operation, and extended surface type wheel structure in the axial flow direction with a geometry that allows for laminar flow over the operating range for minimum air pressure differentials. Provide the dehumidifier complete with a drive system utilizing a fractional-horsepower electric motor and speed reducer assembly driving the rotor. Include a slack-side tensioner for automatic take-up for belt-driven wheels. Provide an adsorbing type desiccant material. Apply the desiccant material to the wheel such that the entire surface is active as a desiccant and the desiccant material does not degrade or detach from the surface of the wheel which is fitted with full-face, low-friction contact seals on both sides to prevent cross leakage. Provide rotary structure that has underheat, overheat and rotation fault circuitry. Provide wheel assembly with a warranty for a minimum of five years.

2.14.5 Plate Heat Exchanger

Provide energy recovery ventilator unit that is factory-fabricated for indoor installation, consisting of a flat plate cross-flow heat exchanger, cooling coil, supply air fan and motor and exhaust air fan and motor. The casing must be 20 gauge G90, galvanized steel, double wall construction with one inch insulation. Provide fibrous desiccant cross-flow type heat exchanger core capable of easy removal from the unit.

2.15 FACTORY PAINTING

Factory paint new equipment, which are not of galvanized construction. Paint with a corrosion resisting paint finish according to ASTM A123/A123M or ASTM A924/A924M. Clean, phosphatize and coat internal and external ferrous metal surfaces with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. Submit evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors. Provide rating of failure at the scribe mark that is not less than 6, average creepage not greater than 1/8 inch. Provide rating of the inscribed area that is not less than 10, no failure. On units constructed of galvanized steel that have been welded, provide a final shop docket of zinc-rich protective paint on exterior surfaces of welds or welds that have burned through from the interior according to ASTM D520 Type I.

Field paint factory painting that has been damaged prior to acceptance by the Contracting Officer in compliance with the requirements of paragraph FIELD PAINTING OF MECHANICAL EQUIPMENT.

2.16 SUPPLEMENTAL COMPONENTS/SERVICES

2.16.1 Chilled, Condenser, or Dual Service Water Piping

The requirements for chilled, condenser, or dual service water piping and accessories are specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS

2.16.2 Refrigerant Piping

The requirements for refrigerant piping are specified in Section 23 23 00 REFRIGERANT PIPING.

2.16.3 Water or Steam Heating System Accessories

The requirements for water or steam heating accessories such as expansion tanks and steam traps are specified in Section [23 52 00 HEATING BOILERS][23 21 13.00 20 LOW TEMPERATURE WATER (LTW) HEATING SYSTEM][23 22 26.00 20 STEAM SYSTEM AND TERMINAL UNITS].

2.16.4 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate in accordance with Section [22 00 00 PLUMBING, GENERAL PURPOSE][23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS] except as modified herein.

2.16.5 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.16.6 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.16.7 Controls

The requirements for controls are specified in [Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS][and][Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][and][Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS].

2.17 RADIANT PANELS

2.17.1 Hydronic Modular Panels

2.17.1.1 Panels

Modular radiant panels will fit into a standard 24 inch x 24 inch or 24 inch x 48 inch suspended T-Bar ceiling grid or flush mounted on a drywall ceiling. For flush mounted ceiling applications, the manufacturer will provide a one piece extruded aluminum frame. Panels must be supported from the T-bar assembly. Panels must be [14 gauge] or [16 gauge] extruded aluminum or sheet steel.

2.17.1.2 Heat Sink

The modular panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face.

2.17.1.3 Water Tubes

Tubes must consist of ASTM B75/B75M [1/2 inch] [5/8 inch] O.D. nominal copper tubing. Water connections will be suitable for solder or compression fittings. Heat pads will be used between the soldered fitting and the panel to protect the panel surface. The manufacturer will provide water pressure drop data as well as heating and cooling output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling). The panels will have the capacity to have multiple passes with connections either on the [same end] or [opposite ends], dependent on the number of passes.

2.17.1.4 Finish

All visible components must be powder coated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Standard finish color must be white.

2.17.1.5 Performance

Manufacturer will provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.17.1.6 Capacity

Modular radiant panel capacity will be tested and certified by manufacturer in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling) to meet the required performance. Should any performance rating, chilled or hot water supply temperature, water pressure drop, etc. deviate from the schedule, the manufacturer will submit the updated capacity. [The manufacturer will have factory testing facility available to perform performance test of units in accordance with said standard.]

2.17.1.7 Water Connections

Connections will be shipped sealed to limit the introduction of dust and dirt during shipping and construction.

2.17.1.8 Installation

Panels will be installed as recommended by the manufacturer.

2.17.1.9 Accessories

Stainless steel braded hoses, 12 inches or 18 inches long will be supplied with the panels.

The top of the heating and cooling panels must be covered with1-1/2 inches thick 1 lb/cu ft formaldehyde-free fiber glass insulation with a minimum R = 4.5 (hr ft2 deg F)/BTU. The insulation must be covered with a foil scrim kraft vapor barrier facing.

2.17.2 Hydronic Linear Panels

2.17.2.1 Panels

Linear radiant panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below. Panels must be [14 gauge] or [16 gauge] extruded aluminum.

2.17.2.2 Heat Sink

The modular panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face.

2.17.2.3 Water Tubes

Tubes must consist of ASTM B75/B75M 1/2 inch or 5/8 inch O.D. nominal copper tubing. Water connections will be suitable for solder or compression fittings. The manufacturer will provide water pressure drop data as well as heating and cooling output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.17.2.4 Mounting

Units must be provided with mounting hardware as required for mounting in T-Bar applications or ceiling flush mounting. The manufacturer's standard hardware for mounting panels abutting each other must be submitted for approval.

2.17.2.5 Finish

All visible components must be powder coated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Standard finish color must be white.

2.17.2.6 Performance

Manufacturer must provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.17.2.7 Capacity

Modular radiant panel capacity must be tested and certified by manufacturer in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling) to meet the required performance. Should any performance rating, chilled or hot water supply temperature, water pressure drop, etc. deviate from the schedule, the manufacturer must submit the updated capacity. [The manufacturer must have factory testing facility available to perform performance test of units in accordance with said standard.]

2.17.2.8 Water Connections

Connections will be shipped sealed to limit the introduction of dust and dirt during shipping and construction.

2.17.2.9 Accessories

Stainless steel braded hoses, 12 inches or 18 inches long will be supplied with the panels.

The top of the heating and cooling panels must be covered with 1-1/2 inches thick 1 lb/cu ft formaldehyde-free fiber glass insulation with a minimum R = 4.5 (hr ft2 deg F)/BTU. The insulation must be covered with a foil scrim kraft vapor barrier facing.

2.17.3 Prefabricated Radiant-Heating Electric Panels

2.17.3.1 Description

Sheet metal enclosed panel with heating element suitable for [lay-in installation flush with T-bar ceiling grid] [surface mounting] [recessed mounting]. Comply with UL 2021

2.17.3.2 Panel

Minimum 0.027 inch thick, galvanized steel sheet back panel riveted to minimum 0.040 inch thick, galvanized steel sheet front panel with fused-on crystalline surface.

2.17.3.3 Heating Element

Powdered graphite sandwiched between sheets of electric insulation.

2.17.3.4 Electrical Connections

Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.

2.17.3.5 Exposed-Side Panel Finish

[Apply silk-screened finish to match appearance of Architect selected acoustical ceiling tiles.] [Baked-enamel finish in color as selected by Architect.]

2.17.3.6 Surface-Mounting Trim

Sheet metal with baked-enamel finish in color as selected by Architect.

2.17.3.7 Wall Thermostat

Bimetal, sensing elements; with contacts suitable for [low] [line]-voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

a. Install materials and equipment in accordance with the requirements of the contract drawings and approved manufacturer's installation instructions. Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.

b. No installation is permitted to block or otherwise impede access to any existing machine or system. Install all hinged doors to swing open a minimum of 120 degrees. Provide an area in front of all access doors that clears a minimum of [3][_____] feet. In front of all access doors to electrical circuits, clear the area the minimum distance to energized circuits as specified in OSHA Standards, part 1910.333 (Electrical-Safety Related work practices)and an additional [3][_____] feet.

c. Except as otherwise indicated, install emergency switches and alarms in conspicuous locations. Mount all indicators, to include gauges, meters, and alarms in order to be easily visible by people in the area.

3.2.1 Condensate Drain Lines

Provide water seals in the condensate drain from all [units] [units except room [fan-coil units][and][coil-induction units]]. Provide a depth of each seal of 2 inches plus the number of inches, measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Provide water seals that are constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Provide pipe cap or plug cleanouts where indicated. Connect drains indicated to connect to the sanitary waste system using an indirect waste fitting. Insulate air conditioner drain lines as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. Anchor and fasten as detailed. Set floor-mounted equipment on not less than 6 inch concrete pads or curbs doweled in place unless otherwise indicated. Make concrete foundations heavy enough to minimize the intensity of the vibrations transmitted to the piping, duct work and the surrounding structure, as recommended in writing by the equipment manufacturer. In lieu of a concrete pad foundation, build a concrete pedestal block with isolators placed between the pedestal block and the floor. Make the concrete foundation or concrete pedestal block a mass not less than three times the weight of the components to be supported. Provide the lines connected to the pump mounted on pedestal blocks with flexible connectors. Submit foundation drawings as specified in paragraph DETAIL DRAWINGS. Provide concrete for foundations as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.3 Access Panels

Install access panels for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance of sufficient size, and locate them so that the concealed items are easily serviced and maintained or completely removed and replaced. Provide access panels as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.2.4 Flexible Duct

Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Provide hangers, when required to suspend the duct, of the type recommended by the duct manufacturer and set at the intervals recommended.

3.2.5 Metal Ductwork

Install according to SMACNA 1966 unless otherwise indicated. Install duct supports for sheet metal ductwork according to SMACNA 1966, unless otherwise specified. Do not use friction beam clamps indicated in SMACNA 1966. Anchor risers on high velocity ducts in the center of the vertical run to allow ends of riser to move due to thermal expansion. Erect supports on the risers that allow free vertical movement of the duct. Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, provide suitable intermediate metal framing. Where C-clamps are used, provide retainer clips.

3.2.5.1 Underground Ductwork

Provide PVC plastisol coated galvanized steel underground ductwork with coating on interior and exterior surfaces and watertight joints. Install ductwork as indicated, according to ACCA Manual 4 and manufacturer's instructions. Maximum burial depth is 6 feet.

3.2.5.2 Radon Exhaust Ductwork

Perforate subslab suction piping where indicated. Install PVC joints as specified in ASTM D2855.

3.2.5.3 Light Duty Corrosive Exhaust Ductwork

For light duty corrosive exhaust ductwork, use PVC plastisol coated galvanized steel with PVC coating on interior [surfaces][and exterior surfaces][and epoxy wash primer coating on exterior surfaces].

3.2.6 FRP Ductwork

Provide fibrous glass reinforced plastic ducting and related structures that conform to SMACNA 1403. Provide flanged joints where indicated. Crevice-free butt lay-up joints are acceptable where flanged joints are not indicated. When ambient temperatures are lower than 50 degrees F, heat cure joints by exothermic reaction heat packs.

3.2.7 Kitchen Exhaust Ductwork

3.2.7.1 Ducts Conveying Smoke and Grease Laden Vapors

Provide ducts conveying smoke and grease laden vapors that conform to requirements of NFPA 96. Make seams, joints, penetrations, and duct-to-hood collar connections with a liquid tight continuous external weld. Provide duct material that is a [minimum 18 gauge, Type 304L or 316L, stainless steel] [minimum 16 gauge carbon steel]. [Include with duct construction an external perimeter angle sized in accordance with SMACNA 1966, except place welded joint reinforcement on maximum of 24 inch centers; continuously welded companion angle bolted flanged joints with flexible ceramic cloth gaskets where indicated; pitched to drain at low points; welded pipe coupling-plug drains at low points; welded fire protection and detergent cleaning penetration; steel framed, stud bolted, and flexible ceramic cloth gasketed cleaning access provisions where indicated. Make angles, pipe couplings, frames, bolts, etc., the same material as that specified for the duct unless indicated otherwise.]

3.2.7.2 Exposed Ductwork

Provide exposed ductwork that is fabricated from minimum 18 gauge, Type 304L or 316L, stainless steel with continuously welded joints and seams. Pitch ducts to drain at hoods and low points indicated. Match surface finish to hoods.

3.2.7.3 Concealed Ducts Conveying Moisture Laden Air

Fabricate concealed ducts conveying moisture laden air from minimum [18 gauge, Type 300 series, stainless steel] [16 gauge, galvanized steel] [16 ounce, tempered copper sheet]. Continuously weld, braze, or solder joints to be liquid tight. Pitch ducts to drain at points indicated. Make transitions to other metals liquid tight, companion angle bolted and gasketed.

3.2.8 Acoustical Duct Lining

Apply lining in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C916, Type I, NFPA 90A, UL 723, and ASTM E84. Provide top and bottom pieces that lap the side pieces and are secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA 1966. Provide welded pins, cup-head pins, or adhered clips that do not distort the duct, burn through, nor mar the finish or the surface of the duct. Make pins and washers flush with the surfaces of the duct liner and seal all breaks and punctures of the duct liner coating with the nonflammable, fire resistant adhesive. Coat exposed edges of the liner at the duct ends and at other joints where the lining is subject to erosion with a heavy brush coat of the nonflammable, fire resistant adhesive, to prevent delamination of glass fibers. Apply duct liner to flat sheet metal prior to forming duct through the sheet metal brake. Additionally secure lining at the top and bottom surfaces of the duct by welded pins or adhered clips as specified for cut-to-size pieces.

Other methods indicated in SMACNA 1966 to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, are acceptable.

3.2.9 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, perform temporary dust control protection. Protect the distribution system (supply and return) with temporary seal-offs at all inlets and outlets at the end of each day's work. Keep temporary protection in place until system is ready for startup.

3.2.10 Insulation

Provide thickness and application of insulation materials for ductwork, piping, and equipment according to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Externally insulate outdoor air intake ducts and plenums [up to the point where the outdoor air reaches the conditioning unit][or][up to the point where the outdoor air mixes with the return air stream].

3.2.11 Duct Test Holes

Provide holes with closures or threaded holes with plugs in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Plug insulated duct at the duct surface, patched over with insulation and then marked to indicate location of test hole if needed for future use.

3.2.12 Power Roof Ventilator Mounting

Provide foamed 1/2 inch thick, closed-cell, flexible elastomer insulation to cover width of roof curb mounting flange. Where wood nailers are used, predrill holes for fasteners.

3.2.13 Power Transmission Components Adjustment

Test V-belts and sheaves for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Uniformly load belts on drive side to prevent bouncing. Make alignment of direct driven couplings to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.3 EQUIPMENT PADS

Provide equipment pads to the dimensions shown or, if not shown, to conform to the shape of each piece of equipment served with a minimum 3-inch margin around the equipment and supports. Allow equipment bases and foundations, when constructed of concrete or grout, to cure a minimum of [28][14][_____] calendar days before being loaded.

3.4 CUTTING AND PATCHING

Install work in such a manner and at such time that a minimum of cutting and patching of the building structure is required. Make holes in exposed locations, in or through existing floors, by drilling and smooth by sanding. Use of a jackhammer is permitted only where specifically approved. Make holes through masonry walls to accommodate sleeves with an iron pipe masonry core saw.

3.5 CLEANING

Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks. When the work area is in an occupied space such as office, laboratory or warehouse [_____] protect all furniture and equipment from dirt and debris. Incorporate housekeeping for field construction work which leaves all furniture and equipment in the affected area free of construction generated dust and debris; and, all floor surfaces vacuum-swept clean.

3.6 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Place sleeves for round duct 15 inches and smaller. Build framed, prepared openings for round duct larger than 15 inches and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide one inch clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with ASTM C553, Type 1, Class B-2.

3.6.1 Sleeves

Fabricate sleeves, except as otherwise specified or indicated, from 20 gauge thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A53/A53M, Schedule 20.

3.6.2 Framed Prepared Openings

Fabricate framed prepared openings from 20 gauge galvanized steel, unless otherwise indicated.

3.6.3 Insulation

Provide duct insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS continuous through sleeves and prepared openings except firewall penetrations. Terminate duct insulation at fire dampers and flexible connections. For duct handling air at or below 60 degrees F, provide insulation continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air.

3.6.4 Closure Collars

Provide closure collars of a minimum 4 inches wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 15 inches in diameter or less from 20 gauge galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with minimum dimension over 15 inches from 18 gauge galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 15 inches or less from 20 gauge galvanized steel. Install collars with fasteners a maximum of 6 inches on center. Attach to collars a minimum of 4 fasteners where the opening is 12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 20 inches in diameter or less.

3.6.5 Firestopping

Where ducts pass through fire-rated walls, fire partitions, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.7 FIELD PAINTING OF MECHANICAL EQUIPMENT

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except clean to bare metal on metal surfaces subject to temperatures in excess of 120 degrees F. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Provide aluminum or light gray finish coat.

3.7.1 Temperatures less than 120 degrees F

Immediately after cleaning, apply one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat to metal surfaces subject to temperatures less than 120 degrees F.

3.7.2 Temperatures between 120 and 400 degrees F

Apply two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of two mils to metal surfaces subject to temperatures between 120 and 400 degrees F.

3.7.3 Temperatures greater than 400 degrees F

Apply two coats of 315 degrees C 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of two mils to metal surfaces subject to temperatures greater than 400 degrees F.

3.7.4 Finish Painting

The requirements for finish painting of items only primed at the factory, and surfaces not specifically noted otherwise, are specified in Section 09 90 00 PAINTS AND COATINGS.

3.7.5 Color Coding Scheme for Locating Hidden Utility Components

Use scheme in buildings having suspended grid ceilings. Provide color coding scheme that identifies points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid, consisting of a color code board and colored metal disks. Make each colored metal disk approximately 3/8 inch diameter and secure to removable ceiling panels with fasteners. Insert each fastener into the ceiling panel so as to be concealed from view. Provide fasteners that are manually removable without the use of tools and that do not separate from the ceiling panels when the panels are dropped from ceiling height. Make installation of colored metal disks follow completion of the finished surface on which the disks are to be fastened. Provide color code board that is approximately 3 foot wide, 30 inches high, and 1/2 inches thick. Make the board of wood fiberboard and frame under glass or 1/16 inch transparent plastic cover. Make the color code symbols approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters. Mount the color code board [where indicated] [in the mechanical or equipment room]. Make the color code system as indicated below:

Color	System	Item	Location
[_____]	[_____]	[_____]	[_____]

3.8 IDENTIFICATION SYSTEMS

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Provide tags that are 1-3/8 inch minimum diameter with stamped or engraved markings. Make indentations black for reading clarity. Attach tags to valves with No. 12 AWG 0.0808-inch diameter corrosion-resistant steel wire, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.9 DUCTWORK LEAK TEST

Perform ductwork leak test for the entire air distribution and exhaust system, including fans, coils, [filters, etc.][filters, etc. designated as static pressure Class 3 inch water gauge through Class 10 inch water gauge.] Provide test procedure, apparatus, and report that conform to SMACNA 1972 CD. The maximum allowable leakage rate is [_____] cfm. Complete ductwork leak test with satisfactory results prior to applying insulation to ductwork exterior or concealing ductwork.

3.10 DUCTWORK LEAK TESTS

The requirements for ductwork leak tests are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

3.11 DAMPER ACCEPTANCE TEST

Submit the proposed schedule, at least 2 weeks prior to the start of test. Operate all fire dampers and smoke dampers under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Test each fire damper equipped with fusible link by having the fusible link cut in place. Test dynamic fire dampers with the air handling and distribution system running. Reset all fire dampers with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, install the damper so it is square and free from racking.

3.12 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC. Begin testing, adjusting, and balancing only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.13 PERFORMANCE TESTS

Conduct performance tests as required in Section 23 05 93 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control for HVAC.

3.14 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Inside of [room fan-coil units][coil-induction units,] [air terminal units,] [unit ventilators,] thoroughly clean ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Provide temporary filters prior to startup of all fans that are operated during construction, and provide new filters after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Perform and document that proper "Indoor Air Quality During Construction" procedures have been followed; provide documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions. Maintain all equipment installed under the contract until close out documentation is received, the project is completed and the building has been documented as beneficially occupied.

3.15 RADIANT PANELS

3.15.1 Installation

Install radiant panels level and plumb, maintaining sufficient clearance for normal services and maintenance.

3.15.2 Soldering

When soldering copper fittings at the panel, a heat pad will be used to protect the panel finish.

3.15.3 Connections

Install piping adjacent to radiant panels to allow for service and maintenance.

3.16 OPERATION AND MAINTENANCE

3.16.1 Operation and Maintenance Manuals

Submit [six] [_____] manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit Data Package 3 for the items/units listed under SD-10 Operation and Maintenance Data

3.16.2 Operation And Maintenance Training

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of [_____] hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Submit the proposed On-site Training schedule concurrently with the Operation and Maintenance Manuals and at least 14 days prior to conducting the training course.

-- End of Section --

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SECTION 23 31 13.00 40

METAL DUCTS
08/22

PART 1 GENERAL

[Section 23 30 00 HVAC AIR DISTRIBUTION apply to work specified in this section.

][Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT applies to work in this section.

][Section 40 17 30.00 40 WELDING GENERAL PIPING applies to work specified in this section.

]1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual
AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE EQUIP IP HDBK	(2012) Handbook, HVAC Systems and Equipment (IP Edition)
ASHRAE FUN IP	(2021) Fundamentals Handbook, I-P Edition

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A924/A924M	(2022) Standard Specification for General Requirements for Steel Sheet,

	Metallic-Coated by the Hot-Dip Process
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D257	(2014) Standard Test Methods for D-C Resistance or Conductance of Insulating Materials
ASTM E477	(2020) Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 150	(2016) National Voluntary Laboratory Accreditation Program Procedures and General Requirements
NIST HB 150-8	(2018) NVLAP Acoustical Testing Services

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1966	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition
SMACNA 1987	(2006) HVAC Duct Systems Inspection Guide, 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Painting Manual	(2002) Good Painting Practice, Steel Structures Painting Manual, Volume 1

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 2480	(2009; Rev H) Phosphate Treatment, Paint, Base

UNDERWRITERS LABORATORIES (UL)

UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S"

classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists; G[, [____]]

Records of Existing Conditions; G[, [____]]

SD-02 Shop Drawings

Connection Diagrams; G[, [____]]

Offset Fitting Configurations; G[, [____]]

SD-03 Product Data

Equipment and Performance Data

Galvanized Steel Ductwork Materials; G[, [____]]

Brazing Materials

Mill-Rolled Reinforcing and Supporting Materials

Round Sheet Metal Duct Fittings; G[, [____]]

Round, High-Pressure, Double-Wall Sheet Metal Ducts; G[, [____]]

Turning Vanes; G[, [____]]

Sound Attenuators; G[, [____]]

Flexible Connectors; G[, [____]]

Flexible Duct Materials

Power-Operated Dampers; G[, [____]]

Fire Dampers and Wall Collars; G[, [____]]

Gravity Backdraft and Relief Dampers; G[, [____]]

Manual Volume Dampers; G[, [____]]

SD-05 Design Data

Design Analysis and Calculations; G[, [____]]

SD-06 Test Reports

Ductwork Leakage Tests; G[, [____]]

Operational Tests; G[, [____]]

SD-07 Certificates

Listing of Product Installations

Galvanized Steel Ductwork Materials

Brazing Materials

Mill-Rolled Reinforcing and Supporting Materials

Round Sheet Metal Duct Fittings

Round, High-Pressure, Double-Wall Sheet Metal Ducts

Turning Vanes

Dampers

Sound Attenuators

Flexible Connectors

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [____]]

Power Operated Dampers; G[, [____]]

Fire Dampers and Wall Collars; G[, [____]]

SD-11 Closeout Submittals

Record Drawings; G[, [____]]

1.3 QUALITY CONTROL

When furnishing the listing of product installations for medium and high pressure ductwork systems include identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. Include purchaser, address of installation, service organization, and date of installation.

PART 2 PRODUCTS

Include the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information within material, equipment, and fixture lists.

2.1 SYSTEM DESCRIPTION

Provide low-pressure systems ductwork and plenums where maximum air velocity is 2,000-feet per minute(fpm) and maximum static pressure is 2-inches water gage (wg), positive or negative.

Submit connection diagrams for low pressure ductwork systems indicating the relation and connection of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

High velocity systems ductwork encompass systems where:

a. Minimum air velocity exceeds 2,000-feet per minute (fpm) or static pressure exceeds 2-inches water gage (wg).

[b. Medium static pressure ranges from over 2-inches wg through 3-inches wg, positive or negative, or over 3-inches wg through 6-inches wg positive.

][c. High static pressure ranges from over 6-inches wg through 10-inches wg, positive.

] d. Do not use rigid fibrous-glass ductwork.

2.1.1 Design Requirements

Submit records of existing conditions including the results of a survey consisting of work area conditions, and features of existing structures and facilities within and adjacent to the jobsite.

Submit equipment and performance data for medium and high pressure ductwork systems consisting of use life, system functional flows, safety features, and mechanical automated details. Submit test response and performance characteristics curves for certified equipment.

Submit design analysis and calculations for ductwork systems indicating the manufacturer's recommended air velocities, maximum static pressure, and temperature calculations.

2.2 COMPONENTS

2.2.1 Round Sheet Metal Duct Fittings

Submit offset fitting configurations for approval. Shop fabricate fittings.

2.2.1.1 Fittings Construction

Manufacture as separate fittings, not as tap collars welded or brazed into duct sections.

Provide two-piece type miter elbows for angles less than 31 degrees, three-piece type for angles 31 through 60 degrees, and five-piece type for angles 61 through 90 degrees. Ensure centerline radius of elbows is 1-1/2 times fitting cross section diameter.

Provide conical type crosses, increasers, reducers, reducing tees, and 90-degree tees.

Ensure cutouts in fitting body are equal to branch tap dimension or, where smaller, excess material is flared and rolled into smooth radius nozzle configuration.

2.2.2 Round, High-Pressure, Double-Wall Sheet Metal Ducts

Shop fabricate ducts and fittings.

Construction comprises of an airtight, vapor barrier, outer pressure shell, a 1 inch insulation layer, and a metal inner liner that completely covers the insulation throughout the system.

Provide insulation conforming to NFPA 90A and ASTM C1071 for thermal conductivity in accordance with ASTM D257.

2.2.3 Reinforcement

Support inner liners of both duct and fittings by metal spacers welded in position to maintain spacing and concentricity.

2.2.4 Fittings

Make divided flow fittings as separate fittings, not tap collars into duct sections, with the following construction requirements:

a. Sound, airtight, continuous welds at intersection of fitting body and tap

b. Tap liner securely welded to inner liner, with weld spacing not to exceed 3-inches.

c. Pack insulation around the branch tap area for complete cavity filling.

d. Carefully fit branch connection to cutout openings in inner liner without spaces for air erosion of insulation and without sharp projections that cause noise and airflow disturbance.

Continuously braze seams in the pressure shell of fittings. Protect galvanized areas that have been damaged by welding with manufacturer's standard corrosion-resistant coating.

Construct two-piece type elbows for angles through 35 degrees, three-piece type for angles 36 through 71 degrees, and five-piece type for angles 72 through 90 degrees.

[Provide conical type crosses, increasers, reducers, reducing tees, and 90-degree tees.

]2.2.5 Turning Vanes

Provide double-wall type turning vanes, commercially manufactured for high-velocity system service.

2.2.6 Dampers

Construct low pressure drop, high-velocity manual volume dampers, and high-velocity fire dampers in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

2.2.7 Sound Attenuators

[Provide sound attenuators.

] Ensure the pressure drop at the rated flow does not exceed ratings in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966 or design criteria.

Ensure the sound attenuators is airtight when operating under an internal pressure of 0.37 pounds per square inch. Provide an air-side surface capable of withstanding air velocities of 10,000-feet per minute without any particulate matter leaving the trap and being carried downstream.

2.2.7.1 Attenuation

Factory fabricate sound attenuators. Confirm pressure drop measurements in accordance with ASHRAE EQUIP IP HDBK, Chapter 18. Units shall be tested in accordance with ASTM E477 silencer test standard in aero-acoustical test facility which is NVLAP accredited for ASTM E477 standard. Submit copy of laboratory's NVLAP accreditation certificate on dynamic insertion loss, self-noise power levels, and aerodynamic performance according to the requirements of NIST HB 150 and NIST HB 150-8. Conduct tests with standard metal inlet and outlet connections under indicated capacity flow.

[Ensure attenuation is in accordance with ASHRAE FUN IP. Include a graphic system noise spectrum certification indicating proposed fan sound power level. Attenuation of ducting system proposed for installation is based on ASHRAE FUN IP for bends, branches, and other duct system construction noise criteria curve.
]
Reduce fan-rated sound-power level to not less than 65 decibels in the 250-hertz third octave band when measured at the sound attenuation discharge end.

2.2.7.2 Construction of Sound Attenuators

Provide double-metal walled, [round] [rectangular] sound attenuators. Provide mill-galvanized sheet metal steel with commercial weight of zinc, conforming to ASTM A653/A653M. Exterior metal acts as a vapor barrier. Metal thickness is not less than that required for the pressure service, in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966, but not less than 22-gage. Cover absorbing material, on the sound-impinging side, with formed perforated mill-galvanized steel of not less than 24-gage. Ensure all exterior sheet joints are continuously welded, or construct with locksets filled with neoprene mastic prior to forming.

Spot weld interior surfaces not more than 3-inches on center. Ensure all connections to duct transitions are flanged with through-bolted 1/8-inch by 1-inch continuous rubber gasketing. Provide vibration isolated trapeze type supports.

Provide fibrous glass absorption material. [Ensure surfaces exposed to airstream are neoprene coated or protected with woven fibrous-glass cloth conforming to ASTM C1071.]Ensure the total compressed thickness gives the required attenuation, and thermal insulation to preclude condensation on exterior surface under normal operating conditions. Compressed material density is approximately 4.5 pounds per cubic foot. Select materials conforming to fire hazard requirements of NFPA 90A.

2.2.8 Flexible Connectors for Sheet Metal

Use UL listed connectors, 30-ounce per square yard, waterproof, fire-retardant, airtight, woven fibrous-glass cloth, double coated with neoprene. Clear width, not including clamping section, is 6 to 8-inches.

[Provide leaded vinyl sheets as a second layer for sound attenuation. Ensure leaded vinyl is not less than 0.055-inch thick, weighing not less than 0.87 pound per square foot, and capable of approximately 10-decibel attenuation in the 10- to 10,000-hertz range.

]2.2.9 Duct Hangers

For duct hangers in contact with galvanized duct surfaces, provide [galvanized] [black carbon] steel painted with inorganic zinc.

2.2.10 Mill-Rolled Reinforcing and Supporting Materials

Provide mill-rolled structural steel conforming to ASTM A36/A36M. Whenever in contact with sheet metal ducting, provide galvanized steel in accordance with ASTM A123/A123M.

In lieu of mill-rolled structural steel, submit equivalent strength, proprietary-design, rolled-steel structural support systems for approval.

2.2.11 Flexible Duct Materials

Ensure flexible duct connectors comply with NFPA 90A, and conform with UL 181, Class 1 material.

[Provide [aluminum] [carbon steel] zinc-coated ASTM A123/A123M metal duct; bendable through 180 degrees without damage, with an inside bend radius not greater than one-half the diameter of duct.

][Provide wire-reinforced cloth duct consisting of a [neoprene] [vinyl-impregnated and coated] fibrous-glass cloth bonded to and supported by a corrosion-protected spring steel helix. Fabric may be a laminate of metallic film and fibrous glass. Ensure working pressure rating of ducting is not less than three times maximum system pressure, and the temperature range is minus 20 to plus 175 degrees F.

][Provide wire-reinforced fibrous-glass duct consisting of a minimum [1] [_____] 1 pound/cubic foot density fibrous glass, bonded to and supported by corrosion-protected spring helix. Vapor barriers are a minimum of [4] [_____] mil, pigmented polyvinylchloride film. Ensure duct is bendable without damage through 180 degrees with an inside bend radius not greater than two duct diameters. Minimum wall thickness is [1][_____]-inch. Thermal conductivity is not greater than [0.23 BTU per hour per square foot per degrees F] [_____] at 75 degrees F mean temperature. Ensure permeance is not greater than [0.10 perm] [_____]. Working pressure range is from minus [1/2][_____]-inch wg to plus [1-1/2][_____]-inches wg. Working temperature ranges from minus 20 to plus 250 degrees F. Minimum sustained velocity without delamination is [2,400] [_____] fpm. Use materials conforming to NFPA 90A.

]2.2.12 Manual Volume Dampers

Conform to SMACNA 1966 for volume damper construction.

Equip dampers with an indicating quadrant regulator with a locking feature externally located and easily accessible for adjustment and standoff brackets to allow mounting outside external insulation. Where damper rod lengths exceed [30][_____]-inches, provide a regulator at each end of damper shaft.

2.2.12.1 Damper Construction

Provide all damper shafts with two-end bearings.

Ensure splitter damper is[[22] [_____]-gage sheet metal][and is [2]

[_____] gages heavier than duct in which installed]. Hinges are [full length piano-type][1/8-inch thick door type].

Provide a full length damper shaft and extend it beyond the damper blade. use a [3/8] [_____]-inch square shaft for damper lengths up to [20] [_____]-inches and a [1/2] [______]-inch square shaft for damper lengths [20] [_____]-inches and larger. Where necessary to prevent damper vibration or slippage, provide adjustable support rods with locking provisions external to duct at damper blade end.

Provide dampers in ducts having a width perpendicular to the axis of the damper that is greater than [12] [_____]-inches of multiblade type having a substantial frame with blades fabricated of [16] [_____]-gage metal. Provide blades not exceeding [10] [_____]-inches in width and [48] [______]-inches in length, [pinned] [welded] to [1/2] [_____]-inch diameter shafts. Ensure dampers greater than [48] [_____]-inches in width are made in two or more sections with intermediate mullions, each section being mechanically interlocked with the adjoining section or sections. Provide blades with [graphite-impregnated nylon] [oil-impregnated sintered bronze] bearings and connect so that adjoining blades rotate in opposite directions.

2.2.13 Gravity Backdraft and Relief Dampers

Construct frames of not less than [1-1/2- by 4-inch] [_____] reinforced [16-gage] [_____] galvanized carbon steel. Solidly secure frames and mullions in place and seal with elastomer caulking against air bypass.

Provide shaft bearings with [graphite-impregnated nylon] [oil-impregnated bronze].

Equip counterbalanced dampers with fixed or adjustable counterbalancing weights.

Gravity backdraft dampers may be equipment manufacturer's standard construction in sizes[18 by 18][_____]-inch or smaller, when furnished integral with air moving equipment.

2.2.13.1 Blade Construction

Maximum blade width is [9] [_____] inches, and maximum blade length is [36] [_____]-inches. Blade material is[16-gage galvanized steel][14-gage [6063] [5052] alloy aluminum][18-gage AISI 18-8 corrosion-resistant steel]. Provide blades with mechanically retained seals and 90-degree limit stops.

Blades linked together for relief service dampers are to open not less than 30 degrees on 0.05-inch wg differential pressure.

2.2.14 Power-Operated Dampers

Ensure dampers conform to applicable requirements specified under Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC.

2.2.15 Fire Dampers and Wall Collars

Ensure fire damper locations are in accordance with NFPA 90A.

Provide fire dampers in ductwork at firewall barriers.

Construct and label fire dampers in accordance with UL 555 to provide damper and mounting fire-resistance that equals or exceeds fire-resistance of the construction in which installed. For link loads in excess of [20] pounds[_____], provide UL-approved quartzoid links.

Construct wall collars in accordance with UL 555.

2.3 MATERIALS

2.3.1 Galvanized Steel Ductwork Materials

Provide hot-dip galvanized carbon steel ductwork sheet metal of lock-forming quality, with regular spangle-type zinc coating, conforming to ASTM A924/A924M and ASTM A653/A653M, Designation G90. Treat duct surfaces to be painted by annealing.

Conform to ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966 for sheet metal gages and reinforcement thickness.

Low pressure ductwork minimum thicknesses are:

MINIMUM SHEET METAL THICKNESS	
DUCT WIDTH	GAGE
0-12	26
13-30	24
31-60	22

2.3.2 Brazing Materials

Provide silicon bronze brazing materials conforming to AWS A5.8/A5.8M.

2.3.3 Mill-Rolled Reinforcing and Supporting Materials

Conform to ASTM A36/A36M for mill-rolled structural steel. Wherever in contact with sheet metal ducting, galvanize to conforming with ASTM A123/A123M [SSPC Painting Manual].

In lieu of mill-rolled structural steel, submit for approval, equivalent strength, proprietary design, rolled-steel structural support systems.

[2.3.4 Manufactured [Round][Round Or Flat Oval] Ductwork (Positive Pressure)

Duct and fittings suitable to positive 10 inches WG. Ducts shall be machine formed round and/or flat oval as shown on drawings, constructed of G90 galvanized steel. Use spiral lockseam construction. Longitudinal seam construction may be used for ductwork over 80 inches diameter with minimum 16 ga. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.

Unless otherwise indicated, connection shall be slip type with minimum 2 inches insertion length or flanged joint in accordance with manufacturer's recommendations. When flange joints are required, use Van Stone angle rings welded to duct. Internal bracing is not allowed.

]PART 3 EXECUTION

3.1 PREPARATION

For sheet metal surfaces to be painted, and surfaces to which adhesives are to be applied, clean surface of oil, grease, and deleterious substances.

Ensure strength is adequate to prevent failure under service pressure or vacuum created by fast closure of duct devices. Provide leaktight, automatic relief devices.

3.1.1 Construction Standards

Provide sheet metal construction in accordance with the recommendations for best practices in ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32, SMACNA 1966, and NFPA 90A.

Design and fabricate supplementary steel in accordance with AISC 360 and AISC 325.

Where construction methods for certain items are not described in the referenced standards or herein, perform the work in accordance with recommendations for best practice defined in ASHRAE EQUIP IP HDBK.

3.2 INSTALLATION

Fabricate an airtight system. Include reinforcements, bracing, supports, framing, gasketing, sealing, and fastening to provide rigid construction and freedom from vibration, airflow-induced motion and noise, and excessive deflection at specified maximum system air pressure and velocity.

Provide offsets and transformations as required to avoid interference with the building construction, piping, or equipment.

Make plenum anchorage provisions, sheet metal joints, and other areas airtight and watertight by caulking, mating galvanized steel and concrete surfaces with a two-component elastomer.

3.2.1 Jointing

Enclose dampers located behind architectural intake or exhaust louvers by a rigid sheet metal collar and sealed to building construction with elastomers for complete air tightness.

Provide outside air-intake ducts and plenums made from sheet metal with soldered watertight joints.

3.2.2 Ducts

Wherever ducts pass through firewalls or through walls or floors dividing conditioned spaces from unconditioned spaces, provide a flanged segment in that surface during surface construction.

Where interiors of ducting may be viewed through air diffusion devices, construct the viewed interior with sheet metal and paint flat black.

3.2.2.1 Ductwork Cleaning Provisions

Protect open ducting from construction dust and debris in a manner approved by the Contracting Officer. Clean dirty assembled ducting by subjecting all main and branch interior surfaces to airstreams moving at velocities two times specified working velocities, at static pressures within maximum ratings. This may be accomplished by: filter-equipped portable blowers which remain the Contractor's property; wheel-mounted, compressed-air operated perimeter lances which direct the compressed air and which are pulled in the direction of normal airflow; or other means approved by the Contracting Officer. Use water- and oil- free compressed air for cleaning ducting. After construction is complete, and prior to acceptance of the work, remove construction dust and debris from exterior surfaces. [Clean in conformance with SMACNA 1987.]

3.3 APPLICATION

3.3.1 Low Pressure Sheet Metal Ducts

Weld angle iron frames at corners and ends, whenever possible. Rivet or weld angle iron reinforcements to ducts not more than [6]-inches [_____] on center, with not less than [two] [_____] points of attachment. Spot welding, where used, is 3-inches on center.

Seal standard seam joints with an elastomer compound to comply with SMACNA 1966 Seal Class A, B or C as applicable.

Limit crossbreaking to [4][_____]-feet and provide on all ducts [8][_____]-inches wide and wider. Provide bead reinforcement in lieu of crossbreaking where panel popping may occur. Where rigid insulation is applied, crossbreaking is not required.

3.3.1.1 Longitudinal Duct Seams

Provide Pittsburgh lock [_____] corner seams.

3.3.1.2 Joints and Gaskets

Bolt companion angle flanges together with [1/4] [_____]-inch diameter bolts and nuts spaced [6] [_____]-inches on center. Gasket flanged joints with neoprene full-face gaskets [1/8] [_____]-inch thick, with Shore A 40 durometer hardness. Use one piece gaskets, [vulcanized] [dovetailed] at joints.

3.3.1.3 Flexible Duct Joints

Between flexible duct without sheet metal collars and round metal ductwork connections make joints by trimming the ends, coating the inside of the flexible duct for a distance equal to depth of insertion with elastomer caulk, and by securing with sheet metal screws or binding with a strap clamp.

3.3.1.4 Square Elbows

[Provide single-vane duct turns in accordance with SMACNA 1966[, use on ducts 12 inches in width and narrower].

][Provide double-vane duct turns in accordance with SMACNA 1966.

]

3.3.1.5 Radius Elbows

Conform to SMACNA 1966 for radius elbows. Provide an inside radius equal to the width of the duct. Where installation conditions preclude use of standard elbows, the inside radius may be reduced to a minimum of [0.25] [_____] times duct width. Install turning vanes in accordance with the following schedule.

	RADIUS OF TURNING VANES IN PERCENT OF DUCT WIDTH		
WIDTH OF ELBOWS INCHES	VANE NO. 1	VANE NO. 2	VANE NO. 3
Up to 16	56	--	--
17 to 48	43	73	--
49 and over	37	55	83

Where two elbows are placed together in the same plane for ducts 30-inches wide and larger, continue the guide vanes through both elbows rather than spaced in accordance with above schedule.

3.3.1.6 Outlets, Inlets, and Duct Branches

Install branches, inlets, and outlets so that air turbulence is reduced to a minimum and air volume properly apportioned. Install adjustable splitter dampers at all supply junctions to permit adjustment of the amount of air entering the branch. Wherever an air-diffusion device is shown as being installed on the side, top, or bottom of a duct, and whenever a branch take-off is not of the splitter type; provide a commercially manufactured 45 degree side-take-off (STO) fitting with manual volume damper to allow adjustment of the air quantity and to provide an even flow of air across the device or duct it services.

Where a duct branch is to handle more than [25] [_____] percent of the air handled by the duct main, use a complete 90-degree increasing elbow with an inside radius of [0.75] [_____] times branch duct width. Size of the leading end of the increasing elbow within the main duct with the same ratio to the main duct size as the ratio of the related air quantities handled.

Where a duct branch is to handle [25] [_____] percent or less of the air handled by the duct main, construct the branch connection with a 45 degree side take-off entry in accordance with SMACNA 1966.

3.3.1.7 Duct Transitions

Where the shape of a duct changes, ensure the angle of the side of the transition piece does not exceed [15] [_____] degrees from the straight run of duct connected thereto.

Where equipment is installed in ductwork, ensure the angle of the side of the transition piece from the straight run of duct connected thereto does not exceed [15] [_____] degrees on the upstream side of the equipment and [22-1/2] [_____] degrees on the downstream side of the equipment.

3.3.1.8 Branch Connections

Construct radius tap-ins in accordance with SMACNA 1966.

3.3.1.9 Access Openings

Construct access door in accordance with SMACNA 1966, except that sliding doors may be used only for special conditions upon prior approval. Provide double-panel type doors.

Install access doors and panels in ductwork [upstream from coils] [upstream and downstream from coils] [adjacent to fire dampers] [at controls or at any item requiring periodic inspection, adjustment, maintenance, or cleaning] [where indicated], and every 20-feet for indoor air quality housekeeping purposes.

Minimum access opening size is [12 by 18] [_____]-inches, unless precluded by duct dimensions or otherwise indicated.

Make airtight access doors that leak by adding or replacing hinges and latches or by construction of new doors adequately reinforced, hinged, and latched.

[3.3.1.10 Duct Access for Cleaning

Make duct access particularly suitable for commercial duct cleaning methods utilizing vacuum devices. Space access openings with a frequency and at points that permits ready access to duct internals with essentially no duct or insulation cutting. Where access through an air-diffusion device or through access doors specified herein is not available at a specific point, provide [8] [_____]-inch diameter, [16] [_____]-gage access plates not more than [10] [_____]-feet on center. Where duct is insulated and vapor-sealed, provide mastic seals around circumference of access. When access plate is in place and insulated, externally identify the location.

]3.3.1.11 Plenum Construction

Provide intake and discharge plenum companion angle joints with the following minimum thickness of materials:

LONGEST ANGLES SIDE INCHES	SHEET METAL USS GAGE ALL SIDES	COMPANION ANGLES INCHES	REINFORCEMENT 24 INCHES ON CENTER MAXIMUM
To 48	20	1-1/2 by 1-1/2 by 1/8	1-1/2 by 1-1/2 by 1/8
49 to 84	18	2 by 2 by 1/8	2 by 2 by 3/16
85 to 120	16	2 by 2 by 1/8	2 by 2 by 1/8
121 and larger	14	2 by 2 by 3/16	2 by 2 by 3/16

At the floor line and other points where plenums join masonry construction, bolt panels [12] [_____]-inches on center to [2- by 2- by 3/16] [_____]-inch thick hot-dip galvanized steel angle that has been secured to the masonry with masonry anchors and bolts [24][_____]-inches on center and caulked tight to the masonry.

Anchor panels to curbing with hot-dip galvanized steel angle iron of a size not less than [2- by 2- by 3/16] [_____]-inch thick. Concrete curbing includes angle iron nosing with welded studs for the anchoring of panels. Level nosing at curb height within plus or minus [1/16] [_____]-inch.

Weld and grind miter corners for angle iron and channel iron.

3.3.1.12 Plenum Door Construction

Construct plenum access doors in accordance with SMACNA 1966 except that access doors smaller than man-access doors have door openings framed with angle iron that is one commercial size smaller than the specified panel reinforcement.

Ensure man-access door size conforms to SMACNA 1966 and paragraph ACCESS OPENINGS. Insulated and uninsulated construction is per SMACNA 1966. Frame door openings with channel iron. Frame doors with angle iron. Size channel iron and angle iron approximately the same size as specified panel reinforcement. Provide exterior door skin [16] [_____] gage. Fabricate latches from steel with hinges at least [4] [_____]-inches long, and bolts at least [3/8] [_____]-inch diameter.

3.3.1.13 Manual Volume Dampers

Provide balancing dampers of the splitter, butterfly, or multilouver type, to balance each respective main and branch duct.

For dampers regulated through ceilings provide a regulator concealed in a box mounted in the ceiling, with a cover finish aesthetically compatible with ceiling surface. Where ceiling is of removable construction, set regulators above the ceiling, and mark the location on ceiling in a manner acceptable to the Contracting Officer.

3.3.1.14 Flexible Connectors for Sheet Metal

Connect air handling equipment, ducts crossing building expansion joints, and fan inlets and outlets to upstream and downstream components by treated woven-cloth connectors.

Install connectors only after system fans are operative, and vibration isolation mountings have been adjusted. When system fans are operating, ensure connectors are free of wrinkles caused by misalignment or fan reaction. Width of surface is curvilinear.

3.3.2 Rectangular Sheet Metal Ducts

3.3.2.1 Medium-Pressure Gages, Joints, and Reinforcement

Ensure minimum sheet metal gages, joints, and reinforcements between joints are in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

Ensure sheet metal minimum thickness, transverse reinforcement between joints, and joints of ducts are in accordance with the following:

LONGEST SIDE (INCHES)	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE (INCHES)	REINFORCEMENT ANGLES 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
97 to 108	16	2 by 2 by 1/8, two tie rods along angle	Two 2 by 2 by 1/8, two tie rods along angle
109 to 132	16	2 by 2 by 3/16, two tie rods along angle	Two 2 by 2 by 3/16, two tie rods along angle

LONGEST SIDE (INCHES)	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE (INCHES)	REINFORCEMENT ANGLES 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
133 and longer	14	2 by 2 by 3/16, with tie rods every 48 inches	Two 2 by 2 by 3/16, with tie rods every 48 inches

3.3.2.2 Medium- And High-Pressure Branches, Inlets, Outlets

Install branches, inlets, and outlets to minimize air turbulence and to ensure proper airflow.

Install dampers so that the amount of air entering duct mains is adjustable.

Provide commercially manufactured air extractors to allow adjustment of the air quantity and to provide an even flow of air across the device or duct served.

3.3.2.3 Duct Branch Transition

Where a duct branch handles over 25 percent of the air transported by the duct main, use a complete 90-degree increasing elbow, with an inside radius of 0.75 times duct branch width. Ensure the size of the trailing end of the increasing elbow within the main duct has the same ratio to the main duct size as the ratio of the relative air quantities handled.

Where a duct branch is to handle 25 percent or less of the air handled by the duct main, provide a branch connection with an inside radius of 0.75 times branch duct width, a minimum arc length of 45 degrees, and an outside radius of 1.75 times duct branch width. Place arc tangent to duct main.

3.3.2.4 High-Pressure Gages, Joints, and Reinforcement

Ensure sheet metal minimum thickness, joints, and reinforcement between joints are in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

Use the following types of ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966 joints and seams:

Transverse Joints:

a. Welded flange joint [with] [without] angle

b. Companion angle flanged joint

Longitudinal Seams:

a. Approved lock seams, back brazed, or continuously brazed seams for ducts with largest dimension up to 72-inches

b. Continuously welded or brazed seams for ducts with largest dimension greater than 72-inches

Sheet metal minimum thickness, transverse reinforcement between joints, and companion angle joints of ducts with longest side greater than 96 inches are in accordance with the following:

LONGEST SIDE (inches)	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE (inches)	REINFORCEMENT ANGLES 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
97 to 108	16	2 by 2 by 1/8, two tie rods along angle	*Two 2 by 2 by 1/8, two tie rods along angle
109 to 132	16	2 by 2 by 3/16, two tie rods along angle	*Two 2 by 2 by 3/16, two tie rods along angle
133 and longer	14	2-1/2 by 2-1/2 by 3/16, with tie rods every 24 inches	*Two 2-1/2 by 2-1/2 by 3/16, with tie rods every 24 inches

3.3.3 Round Sheet Metal Ducts

3.3.3.1 Duct Gages and Reinforcement

Sheet metal minimum thickness, joints, and reinforcement between joints shall be in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

Provide ducts with supplemental girth angle supports, riveted with [solid rivets 6 inches on center] [tack welded] [brazed] to duct. Locate girth angles as follows:

DIAMETER, INCHES	REINFORCEMENT-MAXIMUM SPACING INCHES
25 to 36	1-1/4 by 1-1/4, 1/8 thick, 72 inches on center
37 to 50	1-1/4 by 1-1/4, 1/8 thick, 60 inches on center
51 to 60	1-1/2 by 1-1/2, 1/8 thick, 48 inches on center

Use hex-shaped bolt heads and nuts, 5/16-inch diameter for ducts up to 50-inch diameter, and 3/8-inch diameter for 51-inch diameter ducts and larger.

[Continuously weld] [Braze] flanges to duct on outside of duct and intermittently welded with 1-inch welds every 4-inches on inside joint face. Remove excess filler metal from inside face. Protect galvanized areas that have been damaged by welding with manufacturer's standard corrosion-resistant coating.

3.3.3.2 Duct Joints

Provide duct joints manufactured by machine, with spiral locksets up to and including 60-inch diameters, and to dimensional tolerances compatible with fittings provided. Draw-band girth joints are not acceptable.

Prepare slip joints by coating the male fitting with elastomer sealing materials, exercising care to prevent mastic from entering fitting bore. Leave only a thin annular mastic line exposed internally. Use sheet metal screws to make assembly rigid, not less than four screws per joint, maximum spacing 6-inches. Do not use pop rivets. Tape and heat seal all joints.

3.3.3.3 Duct Transitions

[Where the shape of a duct changes, ensure the angle of the side of the transition piece does not exceed 15 degrees from the straight run of duct connected thereto.

] Where equipment is installed in ductwork, ensure the angle of the side of the transition piece from the straight run of duct connected thereto does not exceed 15 degrees on the upstream side of the equipment and 22-1/2 degrees on the downstream side of the equipment.

3.3.4 Round, High Pressure, Sheet Metal Duct Installation

3.3.4.1 Joints

Provide an inner coupling to align the inner lining to maintain good airflow conditions equivalent to standard round high-pressure duct joints. Butt joints are not suitable for the inner liner. Accomplish this alignment by [extending the liner of the fitting for slip joint into the pipe] [the use of a double concentric coupling with the two couplings held by spacers for rigidity and wall spacing]. For ducts over 34-inches inside diameter, provide a separate coupling for inner alignment, with the pressure shells joined by angle-ring flanged connections.

3.3.4.2 Insulation Ends

At the end of an uninsulated section or run where internally insulated duct connects to uninsulated spiral duct, fitting, fire damper or flexible duct, install an insulated end-fitting to bring the outer pressure shell down to nominal size.

3.3.5 Transverse Reinforcement Joints

Provide transverse reinforcements that are [riveted with solid rivets to duct sides 6 inches on center] [spot welded 4 inches on center]. Weld transverse reinforcement at [all corners] [ends] to form continuous frames.

3.3.6 Joint Gaskets

For flanged joints, use neoprene full-face gaskets 1/8-inch thick, with Shore A 40 durometer hardness. Use one-piece gaskets, [vulcanized] [dovetailed] at joints.

3.3.7 Radius Elbows

Fabricate elbow proportions and radius elbows in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

3.3.8 Plenum Connections

Ensure round duct connections are welded joint bellmouth type.

Ensure rectangular duct connections are bellmouth type, constructed in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

3.3.9 Access Openings

Install access panels in ductwork adjacent to fire dampers.

Minimum size of access opening is 12 by 18 inches, unless precluded by duct dimension.

Frame access openings with welded and ground miter joints, 1/8-inch thick [strap steel] [angle iron], with [1/4] [3/8]-inch studs welded to frame. Ensure cover plates are not less than[16-gage, reinforced as necessary for larger sizes] [constructed of 12-gage metal].

In lieu of access doors, use readily accessible flanged duct sections upon approval. Provide stable hanger supports for disconnected duct terminal.

3.3.10 Duct Supports

Install duct support in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966. Meet the minimum size for duct hangers as specified in ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966. Provide two hangers where necessary to eliminate sway. Support attachment to duct surfaces by [solid rivet] [bolt] [welding] 4-inches on center.

Take the following into account in selection of a hanging system:

a. Location and precedence of work under other sections

b. Interferences of various piping and electrical conduit

c. Equipment, and building configuration

d. Structural and safety factor requirements

e. Vibration, and imposed loads under normal and abnormal service conditions

Support sizes, configurations, and spacing are given to show the minimal type of supporting components required. If installed loads are excessive for the specified hanger spacing, hangers, and accessories [provide heavier-duty components] [reduce hanger spacing]. After system startup, replace any duct support device which due to length, configuration, or size, vibrates or causes possible failure of a member. Do not use a ductwork support system that allows a cascade-type failure to occur.

Do not hang ductwork and equipment from roof deck, piping, or other ducts or equipment. Maximum span between any two points is 10-feet, with lesser spans as required by duct assemblies, interferences, and permitted loads imposed.

[Where support from metal deck systems is involved, coordinate support requirements with installation of metal deck.

][3.3.10.1 Double-wall Ducts

Provide round, double-wall duct supports as recommended by the manufacturer except that minimum hanger ring and strap size is 1-1/2 inches by 1/8 inch.

]3.3.10.2 Hangars

Attach hanger rods, angles, and straps to beam clamps. Receive approval from the Contracting Officer for concrete inserts, masonry anchors, and fasteners for the application.

Hardened high-carbon spring-steel fasteners fitted onto beams and miscellaneous structural steel are acceptable upon prior approval of each proposed application and upon field demonstration of conformance to specification requirements. Make fasteners from steel conforming to AISI Type [1055] [1070], treated and finished in conformance with SAE AMS 2480, Type Z (zinc phosphate base), Class 2 (supplementary treatment). Verify a 72-hour load-carrying capacity by a certified independent laboratory.

Where ductwork system contains heavy equipment, excluding air-diffusion devices and single-leaf dampers, hang such equipment independently of the ductwork by means of rods or angles of sizes adequate to support the load.

Cross-brace hangers to preclude swaying both vertically and laterally.

3.3.10.3 Installation

Ensure hanger spacing gives a 20-to-1 safety factor for supported load.

Maximum load supported by any two fasteners is 100 pounds.

Install hangers on both sides of all duct turns, branch fittings, and transitions.

Friction rod assemblies are not acceptable.

3.3.10.4 Strap-type Hangars

Support rectangular ducts up to 36-inches by strap-type hangers attached at not less than three places to not less than two duct surfaces in different planes.

Perforated strap hangers are not acceptable.

3.3.10.5 Trapeze Hangars

Support rectangular ducting, 36-inches and larger, by trapeze hangers. Support ducts situated in unconditioned areas and required to have insulation with a vapor-sealed facing on trapeze hangers. Space hangers far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside the trapeze. Do not penetrate the vapor-sealed facing with duct hangers.

Where trapeze hangers are used, support the bottom of the duct on angles sized as follows:

WIDTH OF DUCT, INCHES	MINIMUM BOTTOM ANGLE SIZE, INCHES
30 and smaller	1-1/4 by 1-1/4 by 1/8
31 to 48	1-1/2 by 1-1/2 by 1/8
49 to 72	1-1/2 by 1-1/2 by 3/16
73 to 96	2 by 2 by 1/4
97 and wider	3 by 3 by 1/4

3.3.10.6 Purlins

Do not support ducting from roof purlins at points greater than one-sixth of the purlin span from the roof truss. Do not exceed 400 pounds load per hanger.

If the hanger load must exceed the above limit, provide reinforcing of purlin(s) or additional support beam(s). When an additional beam is used, have the beam bear on the top chord of the roof trusses, and also bear over the gusset plates of top chord. Stabilize the beam by connection to roof purlin along bottom flange.

Purlins used for supporting fire-protection sprinkler mains, electrical lighting fixtures, electrical power ducts, or cable trays are considered fully loaded. Provide supplemental reinforcing or auxiliary support steel for these purlins when used to support ductwork.

3.3.10.7 Vibration Isolation

[Isolate the structure from duct support vibration at points indicated. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

][Provide vibration isolators in discharge ducting system for a distance not less than 50-feet beyond the air handling unit. Coordinate deflection of duct and equipment mountings.

]3.3.11 Flexible Connectors for Steel Metal

Connect air-handling equipment, ducts crossing building expansion joints, and fan inlets and outlets to upstream and downstream components with treated woven-cloth connectors.

Install connectors only after system fans are operative and all vibration isolation mountings have been adjusted. When system fans are operating, ensure connectors are free of wrinkles caused by misalignment or fan reaction. Width of surface is curvilinear.

3.3.12 Insulation Protection Angles

Provide galvanized 20-gage sheet, formed into an angle with a 2-inch exposed long leg with a 3/8-inch stiffening break at outer edge, and with a variable concealed leg, depending upon insulation thickness.

Install angles over all insulation edges terminating by butting against a wall, floor foundation, frame, and similar construction. Fasten angles in place with blind rivets through the protection angle, insulation, and sheet metal duct or plenum. Install angles after final insulation covering has been applied.

3.3.13 Duct Probe Access

Provide holes with neat patches, threaded plugs, or threaded or twist-on caps for air-balancing pitot tube access. Provide extended-neck fittings where probe access area is insulated.

3.3.14 Openings In Roofs and Walls

Existing building openings are fixed in size and cannot be resized without authorization. Provide equipment to suit existing opening size.

3.4 FIELD QUALITY CONTROL

[3.4.1 Fire Damper Tests

Perform operational tests on each fire damper in the presence of the Contracting Officer by enervating a fusible link with localized heat. Provide and install new links after successful testing.

]3.4.2 Ductwork Leakage Tests

Conduct complete leakage test of new ductwork in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Perform tests prior to installing ductwork insulation.

[3.4.3 Inspection

Inspect ductwork in accordance with SMACNA 1987.

]3.5 CLOSEOUT ACTIVITIES

3.5.1 Operation and Maintenance

Submit [6] [_____] copies of the operation and maintenance manuals 30 calendar days prior to testing the medium and high pressure ductwork systems. Update data and resubmit for final approval no later than 30 calendar days prior to contract completion.

Ensure operation and maintenance manuals are consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions.

3.5.2 Record Drawings

Provide record drawings with current factual information. Include deviations from, and amendments to, the drawings. Include concealed or visible changes in the work. Label drawings "As-Built".

-- End of Section --

SECTION 23 33 56

SELF-ACTING BLAST VALVES
02/09

PART 1 GENERAL

1.1 SUMMARY

This section specifies self-acting blast valve systems consisting of blast valve units and mountings.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 303	(2016) Code of Standard Practice for Steel Buildings and Bridges
AISC 325	(2017) Steel Construction Manual
AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2012) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS A5.4/A5.4M	(2012) Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding
AWS B2.1/B2.1M	(2021) Specification for Welding Procedure and Performance Qualification
AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A27/A27M	(2020) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A108	(2013) Standard Specification for Steel

	Bar, Carbon and Alloy, Cold-Finished
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A148/A148M	(2020; E 2020) Standard Specification for Steel Castings, High Strength, for Structural Purposes
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A159	(1983; R 2020) Standard Specification for Automotive Gray Iron Castings
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A220/A220M	(1999; R 2018; E 2018) Standard Specification for Pearlitic Malleable Iron
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A276/A276M	(2017) Standard Specification for Stainless Steel Bars and Shapes
ASTM A278/A278M	(2001; R 2020) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A297/A297M	(2021a) Standard Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A313/A313M	(2017) Standard Specification for Stainless Steel Spring Wire
ASTM A351/A351M	(2018) Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A439/A439M	(2018) Standard Specification for Austenitic Ductile Iron Castings
ASTM A447/A447M	(2011; R 2021) Standard Specification for Steel Castings, Chromium-Nickel-Iron Alloy

	(25-12 Class), for High-Temperature Service
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A560/A560M	(2012; R 2018) Standard Specification for Castings, Chromium-Nickel Alloy
ASTM A564/A564M	(2019) Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A666	(2015) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B85/B85M	(2018) Standard Specification for Aluminum-Alloy Die Castings
ASTM B108/B108M	(2019) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B211/B211M	(2019) Standard Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire
ASTM B221	(2021) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Structural Supports by Contractor; G[, [_____]]

Submit fabrication, erection, and installation drawings showing framing layouts, elevations, sections, enlarged details, casing locations with dimensions, connections, and material designations.

SD-03 Product Data

Valve Systems

When data shows several products, identify the actual products proposed.

Manufacturer's Field Service

SD-05 Design Data

Structural Supports by Contractor

SD-06 Test Reports

Blast Tests on Prototype Valve Units

Factory Air Flow Tests

Field Tests

Include an analysis and interpretation of test results in the field test reports.

SD-07 Certificates

Valve Systems

Certify that the valves provided were manufactured using the same materials, dimensions and tolerances as blast tested prototype valve units and that air flow and pressure drop rating meet specification requirements. Each certificate must be signed by an official authorized to certify on behalf of the manufacturer and must identify the quantity and date of shipment or delivery to which the certificate applies.

SD-08 Manufacturer's Instructions

Valve Systems

Submit manufacturer's instructions for valve unit and casing installation and field testing.

SD-10 Operation and Maintenance Data

Systems Manual

Information bound in manual format; in both hard copy and electronic.

1.4 QUALITY ASSURANCE

Welders, welding operators, welding procedures, and weld inspectors must be qualified in accordance with AWS B2.1/B2.1M or AWS D1.1/D1.1M, as applicable.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect valve units, casings, and accessories delivered and placed in storage from weather, excessive humidity and temperature variation, and dirt, dust, or other contaminants.

1.6 WARRANTY

Furnish manufacturer's written warranty covering valve units for 2 years after installation and acceptance by the Government. Provide for repair or replacement of the valve units in the event of malfunction due to defects in materials or workmanship except that finishes need only be warranted for 1 year and the warranty need not cover cleaning and other normal maintenance.

PART 2 PRODUCTS

2.1 VALVE SYSTEMS DESCRIPTION

Provide all valve units and valve mountings from one manufacturer. Submit valve unit data that shows complete dimensions and completely describe overpressure ratings, pass-through impulse leakage ratings, air flow rates, actuation mechanisms, and materials.

2.1.1 Sustained Blast Overpressures

Operate casing mounted [supply valve] [exhaust valve] [valve] units under a zero rise time, sustained (infinite duration) blast overpressure of [260] [160] [40] [_____] psi [, and operate casing mounted exhaust valve units under a zero rise time, sustained (infinite duration) blast overpressure of [260] [160] [40] [_____] psi.] [Operate valve units mounted in [supply] [exhaust] [diesel engine exhaust] piping or ducts under a zero rise time, sustained (infinite duration) blast overpressure of [260] [160] [40] [_____] psi.]

2.1.2 Blast Overpressure Waveforms

Operate casing mounted [supply valve] [exhaust valve] [valve] units under a triangular blast overpressure waveform having a zero rise time and a peak overpressure and duration of [_____] psi and [_____] milliseconds [, and operate casing mounted exhaust valve units under a triangular blast overpressure waveform having a zero rise time and a peak overpressure and duration of [_____] psi and [_____] milliseconds]. [Operate valve units mounted in [supply] [exhaust] [diesel engine exhaust] piping or ducts under a triangular blast overpressure waveform having a zero rise time and a peak overpressure and duration of [_____] psi and [_____] milliseconds.] [Operate valve units under triangular blast overpressure waveforms having a zero rise time and the peak overpressures and durations indicated.] [Operate valve units under the blast waveforms indicated.]

2.1.3 Performance Requirements

2.1.3.1 Field Removable Valve Units

Provide blast valve units that are completely removable from casings or other mountings.

2.1.3.2 Penetrations

Except for air flow openings, seal penetrations through the valve system against blast leakage through the penetration.

2.2 MATERIALS

2.2.1 Iron Castings

Provide iron castings conforming to ASTM A47/A47M, ASTM A48/A48M, ASTM A159, ASTM A220/A220M, ASTM A278/A278M, ASTM A439/A439M, or ASTM A536.

2.2.2 Steel Castings

Provide carbon and alloy steel castings conforming to ASTM A27/A27M Grades U-60-30, 65-35, 70-36 or 70-40, or ASTM A148/A148M.

2.2.3 Corrosion Resistant Alloy Steel Castings

Provide corrosion resistant alloy steel castings conforming to ASTM A297/A297M, ASTM A351/A351M, ASTM A447/A447M, or ASTM A560/A560M.

2.2.4 Structural Steel

Provide structural steel conforming to ASTM A36/A36M.

2.2.5 Stainless Steel

2.2.5.1 Plate, Sheet, and Strip

Provide stainless steel plate, sheet, and strip conforming to ASTM A167, ASTM A240/A240M, or ASTM A666.

2.2.5.2 Bars and Shapes

Provide stainless steel bars and shapes conforming to ASTM A276/A276M or ASTM A564/A564M.

2.2.5.3 Spring Wire

Provide stainless steel spring wire conforming to ASTM A313/A313M.

2.2.6 Aluminum

2.2.6.1 Castings

Provide aluminum-alloy castings conforming to ASTM B85/B85M or ASTM B108/B108M.

2.2.6.2 Sheet and Plate

Provide aluminum sheet and plate conforming to ASTM B209.

2.2.6.3 Bars and Rods

Provide aluminum bars and rods conforming to ASTM B211/B211M ASTM B221.

2.2.7 Anchors

Provide concrete anchors conforming to ASTM A36/A36M, ASTM A108 or ASTM A307.

2.2.8 Primer

Provide primer conforming to SSPC Paint 25.

2.3 COMPONENTS

Furnish valves that close under the positive blast overpressures specified or indicated and that are fully operational after the blast.

2.3.1 Blast Operation of Valves Mounted in Casing Supports

[Provide single-acting nonlatching [supply valves] [valves] that automatically return to the open position except that double-acting valves that close under both positive and negative overpressure may be substituted for single-acting valves.] [Provide double-acting nonlatching [supply valves] [valves] that close under both positive and negative blast pressure and automatically return to the open position.] [Provide latching [supply valves] [valves] that remain in the closed position until manually released.] [Provide single-acting nonlatching exhaust valves that automatically return to the open position except that double-acting valves that close under both positive and negative overpressure may be substituted for single-acting valves.] [Provide double-acting nonlatching exhaust valves that close under both positive and negative blast pressure and automatically return to the open position.] [Provide latching exhaust that remain in the closed position until manually released.]

2.3.2 Blast Operation of Valves Mounted in Piping or Ducts

[Mount single-acting nonlatching valves in diesel engine exhaust piping or ducts that return to the open position under the diesel exhaust pressure.] [Mount single-acting nonlatching [supply valves] [valves] in piping or ducts that automatically return to the open position except that double-acting valves that close under both positive and negative overpressure may be substituted for single-acting valves.] [Mount double-acting nonlatching [supply valves] [valves] in piping or ducts that close under both positive and negative blast pressure and automatically return to the open position.] [Mount latching [supply valves] [valves] in piping or ducts that remain in the closed position until manually released.] [Mount single-acting nonlatching exhaust valves that automatically return to the open position except that double-acting valves that close under both positive and negative overpressure may be substituted for single-acting valves.] [Mount double-acting nonlatching exhaust valves in piping or ducts that close under both positive and negative blast pressure and automatically return to the open position.] [Mount latching exhaust valves in piping or ducts that remain in the closed position until manually released.]

2.3.3 Pass Through Impulse

The incident pass-through impulse leakage behind the valve must not exceed [7] [20] [_____] psi-milliseconds [for supply valves nor [7] [20] [_____] psi-milliseconds for exhaust valves].

2.3.4 Minimum Operating Overpressure

Provide valves that completely close under a minimum blast overpressure of [0.6] [_____] psi.

2.3.5 Operating Temperatures

Furnish valve units that are fully operational over [a temperature range from [-4 to 170] [[_____] to [_____]] degrees F] [a temperature range from [-4 to 170] [[_____] to [_____]] degrees F for supply valves and [-4 to 300] [[_____] to [_____]] degrees F for exhaust valves] [the temperature ranges indicated] [except that the maximum operating temperature for valves mounted in diesel exhaust piping or ducts less than [850] [1200] [_____] degrees F is prohibited].

2.3.6 Air Flow Capacity

Provide valves meeting the air flow rates [and pressure drops] indicated on the valve schedules. [The total pressure drop across each casing mounted supply and exhaust valve must not exceed [1] [_____] inch of water gauge at the air flows indicated.] [The total pressure drop across each valve mounted in [diesel engine exhaust] [supply and exhaust] piping or ducts must not exceed [_____] inch of water gauge at the flows indicated.]

2.4 ACCESSORIES

Furnish blast valve systems complete with valve units, casings, fasteners, anchors, and all other accessories required to provide a complete, operable installation.

2.5 STRUCTURAL SUPPORTS BY CONTRACTOR

In lieu of the concrete openings and supports indicated, the Contractor may design openings and supports to accommodate the proposed valve system. Provide submittals when concrete opening and framing systems require changes to accommodate proposed valve casings. Use weld symbols used conforming to AWS A2.4.

2.5.1 Design

Design openings and framing using loads computed from the blast overpressures specified or indicated. Determine structural steel mechanical properties, such as minimum yield stress, tensile strength and member section properties, based on the proposed framing system. Base dynamic increase factors on applicable strain rates and the concrete unconfined compressive strength, concrete reinforcement yield stress, and structural steel yield stress. Perform flexural analyses using equivalent single degree of freedom or other approved dynamic analysis methods. Select deformation limits so that ultimate deflections do not inhibit proper valve unit operation.

2.5.2 Design and Analysis Calculations

Submit design and analysis calculations showing concrete opening and framing systems requiring changes to accommodate the proposed valve casings. When applicable, include a narrative discussion of the analysis techniques used; sketches showing the design overpressure loadings, member cross-sections, layouts and dimensions; elastic and plastic section properties for all load-carrying members; minimum yield and tensile strengths for steel materials; plastic moment capacities for load-carrying members; resistance function sketches showing equivalent ultimate resistance and elastic deflections; and design deformation limits and response values for maximum deflections, ductility ratios, and support rotations. Provide design and analysis calculations stamped by a Registered Professional Engineer experienced in dynamic analysis and design methods.

2.6 FABRICATION

Provide factory fabricated valve units and mountings. Use approved bolts, nuts, and washers to connect valve units to mountings. Perform welding in accordance with AWS D1.1/D1.1M. Weld stainless steel using electrodes conforming to AWS A5.4/A5.4M.

2.6.1 Valve Units

Provide atmospheric corrosion resistant valve units. Fabricate valve bodies from iron, steel or aluminum-alloy castings except fabricate bodies for valves mounted in diesel engine exhaust piping or ducts from corrosion resistant alloy steel castings. Fabricate internal parts such as spindles and pressure disks from stainless steel or aluminum. Fabricate helical springs from stainless steel spring wire. Special iron, steel and aluminum-alloy castings used to fabricate valve bodies, and special stainless steels and aluminum-alloys used to fabricate internal parts will be permitted when the materials used in the valve units provided are the same as those used in blast tested prototype valve units. Machine or fit valve surfaces that contact to prevent blast leakage with approved neoprene gaskets to ensure a tight fit.

2.6.2 Casing Supports

Furnish valve casing supports consisting of structural steel fabricated in accordance with either AISC 360 or AISC 325. Use groove welds consisting of complete penetration welds with complete joint fusion to splice face plates. In order to reduce distortion and residual stresses, use a welding sequence. Stess relieve all welds, and post weld straighten welded casings. Furnish fabricated steel that is well-formed to shape and size, with sharp lines and angles. Cope or miter intermediate and corner joints. Ground smooth exposed welds other than fillet welds.

2.6.3 Pipe Mountings

Flange connect valves indicated for installation in piping systems. Provide flange dimension compatible with the piping specified or indicated or providecompanion flanges and weld to the adjacent piping.

2.6.4 Surface Preparations, Coatings, and Finishes

Use coatings and finishes that are suitable for preventing atmospheric corrosion and resistant to heat damage under the operating temperatures specified.

2.6.4.1 Valve Unit Finishes

Ferrous metal surfaces other than stainless steel must be prepared and factory coated and finished using the manufacturer's standard process.

2.6.4.2 Casing Support Finishes

[Provide galvanized valve support casings in accordance with ASTM A123/A123M except that surfaces that will be embedded in concrete need not be galvanized. Exposed portions of concrete anchors, fasteners that connect casing parts, and fasteners that connect valve units to casings must be galvanized in accordance with ASTM A153/A153M.][Prepare valve support casings for priming in accordance with either AISC 360 or AISC 325 and factory prime and finish paint. Do not prime and finish paint surfaces that will be embedded in concrete. Use manufacturer's standard finish paint.]

2.7 TESTS, INSPECTIONS, AND VALIDATIONS

2.7.1 Blast Tests on Prototype Valve Units

Validate valve performance under blast by performing blast tests on prototype valve units. Validate that the specified pass-through impulse leakage is not exceeded and that the valve unit is fully operational after blast loading. When finite duration overpressure waveforms are specified, the overpressure waveforms used in the prototype test must exceed the specified waveforms in both overpressure and impulse.

2.7.2 Factory Air Flow Tests

Factory air flow test valve units to ensure that assembled valve units meet the air flow rates and pressure drops specified or indicated. Product sampling and air flow testing methods and procedures must be the manufacturer's standard except that at least [5] [_____] percent of the total number of each valve type must be tested.

2.7.3 Verification Inspection of Welds

Perform verification inspection of welds in accordance with AWS D1.1/D1.1M.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Valve Units

Install valve units in accordance with the valve manufacturer's written instructions.

3.1.2 Casing Supports

Erect structural steel casing supports in accordance with the manufacturer's instructions, AISC 303 and either AISC 360 or AISC 325.

3.2 FIELD QUALITY CONTROL

Perform field tests on valve units in accordance with the valve manufacturer's written instructions and the testing requirements specified in other specification sections. Submit certified blast and air flow test reports for valve units, including the name and location of the testing agency or laboratory, the date of the tests, a description of the valve units tested, the overpressure waveforms, and the testing apparatus. Document the pass-through impulse leakage, the ability of the valve units to resist the specified loads, and the air flow rate versus pressure loss characteristics over the operating pressures.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Systems Manual

Provide a manual consisting of manufacturer's safety precautions, preventative maintenance and schedules, troubleshooting procedures, special tools, parts list, and spare parts data. Edit all data to cover only the valves furnished.

3.3.2 Manufacturer's Field Service

Upon completion of the work, and at a time designated by the Contracting Officer, provide the services of one engineer and other technical personnel, as required, for a period of not less than [4] [_____] hours to instruct Government personnel in the operation and maintenance of the blast valves and all other items furnished under this specification section. Submit information describing training to be provided, training aids to be used, and a description of the training. Also include use of the systems manual and videotapes plus an instruction outline and procedure approved prior to scheduling the instruction.

-- End of Section --

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SECTION 23 34 23.00 40

HVAC POWER VENTILATORS
02/17

PART 1 GENERAL

Provide a power roof ventilator[s] [system] complete with all components and accessory equipment as specified in this section.

[Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

][Section 26 60 13.00 40 LOW-VOLTAGE MOTORS applies to this section.

]1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM B37 (2018) Standard Specification for Aluminum for Use in Iron and Steel Manufacture

ASTM B209 (2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE (2004) NASA Reliability Centered Building and Equipment Acceptance Guide

UNDERWRITERS LABORATORIES (UL)

UL 705 (2017; Reprint Aug 2021) UL Standard for Safety Power Ventilators

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Housing; G[, [____]]

Fan; G[, [____]]

Motor; G[, [____]]

Bases; G[, [____]]

Roof Curbs; G[, [____]]

Dampers; G[, [____]]

Screens; G[, [____]]

Sound Baffles; G[, [____]]

SD-06 Test Reports

Final Test Reports; G[, [____]]

SD-11 Closeout Submittals

Record Drawings; G[, [____]]

1.3 QUALITY CONTROL

Rate and label ventilators in accordance with the applicable standards of the Air Movement Control Association (AMCA), and indicate if the license bears the AMCA seal for both air and sound.

1.3.1 Predictive Testing and Inspection Technology Requirements

This section contains systems or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program (RCBEA). This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with the RCBEA GUIDE to ensure that building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Design Requirements

Submit the manufacturer's catalog data, including equipment and performance data, for power roof ventilator(s). As a minimum, include the following data:

a. Fan Type

b. Fan Specifications, including:

(1) Number of rotating fan blades/vanes

(2) Number of stationary fan blades/vanes

(3) Rotating speed(s)

(4) Number of belts (if belt-driven)

(5) Belt lengths- measured at the pitch line (if belt-driven)

(6) Diameter of the drive sheave at the drive pitch line (if belt-driven)

(7) Diameter of the driven sheave at the drive pitch line (if belt-driven)

c. Location of Installation

d. [_____] Identification Number

e. Date of Installation (Required or Actual Acceptance Date)

f. Applicable [_____] reference drawing number(s)

Submit detailed shop drawings for power roof ventilator systems.

Provide roof ventilators that comply with UL 705 and are furnished complete with bases, curbs, flashing flanges, noise baffles, dampers, damper controls, louvers, and screens, as indicated.

Provide ventilators that are designed for windloads in accordance with ASCE 7-16 with the installed design not less than 130[_____] miles per hour windload. Ensure that the structural bracing is properly spaced to accommodate this loading and meets the design requirements of the covering material. Ensure that ventilators are adequately reinforced and well-braced with the joints properly formed. Ensure that the edges are wired or beaded where necessary to ensure rigidity. Prevent galvanic action between different metals in direct contact by providing nonconductive separators. Make all soldering even and smooth.

Provide corrosion-resistant steel bolts, rivets, and other fastenings used in connection with protected metal.

2.2 COMPONENTS

2.2.1 Housing Style

Provide [round-mushroom style] [louvered-penthouse style] [low-contour style] [vertical-discharge style] power roof ventilator as indicated.

2.2.2 Fan Type

Provide fans of the following types:

2.2.2.1 Type C-PRV Centrifugal, Direct Drive

For Type C-PRV ventilators, provide a centrifugal roof ventilator with direct drive, nonoverloading, backward-inclined wheel. Provide a vibration-isolated drive with an elastomer. Provide drive components that are mounted in a compartment isolated from the airstream.

2.2.2.2 Type CB-PRV Centrifugal, V-Belt Drive

For Type CB-PRV ventilators provide a centrifugal roof ventilator with V-belt drive, nonoverloading, backward-inclined wheel. Provide a vibration-isolated drive with an elastomer. Provide drive components that are mounted in a compartment isolated from the airstream.

2.2.2.3 Type P-PRV Propeller, Direct Drive

For Type P-PRV ventilators, provide a propeller roof ventilator with direct drive that is vibration-isolated with an elastomer. Provide drive components that are mounted in a compartment isolated from the airstream.

2.2.2.4 Type PB-PRV Propeller, V-Belt Drive

For Type PB-PRV ventilators, provide a propeller roof ventilator with V-belt drive that is vibration-isolated with an elastomer. Provide drive components that are mounted in a compartment isolated from the airstream.

2.2.2.5 Type VA-PRV Vane Axial, Direct Drive

For Type VA-PRV ventilators, provide a vane axial roof ventilator with direct drive that is vibration-isolated with an elastomer.

2.2.2.6 Type VAB-PRV Vane Axial, V-Belt Drive

For Type VAB-PRV ventilators, provide a vane axial roof ventilator with V-belt drive that is vibration-isolated with an elastomer.

2.2.2.7 Type TA-PRV Tube Axial, Direct Drive

For Type TA-PRV ventilators, provide a tube axial roof ventilator with direct drive that is vibration-isolated with an elastomer.

2.2.2.8 Type TAV-PRV Tube Axial, V-Belt Drive

For Type TAV-PRV ventilators, provide a tube axial roof ventilator with V-belt drive that is vibration-isolated with an elastomer.

2.2.3 Fan Motor

Provide single-phase, 120 V, 60 Hz, split-phase, belt-driven motors less than 1/2 horsepower, with permanently lubricated ball bearings.

Provide three-phase [_____], 460 [_____] V, 60 Hz motors 1/2 horsepower and larger.

Provide motors with local disconnects to allow for fan and motor maintenance. Provide all motors with thermal-overload protection. For motors located in airstreams, use a totally enclosed type.

Use energy efficient permanent split capacitor motors, single phase, 60 Hz direct-drive motors 1/2 horsepower or less.

2.2.4 Bases

When bases are provided with the ventilators, use factory-formed bases of the type indicated, constructed of the same material as the hoods, and of the thickness necessary to meet the design requirement for connection to the roof. Provide bases that are suitable for raised-curb mounting where indicated. Form curb flanges of the base as cap flashing, extending at least 2 inches over the roofing base. Where indicated or required, extend the shafts of ventilators a sufficient distance through the supporting construction to permit attachment of vent ducts.

2.2.5 Roof Curbs

Provide factory-formed metal ventilator curbs of the type and design required for the ventilator and suitable for the roof configuration and flashing.

Provide job-built curbs that conform to the recommendations of the ventilator manufacturer, that are sized correctly for the ventilator, and that are suitable for the type of supporting roof construction.

2.2.6 Back-Draft Dampers

Provide gravity-operated back-draft dampers with adjustable counterweights constructed of the same material as fan housing.

[Provide motor-operated back-draft dampers constructed of the same material as fan housing.

][Interlock damper-actuating motor with the fan motor.

]2.2.7 Screens

Provide [bird screens] [insert screens] with frames constructed of the same material as that used in the ventilators and ensure the screens are securely attached in a manner that permits easy removal for access and cleaning.

2.2.8 Sound Baffles

Provide permanently constructed sound baffles that are impervious to moisture. Provide removable baffles.

2.3 MATERIALS

Provide manufacturers' standard materials.

2.3.1 Aluminum Alloy

Provide aluminum alloy in accordance with ASTM B209 and ASTM B37.

2.3.2 Zinc-Coated Steel

Provide zinc-coated steel in accordance with ASTM A653/A653M.

2.3.3 Fibrous Glass

Provide fibrous glass ventilators that are molded from a glass-fiber-reinforced polyester resin with a pigmented polyester resin gel coat in the manufacturer's standard color, and that are between 0.02 inches and 0.06 inches thick. Provide a matrix material that is not less than 30 percent, by weight, of chopped-fiber and random-strand glass fibers, and that is thoroughly saturated and impregnated with not more than 70 percent high-solids polyester resin with not less than 5 percent antimony trioxide fire-retardant additive. Provide material that is smooth and uniform in texture, and color throughout the cross section and that is shatter-resistant. Ensure that the material is free from visual defects, foreign inclusions, cracks, crazing, die lines, pinholes, and striations. Ensure that the material has no areas that are unsaturated or lacking resin, and no areas with excessive resin.

PART 3 EXECUTION

3.1 INSTALLATION

Submit installation drawings for power roof ventilators.

Install power roof ventilators in accordance with the manufacturer's installation instructions. Coordinate installation of ventilators with other work. Coordinate anchors, attachments, and other items to be built for installation as the work progresses. Rigidly install ventilators in a weathertight and watertight manner that is free from vibration. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations.

[3.1.1 Lubrication

Ensure the movable parts of dampers and related operating hardware are lubricated in accordance with manufacturer's printed instructions and that they operate smoothly and quietly without binding.

]3.2 FIELD QUALITY CONTROL

3.2.1 Tests

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

[After installation, test each power roof ventilator to demonstrate proper operation at indicated and specified performance requirements, including the running, balance, noise, and proper direction of fan rotation.

][3.2.1.1 Vibration Analyzer

Use an fast Fourier transform (FFT) analyzer to measure vibration levels. Ensure that the ventilator meets the following characteristics: a dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz to 10 KHz (300 600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

Use either a stud-mounted accelerometer or mount the accelerometer using a rare earth, low-mass magnet and a sound disk (or finished surface) with the FFT analyzer to collect data. Provide the accelerometer with a mass and mounting that minimally influence the frequency response of the system over the selected measurement range.

][3.2.2 Acceptance

Prior to final acceptance, use precision alignment devices to demonstrate that the fan and motor are aligned as specified by the manufacturer.

Prior to final acceptance, verify conformance to specifications with vibration analysis. Ensure vibration levels are not more than .075 in/sec at 1 times the run speed and at the fan/blade frequency, and not more than 0.04 in/sec at other multiples of the run speed.

][3.2.3 Final Test Reports

Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the system name, date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

]3.3 CLOSEOUT ACTIVITIES

Submit detailed record drawings upon completion of the installation.

-- End of Section --

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SECTION 23 35 16.17 10

MECHANICAL ENGINE[AND WELDING FUME] EXHAUST SYSTEMS
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A167	(2011) Standard Specification for

	Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A924/A924M	(2022) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM A1011/A1011M	(2018a) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM E2016	(2022) Standard Specification for Industrial Woven Wire Cloth

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1520	(1999) Round Industrial Duct Construction Standards, 3rd Edition
SMACNA 1922	(2004) Rectangular Industrial Duct Construction Standards, 2nd Edition

1.2 SYSTEM DESCRIPTION

Construct, complete and operational, an exhaust system as specified herein. Provide adequate air exhaust quantities and velocities. Properly size all duct for pressure loss and adequate velocity including locating intakes, ductwork size, layout, equipment and controls. Base construction of the exhaust system on the referenced publications, and other provisions as specified herein. Furnish ductwork offsets, fittings, and any other accessories required, as specified, to provide a complete exhaust system installation and to eliminate interference with other construction. Provide controls as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G[, [_____]]

Exhaust System Installation; G[, [_____]]

SD-03 Product Data

Related Submittals

Ductwork Components; G[, [_____]]

Materials and Equipment

Spare Parts

Field Instructions

Final Acceptance Tests

Onsite Training; G[, [_____]]

Exhaust System Specialist; G[, [_____]]

SD-06 Test Reports

Final Acceptance Tests

SD-07 Certificates

Inspection; G[, [_____]]

SD-10 Operation and Maintenance Data

Exhaust System

Operation and Maintenance Manuals

1.4 QUALITY ASSURANCE

1.4.1 Detail Drawings

Submit [3] [_____] copies of the Exhaust System Drawings, no later than [21] [_____] days prior to the start of exhaust system installation. Include a complete list of equipment and materials, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, installation instructions, complete duct, wiring, and schematic diagrams and any other details to demonstrate that the system has been coordinated and will properly function as a unit. Also show proposed layout and anchorage of equipment and appurtenances, and equipment in relation to other parts of the work including clearances required for maintenance and operation.

1.4.2 Exhaust System Specialist

Submit the name and documentation of certification of the proposed Exhaust System Specialists, no later than [14] [_____] days after the Notice to Proceed and prior to the submittal of the exhaust system drawings and hydraulic calculations. Prepare a list of the submittals from the Contract Submittal Register that relate to the successful installation of the exhaust systems(s). Submit the list no later than [7] [_____] days after the approval of the Exhaust System Specialist. The related submittals identified on this list must be accompanied by a letter of approval signed and dated by the Exhaust System Specialist when submitted to the Government. The Exhaust System Specialist must be regularly engaged in the installation of the type and complexity of system specified in the Contract documents, and will have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.5 DELIVERY, STORAGE, AND HANDLING

House all equipment delivered and placed in storage in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all ductwork, flexible connections and pipes until installed.

1.6 EXTRA MATERIALS

Submit spare parts data for each item of equipment and material specified. Include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit manufacturer's catalog data included with the Exhaust System Drawings for all items specified herein. Highlight data to show model, size, options, etc., that are intended for consideration. Demonstrate compliance with all contract requirements. In addition, provide a complete equipment list that includes equipment description, model number and quantity.

b. Where an integrated, packaged exhaust system is furnished, all items will be the product of the system manufacturer. System component parts may be by other manufacturers. Provide equipment by a service organization that is capable of responding to service calls within [four hours] [_____].

c. Asbestos and asbestos-containing products are not acceptable.

2.2 NAMEPLATES

Furnish a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number on all equipment.

2.3 EQUIPMENT GUARDS AND ACCESS

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Properly guard or cover high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard with insulation of a type specified. Provide [catwalks,] [operating platforms,] [ladders,] [and] [guardrails] where shown and construct according to Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS].

2.4 DUCTWORK COMPONENTS

2.4.1 General

Provide duct constructed of [galvanized] [stainless steel] sheets of the minimum gauge thickness for ducts as required in [SMACNA 1922] [SMACNA 1520]. Construct and seal ducts in accordance with [SMACNA 1922] [SMACNA 1520] for a negative pressure of [_____] inch water gauge static pressure. Unless otherwise approved, provide ducts that are round with longitudinal lock seam and conform to the dimensions indicated. Provide ducts that are straight and smooth on the inside with airtight joints. Where ducts with crimped ends are used to make up joints, the joints must have crimp and bead. The bead must provide a rigid stop for the mating open end to seat against. Steel spiral wound duct is not acceptable.

2.4.2 Fittings

Furnish reducing fittings that have a minimum of 1 inch increase in diameter per 8 inches in length. Elbows that have a centerline radius less than 1.5 times the diameter are not permitted. Stub branches into mains at main expansion points at an angle of not more than 30 degrees with the centerline of the main duct in the direction of air flow, unless otherwise indicated or approved. Where riser ducts with single or multiple inlets are indicated, connect the riser duct into the bottom of the main duct at an angle as specified for branches. Where flexible connections connect to the main duct, brace the duct branch takeoff or stub with approved metal straps or members.

2.4.3 Cleanout

Provide cleanout on the end of the main ductwork opposite the end of the fan suction connection. Size the cleanout opening to the approximate inside area of the duct. Provide removable airtight caps or flange type covers of minimum gauge thickness as the main duct. Provide other cleanout openings where indicated.

2.4.4 Apparatus Connections

Where sheet metal connections are made to fan suction and discharge, or where ducts of dissimilar metals are connected, install an approved noncombustible flexible connection approximately 6 inches and securely fasten by zinc-coated steel clinch-type draw bands for round ducts. For rectangular ducts, install the flexible connections locked to metal collars using normal duct construction methods.

2.4.5 Duct Test Holes

Provide test holes with covers where indicated, directed, or where necessary in ducts and plenums for using Pitot tubes for taking air measurements to balance the air systems.

2.4.6 Duct Sleeves and Framed Openings

Provide duct sleeves for all round ducts 15 inch diameter or less passing through floors, walls, ceilings, or roofs. Provide sleeves in non-load bearing walls fabricated of 20 gauge steel sheets conforming to ASTM A924/A924M. Provide sleeves in load-bearing walls fabricated of standard-weight galvanized steel pipe conforming to ASTM A53/A53M. Install round ducts larger than 15 inch diameter and all square and rectangular ducts passing through floors, walls, ceilings, or roofs through framed openings. Furnish structural steel members for framed openings conforming to ASTM A36/A36M. Provide 1 inch clearance between the duct and the opening. Provide closure collars of galvanized steel no less than 4 inches wide on each side of walls or floors where sleeves or framed openings are provided. Fabricate collars for round ducts 15 inch diameter or less from 20 gauge galvanized steel. Fabricate collars for round, square or rectangular ducts with minimum dimension over 15 inches from 18 gauge galvanized steel.

2.5 EXHAUST HOSE SYSTEM

2.5.1 Tailpipe Adapters

Provide tapered-cone adapters with spring clips or other suitable devices for exhaust pipe attachment. The adapter must fit [_____] inch nominal diameter exhaust pipe.

2.5.2 Welding Fume Receptors

Construct welding fume receptors of minimum 20 gauge thick aluminum and equip with 1/2 inch mesh receptor screens; with swivel connections, and magnets on receptor base.

2.5.3 Flexible Exhaust Hose

Flexible exhaust hose must be [0.012 inch minimum strip thickness of stainless steel] [0.012 inch minimum strip thickness of galvanized steel] [approved heat-resistant wire-reinforced glass fiber and neoprene tubing] [approved heat-resistant wire reinforced glass fiber and silicone tubing]. [Provide wye connectors where shown]. Provide flexible tubing inside diameter and length as shown. Connect the tubing to the bottom of the ductwork. Provide a flanged connection where the flexible tubing and overhead ductwork are joined. The flanged connection must consist of steel flanges not less than 0.078 inch thick, 1/8 inch gasket. Provide gasket suitable for the system design temperature shown, in accordance with ASME B16.21, full face or self-centering flat ring type. It must contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Size or design the flange to suit the hose as approved. [The connection of the neoprene hose may be installed with an approved hose clamp or as recommended by the manufacturer.]

2.5.4 Exhaust Hose Suspension System

Suspend the flexible tubing overhead when not in use; allowing it to be lowered to the operating level, when required. Furnish the suspension system complete with cable, and operating mechanism. The suspension system must be [counter-weighted type]or [manually operated balancer type with safety ratchet lock or automatic brake having slip resistant hand grip].

2.6 DAMPERS

Provide dampers of the type indicated and install where shown. Provide circular disk dampers with quadrant locking device or blast gate type. Damper blades less than 16 gauge thickness of stainless steel are not permitted. Provide blast gate dampers consisting of two piece construction with adjustable sliding gate and setscrew.

2.7 MATERIALS

Provide materials conforming to the following requirements.

2.7.1 Screen

ASTM E2016, type and class as required for the application.

2.7.2 Iron and Steel Sheets

2.7.2.1 Galvanized Iron and Steel

ASTM A924/A924M, Coating Designation G90.

2.7.2.2 Uncoated Steel

ASTM A1011/A1011M, condition, and type best suited to intended use.

2.7.2.3 Stainless Steel

ASTM A167, Type 304.

2.7.3 Steel Structural Shapes

ASTM A36/A36M.

2.7.4 Solder Silver

AWS A5.8/A5.8M, brazing alloy; grade to suit application.

2.7.5 Solder

ASTM B32, composition to suit application.

2.7.6 Bolts and Nuts

Furnish bolts and nuts, except as required for high temperature exhaust applications, in accordance with ASTM A307. Use bolts and nuts for exhaust applications where the temperature of the bolt may rise above 400 degrees F or use as flange bolts in corrosion resistant material in accordance with ASTM A193/A193M Class 2. Mark the bolt head to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307 or ASTM A193/A193M as applicable.

2.8 ELECTRICAL WORK

Provide specified electrical motor-driven equipment complete with motor, motor starter, and controls. Unless otherwise specified, provide electric equipment, including wiring and motor efficiencies, according to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical characteristics and enclosure type as shown. Unless otherwise indicated, motors of 1 hp and above must be high efficiency type. Provide motor starters complete with thermal overload protection and other appurtenances necessary. Provide each motor according to NEMA MG 1 and of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, must be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Utilize solid-state variable-speed controllers for motors rated 10 hp or less. Use adjustable frequency drives for larger motors.

2.9 AIR MOVING DEVICES

2.9.1 General

Test and rate fans in accordance with the standards of AMCA 210, Type "D" Ducted Inlet, Ducted Outlet Configuration. [Fans having a capacity of less than 400 cubic feet/minute will be directly connected to the motor shaft] [Where V-belt drives are used, design such drives for no less than 150 percent of the connected driving capacity, and adjust motor sheaves to provide no less than an overall 20 percent speed variation. Select sheaves to drive the fan at such speed as to produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Provide motors for V-belt drives with adjustable rails or bases]. Provide fans with personnel screens or guards on both suction and supply ends except where ducts or dampers are connected to the fan. Provide fans and motors with vibration isolation supports or mountings. Vibration isolation units must be standard products with published load ratings, and mus be single rubber-in-shear, neoprene coated fiberglass, double rubber-in-shear springs, or springs under inertia base. Select each fan to produce the capacity required at the fan total pressure indicated. Provide standard AMCA arrangements unless otherwise indicated and provide the rotation and discharge as indicated. Provide fans with nonoverloading characteristics. Construct fan housing with no less than 16 gauge thick steel. Construct fan impellers to meet AMCA Spark Resistance "B" Classification and accurately balance both statically and dynamically when installed in the assembled fan unit. Coat impellar and housing in the air stream with neoprene, epoxy, phenolic resins, or otherwise be suitable to resist the corrosive gases and temperatures produced. Fans must be free of objectionable vibration or noise. Certified performance curves indicating that the fan supplied will operate in its most efficient operating range will be provided. In addition, furnish "sound power" ratings with each fan. Provide fans indicated to be mounted on exterior of building with weatherproof covers for the motor drive unit or other weatherproofing as recommended by the manufacturer. Select each fan to produce the capacity required at the fan total pressure indicated. Provide weather hoods, flashing, and bird screens where indicated.

2.9.2 Fans

Provide sound power level as indicated and obtain values according to

AMCA 300. Indicate Standard AMCA arrangement, rotation, and discharge. Test and rate fans according to AMCA 210. Select each fan to produce the capacity required at the fan static pressure indicated. Fans may be connected to the motors either directly or indirectly with V-belt drive. Design V-belt drives for no less than [150] [140] [120] percent of the connected driving capacity. Provide variable pitch motor sheaves for 15 hp and below and fixed pitch as defined by AHRI Guideline D. Select variable pitch sheaves to drive the fan at a speed which will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance.

2.9.2.1 Protective Devices

Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Vibration-isolation units must be standard products with published loading ratings.

2.9.2.2 Centrifugal Fans

Centrifugal fans must be fully enclosed, single-width single-inlet, or double-width double-inlet, AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Provide rigidly constructed impellar wheels, accurately balance both statically and dynamically. [Fan blades may be forward curved, backward-inclined or airfoil design in wheel sizes up to 30 inches. Fan blades for wheels over 30 inches in diameter must be backward-inclined or airfoil design]. These fans must be suitable for the temperatures encountered. Provide fan shaft with a heat slinger to dissipate heat buildup along the shaft. Supply an access (service) door to facilitate maintenance with these fans. Fan wheels over 36 inches in diameter must have overhung pulleys and a bearing on each side of the wheel. Indirect drive fan wheels 36 inches or less in diameter may have one or more extra long bearings between the fan wheel and the drive. Provide bearings that are sleeve type, self-aligning and self-oiling with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Connect grease fittings to tubing and service from a single accessible point. Bearing life must be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide steel fan shafts, accurately finish, and provide key seats and keys for impeller hubs and fan pulleys. Provide each fan outlet of ample proportions and design for the attachment of angles and bolts for attaching flexible connections. Provide motors, unless otherwise indicated, that do not exceed 1800 rpm and have [open] [dripproof] [totally enclosed] [explosion-proof] enclosures. [Provide motor starters that are [manual] [magnetic] [across-the-line] [reduced-voltage-start] type with [general-purpose] [weather-resistant] [watertight] enclosure.] [Provide remote manual switch with pilot indicating light where indicated.]

2.9.3 In-Line Centrifugal Fans

Provide in-line centrifugal fans consisting of welded tubular casings, centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Air must enter and leave the fan axially. Inlets must be streamline with conversion vanes to eliminate turbulence and discharge air flow smoothly. Enclose fan bearings and drive shafts and isolate from air stream. Provide fan bearings that are sealed against dust and dirt and permanently lubricated or lubricative type with grease lines extending to the exterior of the housing. Bearing life must be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide motors that have [open] [dripproof] [totally enclosed] [explosion-proof] enclosure. Provide motor starters that are [manual] [magnetic] across-the-line with [general-purpose] [weather-resistant] [explosion-proof] enclosure. [Provide remote manual switch with pilot indicating light where indicated.]

2.10 FACTORY COATING

Provide factory finished equipment and component items, when fabricated from ferrous metal as defined by ASTM (or similar) standard, with the manufacturers standard finish except provide weather-resistant finishes that will withstand 500 hours exposure to the salt spray test specified in ASTM B117 to items located outside of building.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install work as shown and according to the manufacturer's diagrams and recommendations.

3.3 INSPECTION

The Exhaust System Specialist must (1) Inspect the exhaust system periodically during the installation. (2) Witness the final tests, and sign approval of the test results. (3) Certify in writing that the system has been installed in accordance with the contract requirements. Bring any discrepancy to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.4 EXHAUST SYSTEM INSTALLATION

3.4.1 General Requirements

Perform welding and brazing conforming to ASME BPVC SEC IX. Install horizontal sections of the main duct with the longitudinal lock seam on the top. Seal slip joints in accordance with [SMACNA 1922] [SMACNA 1520]. Support and anchor riser duct to the structure as indicated. Attach main duct to the structural members of the building as recommended by [SMACNA 1922] [SMACNA 1520].

3.4.2 Building Surface Penetrations

Utilize sleeves or framed openings where duct penetrates building surfaces. Penetrations must be sealed[, and fireproofed in accordance with Section 07 84 00 FIRESTOPPING]. Pack the space between the sleeve or framed opening and the duct with mineral wool or other approved material.

Install closure collars around the duct on both sides of the penetrated surface. Collars must fit tight against the building surfaces and snugly around the duct.

3.5 PIPE COLOR CODE MARKING

Provide color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE TRAINING

Submit proposed Onsite Training schedule, at least [14] [_____] days prior to the start of related training for the operating staff as designated by the Contracting Officer. The training period must consist of a total [8] [_____] hours of normal working time and must start after the system is functionally completed but prior to final acceptance tests. The field instructions must cover all of the items contained in the approved operation and maintenance manuals, as well as demonstrations of routine maintenance operations. Submit [6] [_____] manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days [_____] prior to on-site training. Include the manufacturer's name, model number, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. [Each service organization submitted must be capable of providing [4] [_____] hour on-site response to a service call on an emergency basis.] Notify the Contracting Officer at least 14 days prior to date of proposed conduction of the training course.

3.7 FINAL ACCEPTANCE TESTS

Balance each exhaust system and inlet to produce the indicated air quantities within 10 percent at the conditions shown. Set control devices to control at the points indicated or directed. Lubricate bearings, and check the speed, direction or rotation of each fan. Check the running current of each motor. Upon completion, and prior to acceptance of the installation, test the exhaust system at operating conditions to demonstrate satisfactory functional and operating efficiency.

a. Operating tests must cover a period of not less than 2 hours for each system, and conduct all tests in the presence of the Contracting Officer. If tests do not demonstrate satisfactory operation of the exhaust system, correct deficiencies and retest. Provide all instruments, facilities, and labor required to properly conduct the tests. The electricity required for testing will be furnished by the Government.

b. Submit [3] [_____] copies of the completed Final Acceptance Tests Reports, no later that [7] [_____] days after the completion of the Tests. Sign all items in the Final Acceptance Report. Submit proposed diagrams, instructions, and other sheets, concurrent with the Final Acceptance Test Procedures. Post framed instructions under glass or in laminated plastic where directed, including wiring and control diagrams showing the complete layout of the entire system. Prepare condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system in typed form, frame as specified above for the wiring and control diagrams and post beside the diagrams. Post the framed instructions before acceptance testing of the systems.

c. Submit proposed procedures for Final Acceptance Tests, no later than [14] [_____] days prior to the proposed start of the tests.

d. Submit proposed date and time to begin Final Acceptance Tests, with the Final Acceptance Test Procedures. Provide notification at least [14] [_____] days prior to the proposed start of the test.

-- End of Section --

SECTION 23 35 19.00 20

INDUSTRIAL VENTILATION AND EXHAUST
02/10, CHG 2: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 99	(2016) Standards Handbook
AMCA 99-0401	(1986) Classifications for Spark Resistant Construction
AMCA 201	(2002; R 2011) Fans and Systems
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 211	(2013; Rev 2017) Certified Ratings Program Product Rating Manual for Fan Air Performance
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating
AMCA CRP	(Online) Directory of Products Licensed Under the AMCA International Certified Ratings Program

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 1060 I-P	(2014) Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Heat Equipment

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH-2092S	(2004) Industrial Ventilation: A Manual of Recommended Practice

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.3/D1.3M	(2018) Structural Welding Code - Sheet Steel
AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A1011/A1011M	(2018a) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM C582	(2009) Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1330	(2004; R 2010) Rubber Sheet Gaskets

ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D1927	(1981; R 1988) Rigid Poly(Vinyl Chloride) Plastic Sheet
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D4167	(2015) Fiber-Reinforced Plastic Fans and Blowers

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 65	(1993) Processing and Finishing of Aluminum
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 91	(2020) Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists and

	Noncombustible Particulate Solids
NFPA 664	(2020) Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

RUBBER MANUFACTURERS ASSOCIATION (RMA)

RMA IP-20	(2007) Specifications for Drives Using Classical V-Belts and Sheaves. Specifications for A, B, C, and D Cross Sections
RMA IP-22	(2007) Specifications for Drives Using Narrow V-Belts and Sheaves (Joint RMA/MPTA), 4th Edition

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1378	(1995) Thermoplastic Duct (PVC) Construction Manual, 2nd Edition
SMACNA 1403	(2008) Accepted Industry Practice for Industrial Duct Construction, 2nd Edition
SMACNA 1520	(1999) Round Industrial Duct Construction Standards, 3rd Edition
SMACNA 1922	(2004) Rectangular Industrial Duct Construction Standards, 2nd Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 11	(1992; E 2000) Paint Specification No. 11Red Iron Oxide, Zinc Chromate, Raw Linseed Oil and Alkyd Primer
SSPC Paint 20	(2019) Zinc-Rich Primers (Type I, Inorganic, and Type II, Organic)
SSPC SP 5/NACE No. 1	(2007) White Metal Blast Cleaning

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-12276	(2006; Rev E; Notice 1 2011; Notice 2 2016; Notice 3 2021) Varnish, Phenolic, Baking
MIL-DTL-24441	(2009; Rev D; Notice 1 2021) Paint, Epoxy-Polyamide, General Specification for

MIL-P-21035	(1991; Rev B; Notice 2 2003; Notice 3 2021) Paint, High Zinc Dust Content, Galvanizing Repair (Metric)
MIL-PRF-23236	(2009; Rev D) Coating Systems for Ship Structures

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-272	(Rev B; Notice 1) Caulking Compounds
FS TT-S-001543	(Rev B; Notice 1) Sealing Compound: Silicone Rubber Base (For Calking, Sealing, and Glazing in Buildings and Other Structures)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219	Mechanical Power Transmission Apparatus

UNDERWRITERS LABORATORIES (UL)

UL 33	(2010; Reprint Apr 2020) Heat Responsive Links for Fire-Protection Service
UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 214	(1997; Rev thru Aug 2001) Tests for Flame-Propagation of Fabrics and Films
UL Bld Mat Dir	(updated continuously online) Building Materials Directory

1.2 GENERAL REQUIREMENTS

1.2.1 SMACNA Duct Construction Manuals

The recommendations in the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) duct construction manuals must be considered mandatory requirements. Substitute the word "must" for "should" in these manuals.

1.2.2 Fan Data

[For fans include fan curves or rating tables and derating factors.]Provide certified performance curves showing total pressure, power, and mechanical efficiency versus flow rate of the operating density and fan speed. All areas of unstable operation must be indicated. For fans equipped with adjustable capacity controls such as variable inlet or vaneaxial fans with adjustable blade settings, minimum and maximum performance must be indicated along with performance for fire intermediate settings.

1.2.3 Natural Ventilation

Evaluate natural ventilation for appropriate spaces, and design air distribution systems to operate in the same direction as natural ventilation to reduce energy cost of pumping outdoor air.

1.2.4 Industrial Ventilation and Exhaust Systems

Submit drawings including fan installation drawings; duct systems[, including welding and vehicle exhaust]; supports and anchor location and load imposed.

1.2.5 Start-Up Tests

Submit start-up tests reports in accordance with the paragraph TESTING, ADJUSTING, AND BALANCING. Submit final test report for [the] system[s] tested, describing all test apparatus, instrumentation calculations, factors, flow coefficients, sound levels, and equipment data based on ACGIH-2092S recommended forms or reasonable facsimiles thereof to suit project conditions. Adjustment and setting data must be included in test report. Submit sound level test reports for high noise level equipment.

1.2.6 Related Requirements

Conform to Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS as well as additional requirements specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Industrial Ventilation and Exhaust Systems; G[, [_____]]

SD-03 Product Data

Fans; G[, [_____]]

Dampers; G[, [_____]]

Flexible Connectors

Flexible Duct; G[, [_____]]

Gaskets

Protective Coating Materials

Sealants

Access Ports; G[, [_____]]

Damper Regulators; G[, [_____]]

Blast Gates; G[, [_____]]

Vibration Isolators; G[, [_____]]

Ductwork, Dust [and Fume] Collection

Steel Ducts; G[, [_____]]

Fiberglass Ductwork; G[, [_____]]

Thermoplastic Ductwork; G[, [_____]]

Vehicle Tail Pipe Exhaust System; G[, [_____]]

Welding Fume Exhaust System; G[, [_____]]

Recycled Content of Ductwork Steel Components; S

Recycled Content of Protectively Coated Steel Ducts; S

Indoor Air Quality for Duct Sealants; S

SD-06 Test Reports

Fan Tests, including Sound Power Level Tests; G[, [_____]]

Ventilation and Exhaust System Start-Up Tests; G[, [_____]]

Sound Level Tests; G[, [_____]]

SD-07 Certificates

Welding Procedures; G[, [_____]]

Welding Test Agenda; G[, [_____]]

Welding Test Procedures; G[, [_____]]

Welders' Identification; G[, [_____]]

Fiberglass Fan Servicer Experience Information; G[, [_____]]

SD-10 Operation and Maintenance Data

Fans, Data Package 2; G[, [_____]]

Vehicle Tail Pipe Exhaust System, Data Package 2; G[, [_____]]

Welding Fume Exhaust System, Data Package 2; G[, [_____]]

Industrial Ventilation and Exhaust Systems, Data Package 2; G[, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted Operating Instructions

Submit text of posted operating instructions for ventilation and exhaust systems.

1.4 QUALITY ASSURANCE

1.4.1 Welders' Identification

Submit a listing of the names and identification symbols to be used to identify the work performed by the welder or welding operator who after completing a welded joint must identify it as his work by applying his assigned symbol for a permanent record.

1.4.2 Fiberglass Fan Servicer Experience Information

Submit text.

1.4.3 Qualified Personnel

Operations involving joining thermoplastic ductwork by solvent or hot gas and joining fiberglass ductwork by laminating must be performed by personnel certified by the manufacturer as qualified for the work.

1.4.4 Qualification of Welders

Qualify each welder or welding operator by tests using equipment, welding procedures and a base metal and electrode or filler wire from the same compatible group number that will be encountered in the applicable welding test procedures. Welders or welding operators who make acceptable procedure qualification test welds will be considered performance qualified for the welding procedure used. Determine performance qualification in accordance with AWS D1.1/D1.1M. Notify the Contracting Officer 24 hours in advance as to the time and place of tests[and wherever practical perform the tests at the work site].

1.4.5 TAB Requirements

Requirements are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING and Section 23 08 01.00 20 TESTING INDUSTRIAL VENTILATION SYSTEMS.

1.5 POSTED OPERATING INSTRUCTIONS

Provide for ventilation and exhaust system. In addition, permanently mark, drill, and pin as an integral part of device, final adjustment and settings pursuant to testing, adjusting, and balancing.

1.6 SAFETY PRECAUTIONS

1.6.1 Guards and Screens

Provide metal personnel safety guards for normally accessible unducted fan inlets and discharges and moving power transmission components in accordance with OSHA 29 CFR 1910.219.

1.6.2 Welding

Conform to AWS Z49.1 for safety in welding and cutting.

PART 2 PRODUCTS

2.1 FANS, GENERAL REQUIREMENTS FOR

2.1.1 General Performance, Component, and Other Requirements

Fans must have certified performance ratings as evidenced by conformance to the requirements of AMCA 211, and must be listed in AMCA CRP, or must be currently eligible for such listing. Fans must generally be in accordance with AMCA 99 unless superseded by other requirements stated elsewhere herein. Determine performance data for fans in accordance with AMCA 210. Select fans to minimize the exposure of personnel working in or occupying the immediate installation area. The total sound power level of the fan tests must not exceed 90 dBA when tested per AMCA 300 and rated per AMCA 301, or it must be provided with an appropriate attenuation device or devices. Scheduled fan performance is the performance required under specified or indicated installation conditions with specified or indicated accessories. The net installed air performance of the fan, with accessories/appurtenances in place, must be sufficient to meet the scheduled performance within the limits of the fan rating certification tolerance. Affix the manufacturer's product identification nameplate to each unit. Apply additional requirements for specific service or generic type or class of fan. If nonuniform air flow conditions are likely to be encountered, contact the fan manufacturer to ensure that the fan is rated for the additional fan inlet and outlet effect. Install fans to minimize fan system effect in accordance with AMCA 201. Fans must be listed in the Directory of Products licensed to use AMCA seal.

2.1.2 Bearings and Lubrication

Precision anti-friction or sleeve type with provisions for self-alignment and for radial and thrust loads imposed by the service. Provide water-cooled bearings where required for the service or recommended by the manufacturer.

2.1.2.1 Anti-friction Bearings

Constructed of steel alloys with a certified L-10 minimum rated life of [20,000] [40,000] [80,000] hours under load conditions imposed by the service. Rated and selected in accordance with ABMA 9 and ABMA 11. Provide with dust-tight seals suitable for environment and lubricant pressures encountered; cast ferrous metal housing, bolted-split pillow block type where located within fan casings; grease lubricated with provisions to prevent overheating due to excess lubricant; surface ball check type grease supply fittings. Provide manual or automatic grease pressure relief fittings visible from normal maintenance locations. Include lubrication extension tubes where necessary to facilitate safe maintenance during operation and fill tubes with lubricant prior to equipment operation. Prelubricated, sealed, anti-friction bearings, which conform to above specified materials and L-10 life requirements, may be provided for fans requiring less than 1/2 horsepower.

2.1.2.2 Sleeve Bearings

Premounted, self-aligning, continuous oil supply, single or double ring lubricated, insert type, with suitable provisions for shaft expansion and such thrust as may be imposed by service loads. Provide water cooling for shaft surface speed exceeding 1200 feet per minute. Provide each sleeve bearing with approximately 16 ounce capacity constant level oiler and oil level gage. Include on sleeve bearing submittal data: Bearing manufacturing source, type, lubricant, clearances, "L/D" ratio, antifriction metal, belt angle, shaft speed, shaft critical speed, Brinell hardness at journal, and shaft surface finish at journal in micro-inches.

2.1.3 Motors and Motor Starters

Conform to NEMA MG 1 and NEMA ICS 1 and NEMA ICS 2. Motors less than one hp must meet NEMA High Efficiency requirements. Motors one hp and larger must meet NEMA Premium Efficiency requirements. Motors must not exceed 1800 rpm, unless otherwise indicated, and must be variable-speed, [[open] [dripproof] enclosure] [totally enclosed fan cooled] [explosion proof] type. Provide [manual] [magnetic-across-the-line] [reduced voltage] [part-winding] [wye-delta] type motor starters with [general-purpose NEMA 1] [weather resistant NEMA 3R] [watertight NEMA 4] [moisture and dusttight NEMA 12] enclosure in accordance with NEMA ICS 6. Provide single-phase motors with inherent thermal overload protection with manual reset. Provide three-phase motors with thermal overload protection in the control panel. Provide permanently lubricated or grease-lubricated ball or roller bearings; auxiliary lubrication and relief fittings on outside of fan casing; arrange grease lines to minimize pressure on bearing seals. Motor power must not be less than brake power required with blades set at maximum pitch angle at any air delivery from the indicated amount down to 50 percent thereof.

2.1.4 Guards and Screens

Construct guards and screens to provide, as applicable: required strength and clearance with minimal reduction in free area at fan inlets and discharges; cooling; access panels for tachometer readings; ease of sectional disassembly for maintenance and inspection functions where guard total weight exceeds 50 pounds; weather protection where components are weather exposed. Installed guards and screens must not negate noise control and vibration isolation provisions.[For burn protection, insulate surfaces when service temperatures exceed 140 degrees F as part of work under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.]

2.1.5 Power Transmission Components

2.1.5.1 Fan Drives

[Direct] [or] [V-belt] type as indicated. V-belt drives must conform to RMA IP-20 and RMA IP-22. Drives must be applied in accordance with the manufacturer's published recommendations, unless specified otherwise. Base power rating of a V-belt drive on maximum pitch diameter of sheaves. Provide classical belt section adjustable sheave type, with a minimum service factor of 1.5 for drives with motors rated up to and including 30 hp.[Provide classical section or narrow section, fixed sheave or adjustable sheave type with a minimum 1.5 service factor for drives with motors rated over 30 hp.][Provide at least two belts for drives with motors rated one hp and above.]

2.1.5.2 Sheaves

Statically and dynamically balanced, machined cast ferrous metal or machined carbon steel, bushing type, secured by key and keyway. Pitch diameter or fixed sheaves and adjustable sheaves, when adjusted to specified limits, must not be less than that recommended by NEMA MG 1. Select adjustable sheaves that provide the required operating speed with the sheave set at midpoint of its adjustment range. The adjustment range for various size and type belts must be: 16 percent, minimum for Classical section belts; 12 percent, minimum for Narrow section belts. [Belt deflection in adjustable sheave drives must not exceed 1 1/2 degrees.]

Provide companion sheaves for adjustable sheave drives with wide groove spacing to match driving sheaves, except that standard fixed pitch spacing may be used for all two-through-four groove drives whose center-to-center dimensions exceed the following: "A" and "B" Section 16 inches; "C" Section 25 inches; "D" Section 36 inches. Furnish endless, static dissipating, oil-resistant, synthetic cloth or filament reinforced elastomer construction belts.

2.1.6 Special Construction for Hazardous Areas

2.1.6.1 Spark-Resistant

Construct [_____] [specified or indicated] units in accordance with AMCA 99-0401; Type [A] [B] [C]. Provide [Type B] [or] [Type C] construction and electrical grounding of fan parts and grounding to building structure where fume or vapor handling systems conforming to NFPA 91 are specified. Do not place bearings in the air stream.

2.1.6.2 Explosion Proof

Construct fans to AMCA 99-0401, Type [A] [B] [C] spark-resistant requirements where explosion-proof electrical components are specified or indicated to conform to NFPA 70, Class [_____], Group [_____], Division [_____] requirements.

2.1.7 Protective Coating for Fans

Prepare and coat fans as follows: Replace bolts required to provide access or adjustment and normally threaded into the coated surface with studs or bolts having heads continuously welded inside. Omit sharp edges, self-tapping screws, and permanent threads protruding into the coated surface. Eliminate hairline cracks and sharp inside corners by continuous welding, brazing, or filling with high melting point solder. Seal impeller hub to the shaft. Construct housing split to use external throughbolts. Flange inlet and outlet and consider as fan interior. Peen or grind welds smooth, and grind outside corners to approximately 1/16 inch radius. Sandblast metal surfaces to white metal in accordance with SSPC SP 5/NACE No. 1. Coat interior surfaces of housing in contact with airstream, including inlet, impeller and shaft, flange faces, shaft seal, [exterior surfaces of housing] [, and bearing and motor pedestal]. Do not coat bearings, coupling, motor, drive, or other auxiliaries.[Prepare and coat stainless steel shaft.][Finish fan in accordance with the manufacturer's standard practice.][Coat fan with [phenolic] [epoxy] [_____].][Coat fan as indicated.] Statically and dynamically balance the fan in two planes after coating and finishing, and where material has been removed, refinish and rebalance the fan as specified herein.

2.2 CENTRIFUGAL FANS

2.2.1 General Requirements for Centrifugal Fans

Provide fan of [forward-curved] [radial] [backward inclined] [airfoil] type blades with [manual] [or] [automatic inlet vanes [as indicated]]. Arrange fans for indicated service, and construct for the applicable AMCA 99Class pressure ratings as indicated for system design pressure and temperature. Fan shaft must be solid steel, ground and finished as required for the service, with first critical speed a minimum 25 percent higher than cataloged fan speed. Select fan for maximum efficiency, minimum noise, and stability during all modes of system operation. [Vibration isolation mountings must be spring type and limit vibration transmissibility to a maximum [_____] [5] percent of the unbalanced force at lowest equipment speed, unless otherwise specified or indicated.] Arrangement and drives must be as indicated.

2.2.2 Industrial Exhauster[s]

Single-width, single-inlet type arranged for indicated service and constructed for duty at indicated system design pressure and temperature not to exceed [150] [200] [350] [500] [700] degrees F. Continuously welded [carbon] [alloy] [copper bearing alloy] [Type [_____] [304L] [316L] stainless] [steel] [[_____] alloy aluminum] scroll with required reinforcement, flanged inlet and outlet connections, [cone] inlet [bolted] [welded] to scroll side sheet, threaded and plugged scroll drain, [quick] [or] [bolted] access door with gasket; [Carbon] [alloy] [Type [_____] stainless] steel shaft, [fitted with] [heat slinger] [shaft seal] [grease lubricated stuffing box]; continuously welded [carbon] [alloy] [copper bearing alloy] [Type [_____] [304L] [316L] stainless] [steel] [_____ alloy aluminum] impeller assembly. [_____] [radial] [paddle type (open radial)] [backplated paddle] type impeller blades [with inlet shroud].[Provide protective coating of [_____].] on fan surfaces exposed to [air] [fume] [vapor] stream; [Motor must be totally enclosed type.] Mount complete assembly including motor, power transmission components, and guards on a common vibration isolation base with spring mountings [conforming to requirements indicated].

2.2.3 Utility Set[s]

Single-width, single-inlet, nonoverloading scroll type. Scroll must be [intermittently] [or] [continuously] welded [carbon] [Type [304L] [316L] stainless] [steel] [_____ alloy aluminum] with required reinforcement, [flanged inlet and outlet connections], streamline orifice inlet bolted [and gasketed] to scroll side sheet, [threaded and] [plugged] [piped] [scroll drain,] [access door with gasket].[Carbon] [Type [304] [316] stainless] [steel] [monel] shaft finished as required [and fitted with] [heat slinger] [shaft seal] [grease lubricated stuffing box]; welded [carbon] [Type [304L] [316L] stainless] [steel] [_____ alloy aluminum] impeller assembly; [backward inclined] flat or single thickness airfoil type impeller blades. Provide protective coating of [_____] for [fan surfaces exposed to [air] [fume] [vapor] stream and weather.] Motor and power transmission components must be enclosed in ventilated weathertight hood. [Discharge must be fitted with an automatic gravity shutter constructed from [specified stainless steel] [aluminum].][Mount complete assembly from individual points of support on rails and vibration isolated by double-rubber-in-shear mountings] [conforming to requirements indicated].

2.2.4 In-line Centrifugal Fans

Welded steel casings, centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards and adjustable motor mounts. Inlet and outlet connections for fan casings to duct work and equipment casings, may be of the slip fit or flanged type. [Provide guards for discharges. Rate fans with guards in place.] Air must enter and leave the fan axially. Inlet must be streamlined and conversion vanes must eliminate turbulence and provide smooth discharge air flow. Enclose fan bearings and drive shafts, and isolate from the air stream. Fan bearings must be mechanically sealed against dust and dirt and must be self-aligning, pillow block ball or roller type. Motor and drive must be provided by fan manufacturer.

2.2.5 Fiberglass Centrifugal Fans

ASTM D4167. Construct of fire retardant fiberglass with a flame spread rating at least equal to or less than that of the duct system. Housing and fan impeller must be fiberglass. Shaft and fan support stand must be steel with protective coating. Provide exterior gel coat, coating, or paint with ultraviolet light inhibiting properties for fans exposed to sunlight. Fiberglass fans must be suitable for [the intended service.] [use in [_____]]. Provide with flanged outlet [and inlet] connections, [threaded [and plugged]] scroll drain, bolted access and inspection doors, and epoxy coated steel fan base and motor mount.

2.3 [VANEAXIAL] [TUBEAXIAL] FANS

Direct-connected with adjustable blade impeller or V-belt driven. When direct connected, fans must be driven by totally-enclosed, air-over (TEAO), flanged or end mounted motors. When belt-driven, provide internal and external belt guards and adjustable motor mounts.

2.3.1 Fan Impeller Blades

Air-foil type [with stationary guide vanes], designed to provide the efficiency [and sound level] indicated. In fan selection, consider and account for any losses due to the size of the motor in relation to the fan hub diameter. Impeller blades of direct-driven fans must be adjustable to permit varying performance over a range of volume and pressure. Index the hub to facilitate setting the angle of the blades uniformly and accurately from minimum to maximum angle; provide stops to avoid overloading motor. Furnish motor with the factory blade maximum setting included in the fan nameplate data.

2.3.2 Fan Casings

Cylindrical, or welded steel construction, with flanged inlets and outlets. Assemble motor support [and guide vanes] by welding. Provide casings with bolted or hinged access plates adequate for inspection and servicing of internal parts.

2.4 BATHROOM AND KITCHEN FANS

Power used must be a maximum of 13 watts for 50 cfm fans; 15 watts for 70 cfm fans; 17 watts for 90 cfm fans; and 20 watts for 100 cfm fans. Noise levels must not exceed 0.5 sones for 50 to 70 cfm fans; 1.0 sones for 90 cfm fans; and 1.5 sones for 100 cfm fans. Fan lights must be compact fluorescent.

2.5 BASIC MATERIALS

2.5.1 Coated and Uncoated Carbon Steel Sheets, Plates, and Shapes

2.5.1.1 Mill Galvanized Steel Sheet

ASTM A653/A653M, lock forming quality, Coating G-90[, 400 degrees F, maximum].

2.5.1.2 Mill Galvanized Steel Shapes

ASTM A36/A36M galvanized in accordance with [ASTM A123/A123M] [

ASTM A653/A653M].

2.5.1.3 Uncoated (Black) Carbon Steel Sheet

ASTM A1011/A1011M.

2.5.1.4 Uncoated (Black) Carbon Steel Plates and Shapes

ASTM A36/A36M.

2.5.2 Corrosion Resistant (Stainless) Steel

ASTM A167, Type 304L or Type 316L with mill finish, except as otherwise specified.

2.5.3 Corrosion Protection

Treat equipment fabricated from ferrous metals that do not have a zinc coating conforming to [ASTM A123/A123M] [ASTM A653/A653M] for prevention of corrosion with a factory coating or paint system that will withstand 125 hours in a salt-spray fog test except that equipment located outdoors must withstand 500 hours. Perform salt-spray fog test in accordance with ASTM B117. Each specimen must have a standard scribe mark as defined in ASTM D1654. Upon completion of exposure, evaluate and rate the coating or paint system in accordance with procedures A and B of ASTM D1654. The rating of failure at the scribe mark must be not less than six (average creepage not greater than 1/8 inch). The rating of the unscribed area must be less than ten (no failure). Thickness of coating or paint system on the actual equipment must be identical to that on the test specimens with respect to materials, conditions of application, and dry-film thickness.

2.6 HEAT RECOVERY SYSTEMS

Heat recovery systems must be utilized in ventilation units (100 percent outside air units) where the temperature differentials between supply air and exhaust air is significant. Heat recovery systems must operate at a minimum of 70 percent efficiency. The heat recovery systems must have factory-installed microprocessor controller that in turn can be connected to a Direct Digital Control (DDC) Building Automation System to monitor temperatures, [wheel operation,] filter cleanliness, defrost control, and other critical conditions. Prefilters must be provided in all heat recovery systems before the heat recovery equipment.

2.6.1 Unit Casing

Provide a self supporting unit casing constructed of minimum 0.04 inches thick extruded aluminum profiles and aluminum zinc sheet steel that create a double wall.[The base of the casing must be constructed as a continuous condensate drain with a total of four connection possibilities.] The casing bottom, top, and sides must be insulated with 2 inch thick fibrous glass insulation with a minimum density of 6 lb per cubic foot or another material with equivalent insulating value.[Provide a partition to isolate the exhaust and supply airstreams from each other to avoid cross contamination.] Partition must be a minimum of [0.075][_____] inches [galvanized steel] [aluminum]. Provide stainless steel casing for corrosive air streams. The casing must be designed for diagonal mounting of the heat exchanger access from the side for maintenance and cleaning. The casing must be designed with an integral defrost control damper on the heat exchanger section for defrost control. Provide full size access doors for checking the heat exchanger section.

2.6.2 Heat Exchanger Section

[2.6.2.1 Enthalpy Wheel

A desiccant-impregnated enthalpy wheel with variable speed rotary wheel must be used in the supply and exhaust systems. Wheels must contain media made of a lightweight polymer that is coated with a corrosion-resistant finish. Etched or oxidized surfaces are not acceptable. Heat transfer surfaces must be coated with a non-migrating (permanently bonded) absorbent.[Desiccant must be silica gel for maximum latent energy transfer.] Wheel must allow laminar flow but not radial, and prevent leakage, bypassing, and cross contamination by cross flow within wheel. The wheel must have rotor seals specifically designed to limit cross-contamination, and a rotation detector. Should rotation stop, the rotation detector must alarm the HVAC control system. Wheel must not condense water directly or require a condensate drain for summer or winter operation. Performance rating must be in accordance with AHRI 1060 I-P.

][2.6.2.2 Heat Pipe

For sensible heat recovery a run-around type heat pipe must use refrigerant to absorb heat from the air stream at the air intake and reject the heat back into the air stream at the discharge of the air-handling unit. The heat transfer between air streams must take place in a counterflow arrangement. The unit must have no moving parts and must be one piece construction. Tube core must be [5/8][1][_____] inch OD seamless aluminum tubing permanently expanded into the fins to form a firm, rigid and complete metal pressure contact between the tube and fin collar of all operating conditions. Provide copper tubes and copper fins for corrosive air streams. Secondary surfaces must be of continuous plate type aluminum fins, [0.007][_____] inch thick, and of corrugated design to produce maximum heat transfer efficiencies. System must have solenoid valve control to operate under partial load conditions.

][2.6.2.3 Run-around Coil

The run-around coils must be used at the exhaust discharge from the building and at the fresh air intake into the building.[A glycol run-around coil must be used with control valves and a pump for part load conditions.]

][2.6.2.4 Sensible Heat Recovery Unit

[A cross-flow, air-to-air (z-duct) heat exchanger must recover the heat in the exhaust and supply air streams. Z-ducts must be constructed entirely of sheet metal.] [Heat wheels must be used for sensible heat recovery. Unit must have variable speed drive for controlling the temperature leaving the unit. Wheels must contain media made of a lightweight polymer that is coated with a corrosion-resistant finish. Etched or oxidized surfaces are not acceptable. Wheel must allow laminar flow but not radial, and prevent leakage, bypassing, and cross contamination by cross flow within wheel. The wheel must have rotor seals specifically designed to limit cross-contamination, and a rotation detector. Should rotation stop, the rotation detector must alarm the HVAC control system. Wheel must not condense water directly or require a condensate drain for summer or winter operation. Performance rating must be in accordance with AHRI 1060 I-P.]

]2.6.3 Defrost Control Damper Section

Provide an integral defrost control damper section with electric damper motor for defrost control of the heat exchanger section. The defrost control dampers must be mounted upstream of the heat exchanger section and must be capable of preventing frost build-up on the plates of the heat exchanger. Drain pan must be stainless steel. The damper motor must be located outside of both airstreams.

2.6.4 Angle Filter Box

Provide a side access, galvanized steel duct mounted filter box assembly with integral holding frames suitable for accommodating [2 inch][_____] thick filters with a minimum efficiency reporting value of 13. Provide filter box constructed of minimum 0.05 inch thick galvanized steel with extruded aluminum tracks and individual universal holding frames with polyurethane foam gaskets and positive sealing clips designed to accommodate various standard size filters in various efficiency ranges. Provide access doors with positive sealing, heavy duty quick opening half-twist latches and sponge neoprene gasketing on each side of filter box for removal and replacement of filters. For each filter box provide one magnehelic gauge or inclined manometer with static pressure taps, shut-off and vent cocks, and aluminum tubing with range 0.0073 to 0.21 psi.

2.7 FIRE DAMPERS

Provide [_____] [single leaf] [guillotine] [recessed] [hinged] [type] [curtain type with interlocking blades] [with frame and operating mechanism housed out-of-[air] [fume] [vapor] stream,] constructed and rated in accordance with AMCA 500-D. Furnish dampers for indicated stream flow, to equal or exceed fire resistance rating of [1 1/2 hours] [3 hours]. Fire damper must be rattle-free and must cause a minimum [5] [10] percent increase in stream velocity or system static pressure.[For [_____] system[s], stream exposed materials of construction must be [_____].] Provide building penetration collars in accordance with AMCA 500-D [and NFPA 91], [unless otherwise indicated]. Provide one spare fusible link for testing of each fire damper operation and one spare fusible link for each [10] fire dampers, but not less than two.

2.8 MISCELLANEOUS MATERIALS

2.8.1 Filler Metal, Welding

AWS filler metal specification and grade compatible with base materials to develop full joint strength.

2.8.2 Flashing Materials

[Mill galvanized, phosphatized, steel sheet with minimum spangle, conforming to ASTM A653/A653M, Coating G90, 24 gage minimum thickness. Mill No. 1 or 2D finished, stainless steel, fully annealed, soft temper, conforming to ASTM A167, Type 304, 0.015 inch minimum thickness. Mill finished copper, conforming to ASTM B152/B152M, minimum 16 ounces per square foot.][As specified in Section [07 60 00] FLASHING AND SHEET METAL.]

2.8.3 Flexible Connectors

2.8.3.1 General Service

Airtight, fire-retardant, fume and vapor resistant, chloroprene or chlorosulfonated polyethylene impregnated, woven fibrous glass fabric, rated for continuous service at 250 degrees F, conforming to UL 214, with 20 ounce per square yard weight for service at 2 inches water gage and under and 30 ounce per square yard weight for service over 2 inches water gage. Provide with or without integral 24 gage mill galvanized sheet metal connectors.

2.8.3.2 Acoustic Service

Provide as second layer for nonpressure service to 140 degrees F, leaded sheet vinyl, a minimum 0.055 inches thick, weighing a minimum 0.87 pounds per square foot, capable of 10 dBA attenuation in 10 to 10,000 Hz range, suitable for solvent seam or overlap joining and banding.

2.8.3.3 [Fume] [Dust Collection] Service

[1/8 inch] [_____] thick, single-ply, synthetic fabric reinforced chloroprene suitable for 225 degrees F.

2.8.3.4 High Temperature Service

a. Bellows type metal expansion joints, temperature range minus 20 degrees F to [800] [1000] degrees F, plus or minus 100 inches water gage [with interior liner [and exterior cover]].

b. Fabric reinforced, insulated, elastomeric cover expansion joint for operating temperature up to [400 degrees F][_____] [belt] [or] [flange] type for [40 inches water gage] [_____] positive or negative pressure [, with interior liner or baffle].

2.8.4 Flexible Duct

2.8.4.1 Metallic Type

Single-ply [zinc-coated carbon steel] [mill galvanized carbon steel] [Type 316 stainless steel] [two-ply aluminum], [self-supporting to 8 foot spans] with corrugated and interlocked, folded and knurled type seam construction, bendable without damage through 180 degrees with a throat radius approximately 10 times the duct diameter, airtight, rated for positive or negative working pressure of 15 inches water gage at [350 degrees F for aluminum] [650 degrees F for galvanized steel and stainless steel] UL 181, Class 1 rated, conforming to NFPA 91.

2.8.4.2 Wire Reinforced Fabric Type

Elastomer impregnated woven synthetic fabric, bonded to and supported by corrosion protected or corrosion resistant spring steel helix, rated for positive or negative working pressure of [15 inches water gage at 250 degrees F] [_____] UL 181, Class 1 labeled. Provide with manufacturer's standard metallic connection collar and clamping fastener assembly [fitted with] [dampers] [and] [extractors] [as indicated].

2.8.4.3 Ball Joints

Fabricated from cast iron or formed sheet metal with outer sections secured with bolts. Provide each half of the ball joint with tubular stubs for connecting ducts.

2.8.4.4 Slip Joints

Fabricated from tubular sheet metal sections. Provide outer tube with formed steel flat bar clamps. Where required or indicated, provide a chain or other means to fix relative longitudinal position of outer and inner joint sections.

2.8.5 Gaskets

2.8.5.1 Elastomer Buna N

Sheet, 1/8 inch thick, conforming to ASTM D2000, Type 2BG410B14.

2.8.5.2 Elastomer Chloroprene

Sheet, 1/8 inch thick, conforming to ASTM D2000, Type 2BE410B14.

2.8.5.3 Rubber

Sheet, 1/8 inch thick red or black, natural, reclaimed, synthetic rubber or mixture thereof, conforming to ASTM D1330.

2.8.6 Protective Coating Materials

2.8.6.1 Baked Unmodified Phenolic

MIL-DTL-12276, Type II.

2.8.6.2 Epoxy Coating

Conform to MIL-PRF-23236, Type I, Class 1 or MIL-DTL-24441 system, Formula 150 green primer 3 mils, Formula 151 haze gray 3 mils, and Formula 152 white 3 mils.

2.8.6.3 Inorganic Zinc Coating

SSPC Paint 20, Type I-C (Self-cure type).

2.8.6.4 Galvanizing Repair Paint

Conform to MIL-P-21035.

2.8.7 Sealants

2.8.7.1 Elastomeric

Sealant specified in these specifications or referenced standards as elastomeric or without further qualification, must be silicone, polyurethane, polysulfide, polyisobutylene, or acrylic terpolymer suitable for the service. For sealing of nongasketed duct joints during fabrication or assembly, sealant must be polyurethane, acrylic terpolymer or polysulfide. Sealants must conform to the following:

a. Silicone: Conforming to FS TT-S-001543, single component type, not requiring primed substrate, with manufacturer published estimated life of 30 years and a maximum 5 percent shrinkage when cured.

b. Polyurethane: Conforming to ASTM C920, Type 2, Class A, single component type, not requiring primed substrate, with manufacturer published estimated life of 20 years and a maximum 10 percent shrinkage when cured.

c. Polysulfide: Conforming to ASTM C920, Type 2, Class A, single component type, not requiring primed substrate, with manufacturer published estimated life of 20 years and a maximum 10 percent shrinkage when cured.

d. Polyisobutylene/Butyl: Conforming to CID A-A-272, Type 1, single component type, not requiring primed substrate, with manufacturer published estimated life of 10 years and a maximum 15 percent shrinkage when cured.

e. Acrylic Terpolymer: Conforming to ASTM C920, single component type, not requiring primed substrate, with manufacturer's published estimated life of 20 years and a maximum 10 percent shrinkage when cured.

f. Provide sealants and non-aerosol adhesive products meeting either emissions requirements of CDPH SECTION 01350 (use the office or classroom requirements, regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants must be classified in the "Other" category within the SCAQMD Rule 1160 sealants table). Provide validation of indoor air quality for duct sealants.

2.8.7.2 Heat Shrinking over Round Exterior Duct

High molecular weight, irradiated polyethylene band with interior heat activated epoxy adhesive coating for heat shrinking and epoxy extrusion over round, exterior, duct joints.

2.8.7.3 Hard Cast Caulking for Exterior Ducts

Mineral and adhesive impregnated woven fiber tape with adhesive activator for exterior round or rectangular duct joints.

2.8.7.4 Caulking of Building Surface Penetration

Foamed silicones, two-component, fire-resistant, [gamma radiation resistant], low-exotherm, room temperature vulcanizing silicone.

2.9 SPECIALTIES

Steel, cast iron, stainless steel, nonferrous metal, or plastic to match duct construction, or as indicated.

2.9.1 Access Ports, Test

With gasketed screw cap and flange, to suit exhaust service[, one inch nominal pipe size].

2.9.2 Damper Regulators

Incremental position indicating and locking type, with satin finish chrome plated, flush surface mounting cover and regulator box where concealment is required in finished spaces. For splitter dampers, provide splitter tip mounted trunnion brackets with self-locking screw regulator or rods with external swivel joint brackets.

2.9.3 Blast Gates

Provide means for locking in adjusted position with bolt and nut.

2.9.4 Cast Iron Access Door

Cast iron frame, [hinged and] gasketed cast iron door, quick closing clamps for watertight sealing[, size as indicated][, 6 by 9 inches minimum size].

2.10 SUPPORTS AND HANGERS

2.10.1 General Requirements for Supporting Elements

Provide ducting systems and equipment supporting elements including but not limited to building structure attachments; supplementary steel; hanger rods, stanchions and fixtures; vertical duct attachments; horizontal duct attachments; anchors; supports. Design supporting elements for stresses imposed by systems, with a minimum safety factor of 4.0 based on duct being 50 percent full of particulate conveyed. Supporting elements must conform to SMACNA 1403, SMACNA 1922, SMACNA 1520, [SMACNA 1378,] and NFPA 91, as applicable, and modified and supplementary requirements specified herein. Do not use weld studs and powder actuated anchoring devices to support mechanical systems components without prior approval.

2.10.2 Vertical Attachments

Provide in accordance with SMACNA Standards, except mill galvanized iron straps must be a minimum of one inch wide, 16 gage thick.

2.10.3 Horizontal Attachments

Provide as indicated in accordance with SMACNA Standards.

2.10.4 Supplementary Steel

Provide where required to frame structural members between existing members or where structural members are used in lieu of commercially rated supports. Such supplementary steel must be fabricated in accordance with the AISC 360.

2.10.5 Vibration Isolators

[Provide vibration isolators with in-series, contained, steel springs, chloroprene elastomer elements, and fasteners for connecting to building structure attachments. Devices must be loaded by support system in operating condition to produce required static spring deflection without exceeding 75 percent of device maximum load rating.] [Conform to Section [22 05 48.00 20] MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL.]

2.11 DUCTWORK, DUST [AND FUME] COLLECTION

2.11.1 General Requirements for Dust [and Fume] Collection Ductwork

[Where specified or indicated] [_____] fabricate system ductwork from black carbon steel [, with welded seams and flanged and gasketed joints]. Provide steel with a minimum of 70 percent recycled content. Provide data identifying percentage of recycled content of ductwork steel components. Construct duct to handle [_____] [wood dust] particulate with an influent loading of [7,000 grains per [standard cubic feet per minute (scfm)] [actual cubic feet per minute (acfm)] [_____]]. Provide ductwork in accordance with best practice recommendations and requirements of SMACNA 1922 and SMACNA 1520, for [Class I] [Class II] [Class III] [Class IV] duct and requirements specified or indicated.

2.11.2 Fabrication of Dust [and Fume] Collection Ductwork

Provide indicated sizes, lengths and configuration without deviation unless otherwise approved. Assemble ductwork airtight [as defined under paragraph DUCTWORK STRUCTURAL INTEGRITY AND LEAKAGE TESTING in this section] and include necessary reinforcements, bracing, supports, framing, gasketing and fastening to guarantee rigid construction and freedom from vibration, airflow induced motion, and excessive deflection. For [_____] system, provide SMACNA Class 1 construction with any of the reference standard seams and connections being acceptable [, except [_____]]. For [_____] system, provide SMACNA Class [2] [3] [4] construction with welded duct and fitting seams and welded companion angle or Van-Stone flanges. Welding must conform to requirements specified herein. Provide flanges at [branches] [hoods,] [equipment] [and] [enclosure connections,] where necessary for ease of access to equipment or maintenance disassembly, and where indicated. Provide elbows and fittings a minimum 2 gages heavier than straight ducts of equal diameter.

2.11.3 Radius Elbows

Fabricated from butt welded specified piece gore sections or from formed welded or seamless tubing to a minimum centerline radius of [2.0] [2.5] [_____] diameters. Assemble, weld, and finish ground gore sections to eliminate internal projections. Construct gored elbow in accordance with the following:

16 inches diameter and less	Over 16 inches diameter
90 degree - 5 piece minimum	90 degree - 7 piece minimum
60 degree - 4 piece minimum	60 degree - 6 piece minimum
45 degree - 3 piece minimum	45 degree - 5 piece minimum
30 degree - 3 piece minimum	30 degree - 4 piece minimum
15 degree - 2 piece minimum	15 degree - 3 piece minimum

2.11.4 Flanged Joints

Gasketed with full face gaskets 1/8 inch thick red or black rubber as specified under paragraph MISCELLANEOUS MATERIALS in this section.

2.11.5 Access Doors

Provide hinged, gasketed, and fitted with snap-action closures access doors. Equip access door with gaskets of common weather stripping type, foamed, closed-cell, elastomer with pressure sensitive adhesive back. Provide cleanout adjacent to every bend and vertical riser. In horizontal duct runs, locate cleanout door with maximum of spacing of 12 feet for ducts 12 inches or less in diameter and 20 feet for larger ducts.

2.11.6 Flexible Connectors

[Provide drawband secured flexible connectors, conforming to requirements specified under paragraph MISCELLANEOUS MATERIALS in this section, utilizing 1/8 inch thick reinforced elastomer, fabricated into a cylindrical shape by vulcanizing or otherwise bonding longitudinal seam.] [Provide flange secured flexible connectors, conforming to requirements specified under paragraph MISCELLANEOUS MATERIALS in this section, utilizing bellows type metal expansion joint. Where service temperature exceeds 300 degrees F, insert one inch thickness of mineral wool.]

2.12 PROTECTIVELY COATED STEEL DUCTS

Ductwork, Protectively Coated Steel, For Corrosive Fume and Vapor Exhaust:

2.12.1 General Requirements for Protectively Coated Steel Ductwork

Fabricate [_____] system ductwork from black carbon steel with welded seams, flanged and gasketed joints and protectively coated interior surfaces including flange faces, provide steel with a minimum of 70 percent recycled content. Provide data identifying percentage of recycled content of protectively coated steel ducts. Construct ductwork to handle [_____] [fumes] [condensing] [noncondensing] [vapors] containing [_____]. Spiral welded duct is prohibited. Provided ductwork in accordance with best practice recommendations and requirements of SMACNA 1922 and SMACNA 1520, for Class [IV] [_____] duct.

2.12.2 Protective Coating

Provide [_____] [and] [_____] protective coatings as specified under PROTECTIVE COATING MATERIALS, a subparagraph of MISCELLANEOUS MATERIALS in this section. Provide [_____] coating to interior of duct [and related fan] surfaces. Coat exterior duct [and related fan] surfaces with same protective coating as specified for exterior surfaces [primed with] [inorganic zinc coating] [_____].[Exterior fan surfaces must be finished [protectively coated] [primed] [as specified under paragraph, "_____".]][Field finish exterior surfaces which have only been primed, as specified in Section 09 90 00 PAINTS AND COATINGS.]

2.12.3 Fabrication of Protectively Coated Ductwork

Construct protectively coated ductwork for corrosive fume and vapor exhaust in accordance with SMACNA 1922 and SMACNA 1520 and as specified herein. Provide indicated sizes, lengths and configuration without deviation, unless otherwise approved. Spiral welded duct is prohibited. Install ductwork to be water washable, watertight, self-draining, and airtight [as defined under paragraph DUCTWORK STRUCTURAL INTEGRITY AND LEAKAGE TESTING in this section]. Provide necessary reinforcements, bracing supports, framing, gasketing, and drainage provisions, and fastening to guarantee rigid construction and freedom from vibration, airflow induced motion, and excessive deflection. Rigid construction is required to prevent damage to or failure of protective coating during construction, transport, erection, and on-off system operation. Only companion angle flanged joints must be permitted. Weld ducting and fittings seams. Avoid seams in bottom 3 inches of ducting and in corners wherever practical by bending of corners and arranging seams high in the side sheets or top sheet. Cracks, laps, sharp inside corners, sharp sheared edges, weld "icicles," flux, pits, weld spatter, burrs, and similar defects which contribute to coating discontinuities must be eliminated by the following: a) welding continuously, b) grinding of metal flush with surface or to 1/32 inch radius or to maximum radius permitted by thinner metals, c) Utilizing other fabrication techniques and subsequent surface preparation abrasive blasting. Removed from the job site for repair rejected ducting not conforming to these requirements and which exhibit coating thickness deficiency. Welding must conform to requirements specified herein. Continuously weld companion flange angles to the inside of the duct and intermittently weld with one inch welds every 4 inches on outside of duct. Intermittently weld girth and transverse reinforcements to duct surface for one inch on 6 inch centers or spot welded on 4 inch centers. Weld and grind flange and reinforcement angles at corners or ends to form continuous frames. Provide flanges at [branches,] [hoods,] [equipment] [and] [enclosure connections,] where necessary for ease of access to equipment or maintenance disassembly, and where indicated. Limit duct lengths in accordance with size, to permit complete and ready access for welding, grinding, blasting, coating, coating continuity checking and testing, and visual inspection during fabrication and immediately prior to erection.

2.12.4 Radius Elbows

Fabricated radius elbows from butt welded specified piece gore sections or from formed welded or seamless tubing to a minimum centerline radius of [2.0] [_____] diameters and preferably 2.5 times the duct diameter. Assemble, weld, and finish ground gore sections to prevent internal crevices and projections. Construct gored elbow in accordance with the following:

16 inches diameter and less	Over 16 inches diameter
90 degree - 5 piece minimum	90 degree - 6 piece minimum
60 degree - 4 piece minimum	60 degree - 5 piece minimum
45 degree - 3 piece minimum	45 degree - 4 piece minimum
30 degree - 3 piece minimum	30 degree - 3 piece minimum
15 degree - 2 piece minimum	15 degree - 2 piece minimum

2.12.5 Flanged Joints

Gasketed with full-face gaskets which are one-piece, heat, adhesive or solvent vulcanized, or bonded and assembled to prevent drainage and limit extrusion or cavity at joint.

2.12.6 Access and Cleanout Door Openings

Provide access plates upstream and downstream of equipment installed in ductwork, at locations to facilitate duct cleaning (such as in horizontal runs, near elbow junctions, and vertical runs), and where indicated. For ducts 12 inches diameter or less, locate cleanout or access openings a minimum of 12 feet apart. Provide 10 by 12 inches minimum size access opening; unless otherwise indicated or prevented by duct dimension. Locate opening a minimum of 3 inches from bottom of duct. Frame access openings by welded and ground miter joint 3/16 inch thick strap iron, or angle iron, with 1/4 inch stainless steel bolt or stud assembly to duct on 4 inch centers. Fabricate plates out of 300 series corrosion-resistant steel or polyvinyl chloride faced sheet backed by 16 gage sheet metal, reinforced as required for larger sizes, or constructed of heavier gage metal. Ensure only corrosion resistant materials are expose to duct interior. Provide one "U" handle on access plates through 10 by 12 inches and two "U" handles on larger sizes. Locate access openings at points which will permit ready access to duct internals with no duct cutting. Where access through equipment or access doors specified herein is not available at a specific point, provide 8 inch diameter gasketed access plates spaced on maximum 10 foot centers. Where penetration of duct surfaces is approved or specified, provide 300 series corrosion resistant steel fastener assemblies. Provide hex type, cadmium plated flange fastener bolts and nuts and [1/8 inch thick acid resistant chloroprene] [1/8 inch thick Buna N] joint gaskets.

2.13 THERMOPLASTIC DUCTWORK

2.13.1 Ductwork

Construct ductwork, fittings, hoods, and accessories in accordance with SMACNA 1378 and NFPA 91. Fabricate supplementary steel in accordance with the AISC 360.

2.13.2 Product Requirements

Provide duct system from a manufacturer recognized in the field of fabrication of PVC material. Fabricating personnel must be certified by the manufacturer as qualified to perform the work in accordance with the specified requirements.

2.13.3 Basic Ductwork Materials

Fabricate ducts, hoods, accessories and components in sheet form from materials conforming to ASTM D1927, [Type I, Grade 1] [Type I, Grade 2]. Utilize extrusions of the same compounds as specified for duct. Solvent cement must conform to ASTM D2564. Construct metal components, when permitted to be located interior to the duct, of [Type] [304 or 304L] [316 or 316L] [_____] [corrosion resistant steel] [_____].

2.13.4 Fasteners

Where penetration of duct surfaces is approved or specified, provide Type 316 corrosion resistant steel fastener assemblies encapsulated with polyester on duct interior, unless total disassembly is intended. Provide flange fastener bolts and nuts of hex type only, cadmium plated, unless exposed to corrosive fumes; in which case provide Type 316 stainless steel. Equip bolted assemblies with two oversized washers, except where assembled with metallic reinforcement contact. Plastic bolting is prohibited.

2.13.5 Joint Gaskets

Provide [1/8 inch thick acid resistant chloroprene.] [1/8 inch thick Buna N.]

2.13.6 Fabrication

Construct water washable, watertight, self-draining, and airtight ductwork as specified or indicated. Provide required reinforcements, bracing, supports, framing, gasketing, sealing, resilient mounting, drainage provisions, and fastening to guarantee rigid construction and freedom from vibration, airflow induced motion and noise, and excessive deflection at specified maximum system pressure and velocity.

2.13.6.1 Flanges

Provide flanges at all branches on maximum 20 foot centers in ducting sized 16 inches and under, on maximum 8 foot centers in duct sized over 16 inches, where required for ease of access to equipment, at hoods, enclosure connections and where indicated. Furnish one piece, heat, adhesive, or solvent vulcanized or bonded full face gaskets at flange joints.

2.13.6.2 Access Plates

Provide access plates upstream and downstream of equipment in ducts at locations to facilitate duct cleaning, and where indicated. Locate access openings a minimum of 2 inches above bottom of duct and externally frame with welded and ground miter joint steel which is isolated from duct interior. Construct access plate with PVC on interior side, backed with steel on exterior side. Provide stainless steel access plate fasteners. For ductwork cleaning access, provide 8 inch diameter gasketed access plates on maximum 10 foot on centers, except where access is available through an air terminal device or other required access.

2.14 FIBERGLASS DUCTWORK

Ductwork, Fiberglass for Nonflammable [Corrosive] [Fume] [Vapor] Exhaust:

2.14.1 Fiberglass Ductwork

Construct ductwork, fittings, accessories, and material of construction in accordance with NFPA 91, and ASTM C582. Fabricate supplementary steel in accordance with the AISC 360.

2.14.2 Basic Ductwork Materials

Fabricate ducts, accessories and components in sheet form from materials conforming to ASTM C582 [, RTP [_____]]. Provide exterior gel coat, coating or paint with ultraviolet light inhibiting properties for ducts exposed to sunlight. Construct metal components, when permitted to be located interior to the duct, of Type 316 corrosion resistant steel.

2.14.3 Fasteners

Where penetration of duct surfaces is approved or specified, provide Type 316 corrosion resistant steel fastener assemblies encapsulated with polyester on duct interior, unless total disassembly is intended. Provide flange fastener bolts and nuts of hex type only, cadmium plated, unless exposed to corrosive fumes; in which case provide Type 316 stainless steel. Equip bolted assemblies with two oversized washers, except where assembled with metallic reinforcement contact. Plastic bolting is prohibited.

2.14.4 Joint Gaskets

Provide [1/8 inch thick acid resistant chloroprene.] [1/8 inch thick Buna N.]

2.14.5 Fabrication

Construct water washable, watertight, self-draining, and airtight ductwork as specified or indicated. Provide required reinforcements, bracing, supports, framing, gasketing, sealing, resilient mounting, drainage provisions, and fastening to guarantee rigid construction and freedom from vibration, airflow induced motion and noise, and excessive deflection at specified maximum system pressure and velocity.

2.14.5.1 Flanges

Provide flanges at all branches on maximum 20 foot centers in ducting sized 16 inches and under, on maximum 8 foot centers in duct sized over 16 inches, where required for ease of access to equipment, at hoods, enclosure connections and where indicated. Furnish one piece, heat, adhesive, or solvent vulcanized or bonded full face gaskets at flange joints. Provide flanges at dissimilar material joints, such as between fiberglass reinforced plastic (FRP) and PVC.

2.14.5.2 Access Plates

Provide access plates upstream and downstream of equipment in ducts at locations to facilitate duct cleaning, and where indicated. Locate access openings at least 2 inches above bottom of duct and externally frame with welded and ground miter joint steel which is isolated from duct interior. Construct access plate with fiberglass on interior side, backed with steel on exterior side. Provide Type 316 stainless steel access plate fasteners. For ductwork cleaning access, provide 8 inch diameter gasketed access plates on not more than 10 foot centers, except where access is available through an air terminal device or other required access provision.

2.15 VEHICLE TAIL PIPE EXHAUST SYSTEM

2.15.1 General Requirements for Vehicle Tail Pipe Exhaust System

Provide a hanging [exposed overhead] [disappearing overhead] [disappearing underfloor] [nondisappearing (plug-in underfloor)] type vehicle tail pipe exhaust system. Construct and install in accordance with applicable requirements of NFPA 91.

2.15.2 Ductwork

Construct ducts and miter or stamped fittings with galvanized steel. Duct sheet metal gages must conform to Class I in SMACNA 1922 and SMACNA 1520.

2.15.2.1 Suction Side Ductwork

Construct suction side ductwork with lock groove seam longitudinal joints. Connect circumferential joints between sections with push-on or bead and crimp type, secured with a minimum 4 rivets or screws on ducts up to and including 4 inches diameter, and with screws or rivets a minimum 3 inches on center on larger sizes of duct. Lap joints in the direction of air flow. On disappearing overhead systems, assemble roller duct sections using pop rivets. Solder all joints or construct ductwork leak-tight as for discharge side ductwork below.

2.15.2.2 Discharge Side Ductwork

Construct ductwork on the discharge side of the fan leak-tight with joints and seams welded, brazed, or soldered. Provide flanges with suitable gaskets, where required. Repair damaged galvanizing with galvanizing repair compound.

2.15.3 Fan

Comply with paragraph CENTRIFUGAL FANS in this section [, subparagraph UTILITY SET,] and special requirements for protective coatings.[Provide unit of all welded construction, utilizing minimum 14-gage carbon steel in AMCA Class II construction.] [Internal and external protective coating must be manufacturer's standard, engineered quality type, with properties comparable to [air-dry or baked phenolic,] [or] [epoxy] applied in multiple coats of 4 to 6 mil dry film thickness.] [Mount entire assembly for vibration isolation on structural steel base and spring or elastomer type isolators with minimum transmissibility of [10] [5] percent.][Provide split sleeve or flexible connection at fan inlet.]

2.15.4 Flexible Tail Pipe Exhaust Tubing and Connectors

Provide interlocking helical seam metallic type construction of 0.012 inch minimum thickness up to and including 6 inch diameter and 0.020 inch minimum thickness over 6 inches diameter Type 302, 304, or 321 corrosion-resistant steel [with inside diameter] [and length as shown.] [of] [3] [4] [5] [6] [8] [inches] and [_____] feet in length. Connect to duct by welding or with screws or flanged joint with gasket [and fit with tail pipe adapters constructed of minimum 20 gage Type 300 or 400 Series stainless steel, and which include provisions for secure tail pipe attachment]. Secure hose terminal connections by screws, clamps, or flanged connections.[Provide winch operated hose assembly.]

2.15.5 Supporting Elements

Support ducting [as indicated] with anti-sway bracing to resist perceptible movement in response to forces imposed by flexible tubing location on handling. Suspend tubing from overhead location and provide means to raise and lower for use. Assemble suspension system with rigid pulley restraint, 1/8 inch diameter aircraft cable, pulleys, and manually operated winch fitted with safety ratchet lock and slip resistant hand grip.

2.16 WELDING FUME EXHAUST SYSTEM

2.16.1 General Requirements for Welding Fume Exhaust System

Provide a [hanging] [long reach type] welding fume exhaust system as specified and indicated. Construct and install in accordance with applicable requirements of NFPA 91.

2.16.2 Ductwork

Construct ducts and stamped fittings with galvanized steel. Duct sheet metal gages must conform to Class I in SMACNA 1922 and SMACNA 1520.

2.16.2.1 Suction Side Ductwork

Construct suction side ductwork with lock groove seam longitudinal joints. Connect circumferential joints between sections with push-on or crimp and bead type, secured with a minimum 4 rivets or screws up to and including 4 inches diameter, and with screws or rivets a maximum 3 inches on center on larger sizes of duct. Lap joints in the direction of air flow.

2.16.2.2 Discharge Side Ductwork

Construct ductwork on the discharge side of the fan leak-tight with joints and seams welded, brazed, or soldered. Provide flanges with suitable gaskets, where required. Repair damaged galvanizing with galvanizing repair compound.

2.16.3 Fan

Comply with paragraph CENTRIFUGAL FANS [, subparagraph UTILITY SET,] in this Section and special requirements for protective coatings.[Provide unit of all welded construction, utilizing a minimum 14-gage carbon steel in AMCA Class II construction.][Internal and external protective coating must be manufacturer's standard, engineered quality type, with properties comparable to [air-dry or baked phenolic,] [or] [epoxy] applied in multiple coats of 4 to 6 mil dry film thickness.] [Mount entire assembly for vibration isolation on structural steel base and spring or elastomer type isolators with a minimum transmissibility of [10] [5] percent.][Provide split sleeve or flexible connection at fan inlet.]

2.16.4 Flexible Welding Fume Exhaust Tubing and Connectors

Provide corrosion protected, spring steel helix reinforced, neoprene impregnated, woven fibrous glass fabric laminate, flexible tubing with cuffed ends or equivalent construction, and with an inside diameter [and length as shown.] of [4] [5] [6] inches [and [_____] feet in length]. Connect to duct with clamp or gasketed flange [and fit with swivel connected conical fume hood, constructed of minimum 20 gage aluminum [or 26 gage galvanized steel] [or ABS plastic] and fitted with 1/2 inch mesh intake screen and magnets for holding receptor in fixed location]. Secure tubing to terminal devices by clamping.[Provide spring or weight counterbalanced supporting arms for flexible hose section of long reach system.]

2.16.5 Supporting Elements

Support ducting [as indicated] with anti-sway bracing to resist perceptible movement in response to forces imposed by flexible tubing location on handling. Suspend tubing from overhead location [and provide means to raise and lower for use].[Assemble suspension system with rigid pulley restraint, 1/8 inch diameter aircraft cable, pulleys, and manually operated winch fitted with safety ratchet lock and slip resistant hand grip.] [Support movable portion of long reach system with brackets.] Observe that hood remain in a fixed position after manual adjustment.

2.17 STACKHEADS

Provide SMACNA 1403 no loss type stackheads for vertical discharge to the atmosphere unless indicated otherwise. Weather caps are prohibited. Provide bracing or guy wires for wind loads on stacks as indicated. Discharge stacks should be vertical and terminate at a point where height or velocity prevents reentry of exhaust air.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Installation Requirements

Install in accordance to NFPA 91, and SMACNA 1922, and SMACNA 1520. Provide mounting and supports for equipment, ductwork, and accessories, including structural supports, hangers, vibration isolators, stands, clamps and brackets, access doors, blast gates, and dampers. Install accessories in accordance with the manufacturer's instructions. Construct positive pressure duct inside buildings airtight.

3.1.1.1 Wood Facilities

For [wood processing] [and] [woodworking] facilities, conform to NFPA 664.

3.1.1.2 Aluminum Facilities

For aluminum [processing] [and] finishing facilities, conform to NFPA 65.

3.1.2 Electrical Ground Continuity

Where electrical ground continuity is required, provide brazed connection insulated, multi-strand, copper wire jumpers across points of discontinuity. Provide connection to ground and continuity testing as part of the work of Division 16.

3.1.3 Special Installation Requirements

Special installation requirements for protectively coated steel ductwork for corrosive fume and vapor exhaust: Slope horizontal ducts [one] [_____] inch in [40] [_____] feet in the direction of air flow or [one] [_____] inch in [10] [_____] feet in the direction opposite to airflow. Where necessary, slope duct to common drainage point. Provide drains at low points, at internal duct restrictions, at base of risers and where indicated. Provide drain connections of one inch pipe size corrosion resistant steel couplings welded to duct and provided with polytetrafluoroethylene paste lubricated PVC plug where drainage piping is not indicated. Provide drain lines with a trap of one inch greater depth than the positive or negative pressure in the duct but not less than 2 inches. Provide duct support system to include additional weight due to collection or [condensate] [and] washing water in nondrainable deflected surface and other areas. Provide duct supports and building structure attachments in accordance with SMACNA 1922 and SMACNA 1520.

3.1.4 Special Requirements for Installation of Thermoplastic Ductwork

Requirements for installation of thermoplastic ductwork for nonflammable corrosive fume and vapor exhaust:

3.1.4.1 Slope

Slope horizontal ducts [one] [_____] inch in [40] feet in the direction of airflow or [one] [_____] inch in [10] [_____] feet in opposite to the direction of airflow. Where necessary, slope duct to common drainage point.

3.1.4.2 Drains

Provide drains at all low points, at internal to duct drainage restrictions, at base of risers, and where indicated. Provide drain connections of one inch IPS couplings with polytetrafluoroethylene paste lubricated plug where drainage piping is not indicated, and where piping is indicated, provide PVC Type DWV piping conforming to ASTM D2665 to points indicated. Provide trap of one inch greater depth than the positive or negative pressure in the duct but not less than 2 inches.

3.1.4.3 Duct Supports

Isolate duct support contact surfaces from supporting steel by 1/4 inch thick closed-cell foamed cellular elastomer insulation material of a width greater than support. Provide duct support system to include additional weight due to collection of condensate and washing water in nondrainable, deflected surface and other areas.

3.1.5 Special Requirements for Installation of Fiberglass Ductwork

Requirements for installation of fiberglass ductwork for nonflammable corrosive fume and vapor exhaust:

3.1.5.1 Slope

Slope horizontal ducts [one] [_____] inch in [40] [_____] feet in the direction of airflow or [one] [_____] inch in [10] [_____] feet in opposite to the direction of airflow. Where necessary, slope duct to common drainage point.

3.1.5.2 Drains

Provide drains at all low points, at internal drainage restrictions, at base of risers, and where indicated. Provide drain connections of one inch IPS couplings with polytetrafluoroethylene paste lubricated plug where drainage piping is not indicated, and where piping is indicated, provide PVC Type DWV piping conforming to ASTM D2665 to points indicated. Provide a trap of one inch greater depth than the positive or negative pressure in the duct but not less than 2 inches.

3.1.5.3 Duct Supports

Isolate duct support contact surfaces from supporting steel by 1/4 inch thick closed-cell foamed cellular elastomer insulation material of a width greater than support. Design duct supporting system to include additional weight due to collection of condensate and washing water in nondrainable, deflected surface and other areas.

3.1.6 Miscellaneous Sheet Metal Work

Provide [_____] and [_____], fabricated from [mill galvanized steel] [black steel and protectively coated] [aluminum] [_____], as indicated. Sheet metal thickness, reinforcement and fabrication, where not indicated, must conform to SMACNA 1403.

3.1.7 Building Penetrations

3.1.7.1 General Penetration Requirements

Provide properly sized, fabricated, located, and trade coordinated sleeves and prepared openings, for duct mains, branches, and other item penetrations, during the construction of the surface to be penetrated. Provide sleeves for round duct 15 inches and smaller and prepared openings for round duct larger than 15 inches and square or rectangular duct. Fabricate sleeves, except as otherwise specified or indicated, from 20 gage, 0.0396 inch thick mill galvanized sheet metal. Sleeves penetrating load bearing surfaces must be standard weight galvanized steel pipe. Provide roof penetrations as shown in SMACNA 1403.

3.1.7.2 Framed Opening

Provide framed openings in accordance with approved shop drawings. Refer to paragraph FIRE DAMPERS in this section, for related work.

3.1.7.3 Clearances

Provide a minimum one inch clearance between penetrating and penetrated surfaces. Fill clearance space with bulk fibrous glass or mineral wood [or foamed silicone] and seal and close.

3.1.7.4 Tightness

Penetration must be [weathertight] [fireproof where fire rated surfaces are penetrated] [vaportight to prevent vapor transmission to conditioned spaces] [sound tight to prevent sound transmission to or between normally occupied or finished spaces] [deleterious or hazardous substance-tight where] [toxic] [flammable] [_____] [substances or gases could migrate].

3.1.7.5 Sealants

Provide sealant of [_____] [elastomeric] type [or foamed silicone type], as specified under paragraph SEALANTS in this section. Apply to oil free surfaces to a minimum 3/8 inch depth.

3.1.7.6 Closure Collars

Provide a minimum 4 inches wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around penetrating item without contact. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 15 inches in diameter or less from 20 gage, 0.0396 inch nominal thickness, mill galvanized steel. Attach collars a minimum of 4 fasteners to where the opening is 12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 20 inches in diameter or less. Fabricate collars for square and rectangular ducts with a maximum side of 15 inches or less from 20 gage, 0.0396 inch nominal thickness, mill galvanized steel. Fabricate collars for round, square, and rectangular ducts with minimum dimension over 15 inches from 18 gage, 0.0516 inch in nominal thickness, mill galvanized steel. Install collars with fasteners a maximum of 6 incheson center.[Where penetrating items are irregularly shaped and where approved, smoothly finished, fire-retardant, foamed silicone elastomer may be utilized without closure collar.]

3.1.8 Installation of Fire Dampers

Install fire dampers at locations indicated. Provide units and connecting ductwork in accordance with applicable provisions of [NFPA 91,] [UL Bld Mat Dir,] AMCA 500-D [and UL 33], [and as indicated]. Install retaining angles, sleeves, break-away connections, and duct access doors at each damper, as required. Minimum thickness of sleeves must be 14 gage [, except as otherwise indicated]. Duct access doors must be hinged [and fitted with UL listed glass viewing port assembly]. Prior to acceptance, simulate conditions to cause each unit to function automatically. Apply safe, nonflame, heat source to fusible links and replace test activated fusible links.

3.1.9 Installation of Flexible Connectors

Flexibly connect duct connected and vibration isolated fans [, ducts crossing building expansion joints] and specified or indicated components [, except where direct connections are specified or indicated]. When fans are started, stopped, or operating, flexible connector surfaces must be curvilinear, free of stress induced by misalignment or fan reaction forces, and must not transmit vibration. Leakage must not be perceptible to the hand when placed within 6 inches of the flexible connector surface or joint. Provide a minimum of 6 inches and a maximum of 2 feet active length with a minimum of one inch of slack, secured at each end by folding in to 24 gage sheet metal or by metal collar frames.

3.1.10 Installation of Supports

3.1.10.1 Selection

Select duct and equipment support system taking into account the best practice recommendations and requirements of SMACNA 1922, SMACNA 1520, and NFPA 91; location and precedence of work under other sections; interferences of various piping and electrical work; facility equipment; building configuration; structural and safety factor requirements; vibration and imposed loads under normal and abnormal service conditions. Indicated support sizes, configurations, and spacings are the minimal type of supporting component required for normal loads. Where installed loads are excessive for the normal support spacings, provide heavier duty components or reduce the element spacing. After system start-up, replace or correct support elements which vibrate and cause noise or possible fatigue failure. Exercise special care to prevent cascading failure.

3.1.10.2 General Requirement for Supports

Securely attach supporting elements to building structural steel or structural slabs. Where supports are required between building structural members provide supplementary structural steel as specified for work under this section. On submittals show location of supports and anchors and loads imposed on each point of support or anchor. Do not hang ductwork or equipment from piping, or other ducts or equipment. Attach supports to structural framing member and concrete slab. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required, between structural framing members, provide suitable intermediate metal framing. Where C-clamps are used, provide retainer clips. A maximum span of 10 feet must exist between any two points, with lesser spans as specified or as required by duct assemblies, interferences, and loads imposed or permitted. Provide a minimum one set of two vertical support elements for each point of support and each length of duct, except as otherwise specified. Install supports on both sides of all duct turns, branch fittings, and transitions. Cross-brace hangers sufficiently to eliminate sway. Perforated strap hangers are prohibited. Where ductwork system contains heavy equipment, hang such equipment independently of the ductwork.[Duct supports must be vibration isolated from structure at points indicated.][Provide vibration isolators in indicated discharge ducting system for a minimum distance of [50 feet] [_____] beyond the fan. Coordinate deflection of duct and equipment mountings and conform to Section [22 05 48.00 20] MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL.][The location of supporting elements must be limited by the allowable load on the purlin which must be limited to that no greater than the moment produced by one Kip load at mid-span of purlin. When the hanger load exceeds these limits, provide reinforcing of purlin[s] or additional support beam[s]. When an additional beam is used, the beam must bear on the top chord of the roof trusses and bearing must be over gusset plates of top chord. Stabilize beam by connection to roof purlin along bottom flange.]

3.1.10.3 Methods of Attachment

Clamp, or weld when approved, attachment to building structural steel in accordance with AWS D1.1/D1.1M. Construct masonry anchors selected for overhead applications of ferrous materials only. Install masonry anchors in rotary, non-percussion, electric drilled holes. Self-drilling anchors may be used provided masonry drilling is performed with electric hammers selected and applied in such a manner as to prevent concrete spalling or cracking. Pneumatic tools are prohibited.

3.1.11 Welding

Welding test agenda must be done in accordance with the applicable provisions of AWS D1.1/D1.1M and AWS D1.3/D1.3M.

3.1.12 Test Ports

Provide test access ports at points required for work under paragraph TESTING, ADJUSTING, AND BALANCING in this section. Locate test ports in straight duct as far as practical downstream of fans, change of direction fittings, takeoffs, interior to duct accessories, and like turbulent flow areas.

3.1.13 Ductwork Cleaning

Protect duct openings from construction debris using temporary caps, flanges, or other approved means. Clean ductwork in accordance with manufacturer's recommendations [and the North American Insulation Manufacturers Association (NAIMA) Guide on Cleaning of Duct Board Materials].[Clean dirty duct interior with high velocity water and oil-free air streams or by vacuum cleaning as required by project conditions.][Test watertight duct work for proper support, leakage, and unacceptable drainage provisions by intermittently spraying interior with garden hose nozzle, at a rate of 3 gallons per minute, exercising care to prevent excessive water accumulation.] After construction is complete but accessible and prior to acceptance, remove all construction debris from exterior surfaces. Do not close duct inspection ports until inspected by the Contracting Officer.

3.1.14 Protective Coating Work

3.1.14.1 General Requirements for Protective Coating Work

Provide protective coating on interior [and exterior] surfaces of [_____] [and] [interior] [and] [exterior] surfaces of [_____] with [_____] system as specified hereafter. Prime coat exterior surfaces of [_____] [and] [_____] with [_____] [inorganic zinc coating as part of work under this section] [.] [, for field finishing of exterior surfaces as part of work under Section [09 90 00] PAINTS AND COATINGS.] Brush primer, or protective coating where no primer is specified, onto corners and into crevices and welds, working the material into irregular surfaces for a holiday free finish.

3.1.14.2 Baked, Unmodified Phenolic System

a. General: The following must govern for a protective coating system based on unmodified phenol-formaldehyde resin intended for shop application to [black carbon steel] [_____] surfaces in [fume] [vapor] exhaust service with possibility of materials concentration by condensation and subsequent evaporation. Shop apply coating by an applicator approved or licensed by the coating manufacturer.

b. Surface Preparation: Clean and blast surfaces with dry abrasive to "White Metal" and critical profile and anchor pattern in accordance with SSPC SP 5/NACE No. 1, and requirements and recommendations of the coating manufacturer.

c. Application: The complete system must include the application of two coats of red pigmented base followed by not less than one coat of the clear finish, to provide a total minimum dry film thickness of [6 mils] [_____]. Apply coating materials by conventional industrial pressure spray equipment. Use only those thinners and cleaners in amounts recommended by the manufacturer. Heat-cure each coat between coats and bake surfaces after the last coat in accordance with manufacturer's applicable published instructions and specific instructions for the specified application. Baking time between coats must be a minimum 1 1/2 to 2 hours at 200 to 250 degrees F. Baking after top coat must be one hour at 200 to 350 degrees F, plus 2 hours final bake at a temperature of [350] [400] degrees F. Other baking schedules to achieve required quality coating may be proposed.

d. Repair: Return damaged surfaces to the applicator's shop for repair, unless otherwise approved by the Contracting Officer.

3.1.14.3 Inorganic Zinc Coating System

a. General Requirements, Inorganic Zinc Coating System: The following must govern for a protective coating system primer based on inorganic zinc coating intended for shop application to [_____] [specified] black carbon steel surfaces with subsequent field finishing with compatible tie coat and [epoxy] [acrylic latex] [modified acrylic] [chlorinated rubber] top coat [applied as part of work under Section 09 90 00 PAINTS AND COATINGS.]

b. Surface Preparation: SSPC SP 5/NACE No. 1.

c. Application: Apply one coat at [2 to 3] [3 to 5] mils dry film thickness by airless or conventional spray equipment. Use only those thinners and cleaners in amounts recommended by the manufacturer.

d. Repair: Field repair damaged surfaces in accordance with manufacturer's instructions.

3.1.14.4 Field Inspection of Protective Coating Work

Visually inspect coated surfaces from a maximum distance of 5 feet with special attention given to corners and crevices. Check coating thickness in accordance with SSPC Paint 11. Perform inspection immediately prior to erection of ductwork and equipment and in the presence of the Contracting Officer. Repair coating as required. Apply additional coating if thickness is not sufficient.

3.1.15 Factory and Field Painting and Finishing

3.1.15.1 Factory Work

Factory finish interior ferrous metal and other specified metallic equipment and component surfaces with manufacturer's standard surface preparation, primer, and finish coating. Factory finish exterior to building space ferrous metal surfaces and other exterior to building and interior to building metallic or nonmetallic surfaces with specified protective coating system in accordance with the paragraph PROTECTIVE COATING MATERIAL in this section and otherwise with manufacturer's standard surface preparation, primer and finish which meet the requirements of paragraph CORROSION PREVENTION.

3.1.15.2 Field Work

Touch-up or if necessary, repaint factory applied finishes which are marred, damaged, or degraded during shipping, storage, handling, or installation to match the original finish. Clean and prime field or shop fabricated ferrous metals required for the installation specified under this section in accordance with the applicable provisions of Section [09 90 00] PAINTS AND COATINGS. Painting of surfaces not otherwise specified and finish painting of items only primed at the factory or elsewhere, are specified as part of the work under Section [09 90 00] PAINTS AND COATINGS.

3.2 TESTING, ADJUSTING, AND BALANCING

3.2.1 Ductwork Structural Integrity and Leakage Testing

Inspect and test systems pressure rated higher than 2 inches water gage for structural integrity and leakage as systems or sections during construction but after erection, as work progresses, in system or section lengths not exceeding 100 feet. Test for structural integrity at [_____] percent in excess of system fan positive or negative total pressure. Test for leakage at [_____] percent in excess of system fan positive or negative total pressure.[Leakage test procedure and apparatus must be in accordance with SMACNA 1972 CD. Total leakage, prorated to length of duct under test, must not exceed one percent of system capacity.][Confirm that duct leakage is less than three percent of coil airflow for new systems and less than six percent for existing systems.] Do not permit leakage in positive pressure ducts in buildings carrying flammable or toxic materials.

3.2.2 Power Transmission Components Adjustment

Test and adjust V-belts and sheaves for proper alignment and tension preliminary to operation and after 72 hours of operation at final speed, in the presence of the Contracting Officer. Belts on drive side must be uniformly loaded, not bouncing.[Align direct-drive couplings to less than half of manufacturer's allowable range of misalignment.]

3.2.3 Preliminary Tests

Conduct an operational test on the entire exhaust duct systems, components, and equipment for a period of not less than 6 hours after power transmission components are adjusted. Replace filters, if any, after preliminary tests and prior to conducting final acceptance tests.

3.2.4 Testing, Adjusting, and Balancing Work

Perform work in accordance with the applicable and recommended procedures of: ACGIH-2092S. Provide apparatus, certified, calibrated, instrumentation including that to measure sound levels, motor current, and power factor. Unless approved otherwise, instruments must be limited to manometers and approved aneroid type gages (such as a Magnehelic). Velometers may be used for low velocity measurements if approved by the Contracting Officer.

3.2.5 Systems Volume Acceptance Criteria

Systems final volume must be within the following limits:

Fan: Plus 10 percent, minus zero percent of design volume at design temperature

Hood or Equipment: Plus or minus [5] [10] percent of design volume at design temperature

Note: Tolerances must be taken on clean or dirty conditions as indicated on the drawings.

3.2.6 Sound Level Tests

Report to the Contracting Officer in writing, sound levels higher than 84 dBA at hoods or at workers' normal operating positions at equipment in addition to being included in the required test reports.

3.3 SYSTEM[S] OPERATION DEMONSTRATION

After systems and equipment testing, adjusting, and balancing has been completed and accepted, demonstrate the complete and correct functioning of systems equipment and controls by operation through normal ranges and sequences, and by simulation of abnormal conditions, [including the manual tripping of fire dampers]. Manually and automatically cause every device to function as intended. Readjust, as necessary, any settings and after sufficient operating time, but not less than [6] [_____] hours, verify ability of equipment and controls to establish and maintain stable and accurate operation and required system performance. Note any abnormal deviations, such as excessive vibration, noise, and heat, binding damper mechanisms, and incorrect fan rotation. Make any necessary repairs, replacements or adjustments.

-- End of Section --

SECTION 23 36 00.00 40

AIR TERMINAL UNITS
08/22

PART 1 GENERAL

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR DUCT COUNCIL (ADC)

ADC Standards Manual (2008; 5th Edition) Flexible Duct Performance Installation Standards

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 880 I-P (2011) Performance Rating of Air Terminals

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 130 (2008) Method of Testing for Rating Ducted Air Terminal Units

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM C1071 (2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

ASTM E84 (2020) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14;

	TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors

1.2 ADMINISTRATIVE REQUIREMENTS

Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, communication and security systems, and partition assemblies.

1.2.1 Pre-Installation Meetings

Submit itemized lists for all materials, equipment, and fixtures to be incorporated in the work [30][_____] days prior to commencement of work. Ensure list includes manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information. Submit product data for each type of air terminal unit indicated, including rated capacities, furnished specialties, sound-power ratings, and accessories:

[a. Bypass Single-Duct Air Terminal Units

][b. Dual-Duct Air Terminal Units

][c. Fan-Powered Air Terminal Units

][d. Induction Air Terminal Units

][e. Shutoff Single-Duct Air Terminal Units

][f. Integral-Diffuser Air Terminal Units

][g. High-Pressure Dual-Duct Mixing Boxes

][h. Low-Pressure Dual-Duct Mixing Boxes

] Submit records of existing conditions consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work constitutes acceptance of existing conditions.

Submit shop drawings which detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished. Include wiring diagrams to show power, signal, and control wiring.

Provide units with the configuration, capacity, and static-pressure characteristics indicated.

Ensure dimensional data stated constitutes nominal sizing, which has been adjusted by the manufacturer when necessary to accommodate acoustic material thickness.

Ensure units proposed are identical to units having at least 2 years of proven satisfactory field service.

Provide certification that units and the list of spare parts are ADC Standards Manual tested and rated.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Records of Existing Conditions

SD-02 Shop Drawings

Bypass Single-Duct Air Terminal Units; G[, [____]]

Dual-Duct Air Terminal Units; G[, [____]]

Fan-Powered Air Terminal Units; G[, [____]]

Induction Air Terminal Units; G[, [____]]

Shutoff Single-Duct Air Terminal Units; G[, [____]]

Integral-Diffuser Air Terminal Units; G[, [____]]

High-Pressure Dual-Duct Mixing Boxes; G[, [____]]

Low-Pressure Dual-Duct Mixing Boxes; G[, [____]]

SD-03 Product Data

Bypass Single-Duct Air Terminal Units; G[, [____]]

Dual-Duct Air Terminal Units; G[, [____]]

Fan-Powered Air Terminal Units; G[, [____]]

Induction Air Terminal Units; G[, [____]]

Shutoff Single-Duct Air Terminal Units; G[, [____]]

Integral-Diffuser Air Terminal Units; G[, [____]]

High-Pressure Dual-Duct Mixing Boxes; G[, [____]]

Low-Pressure Dual-Duct Mixing Boxes; G[, [____]]

SD-06 Test Reports

Test Report

SD-07 Certificates

List of Spare Parts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings

1.4 QUALITY CONTROL

Indicate on drawings the size, profiles, and dimensional requirements of air terminal units that are based on the specific system indicated.

Conform to NFPA 70, Article 100 for electrical components, devices, and accessories. List and label items as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

Ensure Air Terminals are certified under the AHRI 880 I-P Certification Program and carry the ARI Seal.

When air terminal devices are furnished with reheat coils, either integrally or remotely mounted, control panels of terminal devices shall be mounted on the same side of air terminal device as reheat coil piping connection.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Verification of Performance

Rate air terminal units according to AHRI 880 I-P.

2.1.2 Bypass Single-Duct Air Terminal Units

2.1.2.1 Configuration

Provide diverting-damper assembly inside unit casing with control components located inside a protective metal shroud.

2.1.2.2 Casing

Provide[0.034-inch steel][0.032-inch aluminum] casing. Ensure the casing includes an integral mixing baffle to efficiently mix the hot and cold airstream.

2.1.2.2.1 Casing Lining

Provide[1/2-inch][3/4-inch][1-inch] thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections. Provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket.

[Provide additional factory installed reheat coil inspection/cleaning access door at the inlet and outlet of the coil within the unit casing. The access doors shall be gasketed and insulated.

]2.1.2.3 Diverter Assembly

Provide [galvanized-steel gate, with polyethylene linear bearings][aluminum blade, with nylon-fitted pivot points][_____] diverter assembly.

2.1.2.4 Multi-Outlet Attenuator Section

Provide [two][three][four][_____],[6-inch][8-inch][10-inch][_____] diameter collars, each with locking butterfly balancing damper.

[2.1.2.5 Hot-Water Heating Coil

Provide a copper tube heating coil, mechanically expanded into aluminum-plate fins. Verify heating coil passes underwater leak test to 200 psig.

][2.1.2.6 Electric Heating Coil

Provide a factory installed and wired slip-in-type, open-coil design with integral control box. Include the following features:

a. Primary and secondary over temperature protection

b. Nickel chrome 80/20 heating elements

c. Airflow switch

d. Non-interlocking disconnect switch

[e. Fuses (for coils more than 48 A)

] f. Switches and relays.

g. Magnetic contactor for each step of control (for three-phase coils)

h. SCR controller

][2.1.2.7 Electric Controls

Provide a 24 V damper actuator that is powered closed and powered open with a microswitch to energize heating control circuit.

Provide a wall-mounting electric type thermostat with temperature display in Celsius and Fahrenheit, and with a space temperature set point.

Provide a changeover thermostat of duct-mounting, electric type that reverses action of controls when the duct temperature rises 70 degrees F.

][2.1.2.8 Electronic Controls

Provide a 24 V damper actuator that is powered closed and powered open.

][2.1.2.9 Pneumatic Controls

Provide a pneumatic damper operator with a[8 to 13 psig][3 to 13 psig] spring range.

Provide a factory calibrated and field adjustable velocity controller capable of handling minimum and maximum air volumes. Ensure controllers maintain a constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inches wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlets and air outlets.

]2.1.2.10 Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Ensure thermostat is time-proportional type with a reheat-coil control feature. Display temperature set-points in Celsius and Fahrenheit. Ensure the auxiliary switch energizes the heating control circuit, and changeover thermistor has a reverse action feature.

2.1.3 Dual-Duct Air Terminal Units

2.1.3.1 Configuration

Provide two volume dampers inside the unit casing with mixing attenuator section and control components located inside a protective metal shroud.

2.1.3.2 Casing

Provide[0.034-inch][0.032-inch] casing. Include with casing an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide 0.034-inch casing. Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with a NFPA 90A approved seal.

For the air inlet, provide round stub connection for duct attachment. For the air outlet, provide s-slip and drive connections. Provide removable panels with an airtight gasket for access to the diverter and other parts requiring service, adjustment, or maintenance.

2.1.3.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for 3 percent of nominal airflow at[3-inch wg][6-inch wg] inlet static pressure.

Select either Damper Position, Hot Deck: normally [open][closed] or Damper Position, Cold Deck: normally [closed][open].

2.1.3.4 Attenuator Section

Provide[0.034-inch][0.03-inch aluminum] sheet metal. Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

2.1.3.5 Multi-Outlet Attenuator Section

Provide [two][three][four][_____],[6 inch][8 inch][10 inch] [_____] diameter collars; each with locking butterfly balancing damper.

2.1.3.6 Pneumatic Controls

a. Pneumatic Damper Operator

Provide a pneumatic damper operator with a[8 to 13 psig][3 to 13 psig] spring range.

b. Velocity Controllers

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controllers maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

2.1.3.7 Electronic Controls

a. Damper Actuator

Provide a 24 V, powered closed, [spring return open][powered open] damper actuator.

b. Velocity Control

Provide a factory calibrated controller, with settings for minimum and maximum air volumes, and field adjustable at thermostat. Ensure controller maintains constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg, when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature, time-proportional with reheat-coil control feature. Provide a temperature set-point display in Celsius and Fahrenheit.

[2.1.3.8 DDC Controls

a. Damper Actuators

Provide a 24 V, powered closed, powered open damper actuator.

b. Velocity Sensors

Provide a multipoint array with velocity sensors in cold-deck and hot-deck air inlet and air outlet.

c. Terminal Unit Controller

Provide a pressure independent, [variable-air] [constant] volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes. Include the following features:

(1) Proportional, plus integral control of room temperature

(2) Time-proportional reheat-coil control

(3) Occupied and unoccupied operating mode

(4) Remote reset of airflow or temperature set points

(5) Adjusting and monitoring with portable terminal

d. Room Sensor

Provide a wall mounting room sensor, with temperature set-point adjustment and access for connection of portable operator terminal.

]2.1.3.9 Control Sequence

Modulate cold-air damper to maintain room temperature. Modulate warm-air damper to maintain constant airflow.

2.1.4 Fan-Powered Air Terminal Units

2.1.4.1 Configuration

Provide volume-damper assembly and fan in [series] [parallel] arrangement inside unit casing with control components inside a protective metal shroud.

2.1.4.2 Casing

Provide[0.034-inch][0.032-inch] casing. Include with casing an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide[1/2-inch][3/4-inch][1-inch] thick with 1.5 pounds per cubic foot density, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

Provide a round stub connection for the air inlet duct attachment. For the air outlet provide s-slip and drive connections. Provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn gaskets.

[Provide additional factory installed reheat coil inspection/cleaning access door at the inlet and outlet of the coil within the unit casing. The access doors shall be gasketed and insulated.

]2.1.4.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for [2][3] percent of nominal airflow at[3-inch wg][6-inch wg] inlet static pressure, when tested in accordance with ASHRAE 130.

Select damper position: Normally [open][closed].

2.1.4.4 Fan Section

Provide a galvanized-steel plenum, with direct-drive, forward-curved fan with air filter and backdraft damper.

a. Lining

Provide[1/2-inch][3/4-inch][1-inch] thick, coated, fibrous-glass duct liner complying with ASTM C1071; secured with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

b. Motor

Comply with requirements in Section 26 60 13.00 40 LOW-VOLTAGE MOTORS for [Multi-speed] [_____] motors. Provide motor which includes a speed control feature that is infinitely adjustable with pneumatic-electric and electronic controls. Provide rubber isolators with fan-motor assembly.

c. Air Filter

Provide[2-inch][1-inch] thick, [fiberglass throwaway] [polyurethane] air-filter.

2.1.4.5 Attenuator Section

Provide[0.034-inch][0.03-inch aluminum] sheet metal. Provide 1/2-inch, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

[2.1.4.6 Hot-Water Heating Coil

Provide a copper tube mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

][2.1.4.7 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

a. Primary and secondary over-temperature protection

b. Nickel chrome 80/20 heating elements

c. Fan interlock contacts

d. Non-interlocking disconnect switch

e. Fuses (for coils more than 48 A)

f. Switches and relay

g. Magnetic contactor for each step of control (for three-phase coils)

h. SCR controller

]2.1.4.8 Factory-Mounted and -Wired Controls

Mount electrical components in control box with removable cover. Incorporate single-point electrical connection to power source.

Provide factory mounted control transformer for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.

Provide fan and controls to terminal strip, with terminal lugs which match quantities, sizes, and materials of branch-circuit conductors for wiring terminations. Enclose terminal lugs in terminal box that is sized according to NFPA 70.

Factory-mount a fused type disconnect switch.

2.1.4.9 Control Panel Enclosure

Provide control panel enclosure conforming to NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

2.1.4.10 Electric Controls

Provide a 24 V damper actuator with wall-mounting electric thermostat and appropriate mounting hardware.

2.1.4.11 Pneumatic Controls

a. Pneumatic Damper Operator

Provide a pneumatic damper operator with a[8 to 13 psig][3 to 13 psig] spring range.

b. Velocity Controllers

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controllers maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

2.1.4.12 Electronic Controls

Provide a bi-directional damper operator and microprocessor-based controller with integral airflow transducer and room sensor compatible with temperature controls, having the following features:

a. Proportional, plus integral control of room temperature

b. Time-proportional reheat-coil control

c. Occupied and unoccupied operating mode

d. Remote reset of airflow or temperature set points

e. Adjusting and monitoring with portable terminal

f. Communication with temperature-control system

2.1.5 Induction Air Terminal Units

2.1.5.1 Configuration

Provide a volume-damper assembly inside the unit casing with a mechanical induction damper mounted on the casing with control components located inside a protective metal shroud.

2.1.5.2 Casing

Provide[0.034-inch][0.032-inch] casing. Ensure the casing includes an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide[1/2-inch][3/4-inch][1-inch] thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections [size matching inlet size]. Provide removable panels with an airtight gasket, for access to diverter and other parts requiring service, adjustment, or maintenance.

[Provide additional factory installed reheat coil inspection/cleaning access door at the inlet and outlet of the coil within the unit casing. The access doors shall be gasketed and insulated.

]2.1.5.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearing.

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for [2][3] percent of nominal airflow at[3-inch wg][6-inch wg] inlet static pressure, when tested in accordance with ASHRAE 130.

Select Damper Position, normally [open][closed].

2.1.5.4 Induction Damper

Provide galvanized-steel, multi-blade assembly with self-lubricating bearings.

2.1.5.5 Hot-Water Heating Coil

Provide a with a factory installed copper tube mechanically expanded into aluminum-plate fins and leak tested underwater to 200 psig.

2.1.5.6 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

a. Primary and secondary over-temperature protection

b. Nickel chrome 80/20 heating elements

c. Airflow switch

d. Non-interlocking disconnect switch

e. Fuses (for coils more than 48 A)

f. Switches and relays

g. Magnetic contactor for each step of control (for three-phase coils)

h. SCR controller

2.1.5.7 Pneumatic Controls

a. Damper Operator

Provide a pneumatic, 5 to 10 psig spring range damper operator.

b. Velocity Controller

Provide a factory calibrated velocity controller; field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining constant airflow dictated by a thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4 inch wg when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor at air inlet.

c. Induction Damper Operator

Provide a pneumatic, spring range induction damper operator matching reset range of controller.

d. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

2.1.5.8 Electronic Controls

a. Damper Actuator

Provide a 24 V, powered closed, [spring return open][powered open] damper actuator.

b. Velocity Controller

Provide a factory calibrated velocity controller; field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor at air inlet.

c. Induction Damper Operator

Provide a 24 V, powered closed, [spring return open][powered open] damper actuator.

d. Thermostat

Provide a wall-mounting electronic type thermostat with appropriate mounting hardware with the following features:

(1) Proportional, plus integral control of room temperature

(2) Time-proportional reheat-coil control

(3) Temperature set-point display in Celsius and Fahrenheit

2.1.6 Shutoff Single-Duct Air Terminal Units

2.1.6.1 Configuration

Provide a volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

2.1.6.2 Casing

Provide[0.034-inch][0.032-inch aluminum] casing. Ensure the casing includes an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide[1/2-inch][3/4-inch][1-inch] thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections. Provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket.

[Provide additional factory installed reheat coil inspection/cleaning access door at the inlet and outlet of the coil within the unit casing. The access doors shall be gasketed and insulated.

][2.1.6.3 Regulator Assembly

Provide[extruded-aluminum][galvanized-steel] components with key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.

a. Automatic Flow-Control Assembly

Match combined spring rates for each volume-regulator size with machined dashpot for stable operation. Provide factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

][2.1.6.4 Regulator Assembly

Provide system-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Ensure the bellows operate at temperatures from 0 to 140 degrees F; are impervious to moisture and fungus; are suitable for 10-inch wg static pressure when tested in accordance with ASHRAE 130, and are factory tested for leaks.

]2.1.6.5 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test (MDLT)in conformance to AHRI 880 I-P, for [2][3] percent of nominal airflow at[3-inch wg][6-inch wg] inlet static pressure when tested in accordance with ASHRAE 130.

Select Damper Position, normally [open][closed].

2.1.6.6 Attenuator Section

Provide[0.034-inch][0.03-inch aluminum] sheet metal attenuator section.

Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

2.1.6.7 Multi-Outlet Attenuator Section

Provide [two][three][four][_____],[6-inch][8-inch][10 inch][_____] diameter collars; each with locking butterfly balancing damper.

[2.1.6.8 Hot-Water Heating Coil

Provide a copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

][2.1.6.9 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

a. Primary and secondary over-temperature protection

b. Nickel chrome 80/20 heating elements

c. Airflow switch

d. Non-interlocking disconnect switch

[e. Fuses (for coils more than 48 A)

] f. Switches and relays

g. Magnetic contactor for each step of control (for three-phase coils)

h. SCR controller

]2.1.6.10 Electric Controls

a. Damper Actuator

Provide a 24 V, powered closed, [spring return open][powered open] damper actuator.

b. Thermostat

Provide a wall-mounting electronic type thermostat with clock display, temperature display in Celsius and Fahrenheit, and space temperature set point.

2.1.6.11 Pneumatic Controls

a. Pneumatic Damper Operator

Provide a[8 to 13 psig][3 to 13 psig] spring range.

b. Velocity Controllers

Provide a factory calibrated controller, field adjustable to minimum and maximum air volumes. Ensure controllers maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg, when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

2.1.6.12 Electronic Controls

Provide bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer. Ensure room sensor is compatible with temperature controls specified.

a. Damper Actuator

Provide a 24 V, powered closed, [spring return open] [powered open] damper actuator.

b. Velocity Controller

Provide a factory calibrated controller set to minimum and maximum air volumes, field adjustable at thermostat. Ensure controller maintains constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg, when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature, time-proportional with reheat-coil control feature, and displaying a temperature set-point in Celsius and Fahrenheit.

[2.1.6.13 DDC Controls

Provide bidirectional damper operators and microprocessor-based controller. Provide with room sensor that is compatible with temperature controls specified.

a. Damper Actuators

Provide a 24 V, powered closed, [spring return open][powered open] damper actuator.

b. Terminal Unit Controller

Provide a pressure independent, [variable-air][constant] volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes. Include the following features:

(1) Proportional, plus integral control of room temperature

(2) Time-proportional reheat-coil control

(3) Occupied and unoccupied operating mode

(4) Remote reset of airflow or temperature set points

(5) Adjusting and monitoring with portable terminal

(6) Room Sensor

Provide a wall mounting room sensor, with temperature set-point adjustment and access for connection of portable operator terminal.

]2.1.6.14 Control Sequence

Make suitable for operation with duct pressures between 0.25 and 3.0-inch wg inlet static pressure. Provide a factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control, with amplifying relay. Provide a system-powered, wall-mounting thermostat.

2.1.7 Integral-Diffuser Air Terminal Units

2.1.7.1 Configuration

Provide a volume-damper assembly inside unit casing with [integral] [attached] [linear-slot] [square-ceiling] [louver-face] [perforated] diffuser.

2.1.7.2 Casing

Provide[0.034-inch steel][0.032-inch aluminum] casing. Ensure the casing includes an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide[1/2-inch][3/4-inch][1-inch] thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections. Provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket.

2.1.7.3 Volume Damper

Provide galvanized steel with peripheral gasket and self-lubricating bearings.

Damper Position: Normally [open] [closed].

2.1.7.4 Diffuser

Provide a galvanized-steel insulated plenum with extruded-aluminum or sheet-steel diffuser, having fixed or variable geometry designed to operate from 100 percent to minimum airflow, manual adjustment of airflow direction[, and a baked-enamel finish].

[2.1.7.5 Electric Controls

a. Damper Actuator

Provide a 24 V, powered closed, [spring return open][powered open].

b. Thermostat

Provide a wall-mounting electronic type thermostat with clock display, temperature display in Celsius and Fahrenheit, and space temperature set point.

][2.1.7.6 Pneumatic Controls

Provide damper operator[, velocity controller,] and thermostat compatible with temperature controls specified.

a. Pneumatic Damper Operator

Provide a[8 to 13 psig][3 to 13 psig] spring range.

b. Velocity Controller

Provide a factory calibrated velocity controller, which is field adjustable to minimum and maximum air volumes capable of maintaining constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor at air inlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

][2.1.7.7 Electronic Controls

Provide bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer. Provide with room sensor that is compatible with temperature controls specified.

a. Damper Actuator

Provide a 24 V, powered closed, [spring return open] [powered open].

b. Velocity Controller

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor at air inlet.

c. Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Ensure thermostat is time-proportional with reheat-coil control feature, and displays a temperature set-point in Celsius and Fahrenheit.

]2.1.7.8 Control Sequence

Make suitable for operation with duct pressures between 0.25 and 3.0-inch wg inlet static pressure. Provide factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control; and amplifying relay with a system-powered, wall-mounting thermostat.

2.1.8 High-Pressure Dual-Duct Mixing Boxes

Provide mechanical constant-volume control type units with a mechanical controller that is operated by the entering mixed-airstream and maintains a constant airflow through the unit.

[Provide factory preset units to deliver air volumes indicated.

]2.1.8.1 Construction

Provide factory assembled units, complete with casing, air mixing valve assembly, single air mixing valve operator, and mechanical constant-volume control, ready for field mounting and connection to control.

Verify casing exterior is not less than 0.040-inch thick aluminum, or 20 gage mill-galvanized steel with not less than 1.25 ounces of zinc per square foot of two-sided surface, conforming to ASTM A653/A653M.

Ensure casing interior is acoustically baffled and lined with fibrous glass thick enough to attain required sound power level performance and preclude condensation on any exterior surface, but in no case less than1-inch. Verify air side of fibrous glass is chloroprene-impregnated and manufactured to resist delamination or surface erosion at air velocities to 4,000-feet per minute. Ensure liner edges exposed to airstream are protected by metal turnovers. Verify liner and fibrous-glass baffle material conforms to NFPA 90A.

Ensure inlet valves and connecting linkage are constructed for modulation by a single operator. Verify hot inlet valve is normally open, and the cold inlet valve is normally closed. Ensure hot and cold inlet ports are field reversible.

[Verify mechanical constant-volume control is externally adjustable and has a cubic feet-per-minute graduated capacity scale, which also indicates minimum/maximum range of the unit.

][Ensure mechanical constant-volume control is externally adjustable. Provide a calibration chart with each unit indicating capacity per revolution of mechanical constant-volume device. Clearly label each unit with minimum/maximum volume range to facilitate field adjustment.

] Ensure components subject to friction have oil-impregnated bronze bearings, graphite-impregnated nylon bearings, and lubricant-impregnated elastomers, corrosion-resistant steel, and similar materials.

Ensure casing is fitted with rigid, airtight access panels, easily removable and of ample size to give free access to interior parts. Verify closure is achieved by spring-retained, quarter-turn, slotted-cam captive devices, or similar operating fasteners.

Verify that all caulking compounds are chloroprene, polyurethane polysulfides, or silicone elastomers, with chloroprene, polyurethane, or vinyl gaskets.

2.1.8.2 Casing Leakage

Verify casing joints are sealed to prevent leakage of more than 2 percent of rated capacity with all connections sealed and with an internal static pressure of 1-inch wg.

2.1.8.3 Inlet Valve Leakage

Verify leakage in fully closed valve position does not exceed 2 percent of unit rated capacity against inlet pressure of 8-inches wg.

2.1.8.4 Mixed-Air Temperature Requirements

Verify that a thermometer traverse of all unit outlets shows variation of not more than 5 percent of the difference, at the time, between the temperatures of equal quantities of cold and warm airstreams entering the unit.

2.1.8.5 Volume Control Requirements

Verify mechanical constant-volume control maintains design volume within plus or minus 5 percent, regardless of the modulation position of inlet valves or the fluctuation of inlet or outlet pressure, within limits of indicated minimum pressure.

2.1.8.6 Sound Level Requirements

[When determining equipment sound-power level performance and when no space-attenuation criteria are given, assume 18 dB space attenuation in all octave bands. Verify manufacturer's design incorporates sound correction factors for equipment.

][Verify the scheduled airborne and radiated sound-power level (PWL) requirements, to attain the specified NC levels. Assume an 18 dB space attenuation in all octave bands with consideration given to downstream duct construction and configuration in determining airborne NC levels.

] Assume the following ceiling sound-transmission loss (TL) characteristics, based on 1-inch acoustic lay-in panels and T-bar suspension, in computing resultant space radiated NC levels:

OCTAVE BAND	2ND	3RD	4TH	5TH	6TH	7TH
PWL-TL	-2	-4	-9	-10	-13	-15

[NC40 is the limiting factor.

]2.1.8.7 Control Requirements

Ensure operating-control power source is dry, compressed air of instrument quality at 15 psig, unless otherwise approved.

Provide for an air mixing valve operator from the automatic temperature control manufacturer, and installation by the unit manufacturer, unless field installation for specific construction is pre-approved by the Contracting Officer. Ensure operator is controlled by a direct-acting thermostat.

Provide copper pneumatic control tubing brought to the exterior of the casing for connection to automatic temperature control system.

[2.1.9 Low-Pressure Dual-Duct Mixing Boxes

Provide manual-damper volume control type units. Provide a calibration chart with each unit. Label each unit with capacity minimum/maximum range to facilitate field adjustment.

Verify volume control damper is externally adjustable over an inlet pressure range of 0.05 to 1-inch wg.

Ensure components subject to friction have oil-impregnated bronze bearings, graphite-impregnated nylon bearings, and lubricant-impregnated elastomers, corrosion-resistant steel, and similar materials.

Ensure casings are fitted with rigid, airtight access panels, easily removable, and of ample size to give free access to interior parts. Provide closure mechanism which is achieved by spring-retained, quarter-turn, slotted-cam captive devices or similar operating fasteners.

Provide caulking compounds which are chloroprene, polyurethane polysulfides, or silicone elastomers. Provide chloroprene, polyurethane, or vinyl gaskets.

2.1.9.1 Casing Leakage

Seal all casing joints to prevent leakage of more than 2 percent of rated capacity, with all connections sealed and with an internal static pressure of 1-inch wg.

2.1.9.2 Inlet Valve Leakage

Leakage in fully closed valve position is not to exceed 2 percent of unit rated capacity against inlet pressure of 1 inch wg.

2.1.9.3 Mixed-Air Temperature Requirements

Ensure a thermometer traverse of all unit outlets shows variation of not more than 5 percent of the difference, at the time, between the temperatures of equal quantities of cold and warm airstreams entering the unit.

2.1.9.4 Sound Level Requirements

When determining equipment sound power level performance when no space-attenuation criteria are given, assume 18 dB space attenuation in all octave bands. Verify manufacturer designs incorporates sound correction factors for equipment.

2.1.9.5 Control Requirements

Ensure operating-control power source is dry, compressed air of instrument quality at 15 psig, unless otherwise approved.

Provide an air mixing valve operator from the automatic temperature control manufacturer and install using the unit manufacturer, unless field installation for specific construction is pre-approved by the Contracting Officer. Ensure operator is controlled by a direct-acting thermostat.

Provide copper pneumatic control tubing brought to the exterior of the casing for connection to the automatic temperature control system.

]PART 3 EXECUTION

3.1 INSTALLATION

Install air terminal units level and plumb, and in accordance with NFPA 90A. Maintain sufficient clearance for normal service and maintenance.

3.1.1 Identification

Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

3.1.2 Connections

Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems.

Install piping adjacent to air terminal units to allow service and maintenance.

3.1.2.1 Hot-Water Piping

Connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

Connect ducts to air terminal units.

Ground units with electric heating coils.

Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

3.2 FIELD QUALITY CONTROL

[Engage a factory-authorized service representative to inspect[, test, and adjust] field-assembled components and equipment installation, including connections[, and to assist in field testing].

][Perform the following field tests and inspections and prepare a test report.

] After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

3.2.1 Leak Test

After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3.2.2 Operational Test

After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest.

3.3 SYSTEM STARTUP

Engage a factory-authorized service representative to perform startup service.

Complete installation and startup checks according to manufacturer's written instructions and do the following:

a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.

b. Verify that controls and control enclosure are accessible.

c. Verify that control connections are complete.

d. Verify that nameplate and identification tag are visible.

e. Verify that controls respond to inputs as specified.

3.4 CLOSEOUT ACTIVITIES

3.4.1 Operation and Maintenance

Submit [6][_____] copies of the operation and maintenance manuals 30 calendar days prior to testing the following items. Update and re-submit data for final approval no later than 30 calendar days prior to contract completion. Concurrently, submit record drawings providing current factual information, including deviations and amendments to the drawings, and concealed and visible changes in the work.

3.4.2 Demonstration

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

-- End of Section --

SECTION 23 37 13.00 40

DIFFUSERS, REGISTERS, AND GRILLES
08/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 113	(2013) Method of Testing for Room Air Diffusion
ASHRAE EQUIP IP HDBK	(2012) Handbook, HVAC Systems and Equipment (IP Edition)
ASHRAE FUN IP	(2021) Fundamentals Handbook, I-P Edition

1.2 ADMINISTRATIVE REQUIREMENTS

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists[; G[, [____]]]

Records of Existing Conditions[; G[, [____]]]

SD-02 Shop Drawings

Fabrication Drawings[; G[, [____]]]

Installation Drawings[; G[, [____]]]

SD-03 Product Data

Equipment and Performance Data[; G[, [____]]]

SD-04 Samples

Manufacturer's Standard Color Chart[; G[, [____]]]

SD-10 Operation and Maintenance Data

Type TS Supply Troffer[; G[, [____]]]

Type TSR Combination Supply and Return Troffer[; G[, [____]]]

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

Certify air diffusion devices having been tested and rated in accordance with Chapter 19-ASHRAE EQUIP IP HDBK, Chapter 16-ASHRAE FUN IP, and ASHRAE 113, where such certification is required.

Submit equipment and performance data for air-diffusion devices consisting of [sound data in terms of Noise Criteria (NC) index for the capacity range of the device.][sound data in terms of sound-power level in octave bands second through eighth and Noise Criteria (NC) index for the capacity range of the device. Where room attenuation is not specified or indicated, assume 18 decibels. Where space or sound data are not specified or indicated, assume NC40.]

2.2 COMPONENTS

2.2.1 Air Diffusion Device Construction

Preclude flutter, rattle, or vibration on air-diffusion device construction and mounting. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations. Modify devices and provide accessories necessary for mounting in indicated surface construction.

[Select color from manufacturer's standard color chart which indicates the manufacturer's standard color selections and finishes for air-diffusion devices.

][Match color with architectural background.

][Provide color as indicated on drawings.

] Provide supply diffusers with combination damper and equalizing grid. Ensure dampers are extracting-splitter type, except as otherwise indicated. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.

Ensure air-diffusion device volume and pattern adjustments can be made from the face of the device. Make volume adjustments by [removable key] [tamper-deterring device].

Provide gaskets for supply-terminal air devices mounted in finished surfaces.

Include within the material, equipment, and fixture lists the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Submit records of existing conditions consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work constitutes acceptance of existing conditions.

Submit fabrication drawings for air-diffusion devices consisting of fabrication and assembly details to be performed in the factory.

2.2.2 Types of Air Diffusion Devices

2.2.2.1 Type DRA

Provide type DRA supply diffuser, round with five or more expanding cones with beaded edges to provide hemispherically diffused discharge air. Arrange cones to provide a minimum of [four] [_____] air paths which simultaneously diffuse air at 20 to 50 feet per minute (fpm) and aspirate room air at 25 to 35 percent of discharge volume.

Provide aluminum diffuser with baked enamel finish.

Provide antismudge rings and extended cones.

2.2.2.2 Type DRB

Provide type DRB supply diffuser, round with [four] [_____] more expanding cones to provide hemispherically diffused discharge air. Arrange cones to provide a minimum of [three] [______] air paths which simultaneously diffuse air at 20 to 50 fpm. Provide a pattern adjustment range from horizontal to downward projection, and any intermediate point, when mounted on exposed ductwork.

Provide aluminum diffuser with baked enamel finish.

Provide [Integral][Separate] antismudge rings and extended cones.

2.2.2.3 Type DRC

Provide type DRC combination supply and return diffuser, round with four expanding cones. Arrange cones to provide one return air path and two supply air paths. Provide a butterfly supply-air damper and an annular return-air damper. [Provide a baked enamel finish][Provide aluminum construction.]

[Provide antismudge rings.

]2.2.2.4 Type DRE

Provide type DRE supply diffuser, round with [three] [_____] expanding cones to provide discharge air paths, minimally, two-position adjustable for horizontal or vertical discharge. [Provide a baked enamel finish.]

[Provide antismudge rings.

]2.2.2.5 Type DRH

Provide type DRH supply diffuser, half-round with [four][_____] semiconical expanding members to discharge diffused air in a 180-degree pattern. Arrange cones to provide a minimum of [three] [_____] air paths which simultaneously diffuse air at 20 to 50 fpm. Provide opposed-blade volume control.

[Provide a baked enamel finish.

][Provide antismudge rings.

]2.2.2.6 Type DP Series

Provide type DP series supply diffuser with a [square] [rectangular], perforated, face plate with [opposed blade] [splitter-damper] volume control, white baked enamel exterior finish, and black matte finish on exposed-to-view interior surface. Provide hinges and latches for removal of perforated face plates to allow for cleaning and adjustment of baffle or damper.

[Provide one-way deflection.

][Provide two-way opposed deflection.

][Provide two-way diagonal deflection.

][Provide three-way deflection.

][Provide four-way deflection.

][Provide flush face.

][Provide drop face.

][Provide aluminum construction.

][Provide steel construction.

]2.2.2.7 Type DLB

Provide type DLB supply diffuser, linear bar type, frame mounted, with extruded-aluminum bar and frame.

Ensure bars are [1/4] [_____] inch thick by [3/4] [_____] inch high, [1/2] [_____] inch on center, pencilproof spacing, with zero degree bar deflection angle.

For floor- and sill-mounted diffusers provide heavy-duty reinforced construction to carry loads of not less than [100] [_____] pounds per square foot.

Provide continuous length diffuser with hairline butt joints.

Provide mitered end caps where diffuser run terminates.

Provide opposed-blade type dampers.

Provide an integral, pivoted, bar-type access door where indicated.

Provide straightening grids where indicated.

2.2.2.8 Type DLS

Provide type DLS supply diffuser, linear slot type, extruded aluminum construction, with fully adjustable integral air pattern and volume control vanes that deflect air pattern from horizontal along ceiling to straight down. Ensure any intermediate setting and a pattern control element that permits complete blanking-off of slot.

Slot width: [3/4] [_____] inch.

Provide number of slots per unit run as indicated.

Align butts in continuous runs for hairline joints.

Butt ends of diffuser against walls without mitered end caps. Provide end caps where slot terminates.

Provide exposed-to-view part of frame with anodized aluminum, and all interior exposed-to-view components with a black matte finish.

2.2.2.9 Type DSA

Provide type DSA supply diffuser, square with [four] [_____] expanding flared members to provide radially diffused discharge air. Arrange flared members to provide a minimum of four air paths which simultaneously diffuse air at 20 to 50 fpm. Include pattern adjustments horizontal, vertical projection, and an intermediate position or range.

[Provide a baked enamel finish.

][Provide aluminum construction.

][Provide antismudge rings.

][Provide integral extended surface to fit into module of lay-in ceiling.

]2.2.2.10 Type GS

Provide type GS supply grilles double deflection type with adjustable face bars parallel to short dimension and adjustable rear bars parallel to long dimension.

[Provide a baked enamel finish.

][Provide aluminum construction.

][Provide antismudge rings.

][Provide integral extended surface to fit into module of lay-in ceiling.

]2.2.2.11 Type GSP

Provide type GSP series supply grille with a [square] [rectangular], perforated face plate, white baked enamel exterior finish, black matte finish on exposed-to-view interior surface for lay-in or surface mounting. Perforated face plate to be removeable, hinged or unlatched, for cleaning.

[Provide aluminum construction.

][Provide steel construction.

]2.2.2.12 Type GEP

Provide type GEP series return or general exhaust grille with a[square][

rectangular], perforated face plate, white baked enamel exterior finish, black matte finish on exposed-to-view interior surface for lay-in or surface mounting. Perforated face plate to be removeable, hinged or unlatched for cleaning.

[Provide aluminum construction.

][Provide steel construction.

][Provide aluminum filter track.

]2.2.2.13 Type GSE

Provide type GSE series return or general exhaust grille with a[square][rectangular], eggcrate face with a1/2 by 1/2 by 1/2 inch aluminum core, white baked enamel exterior finish, black matte finish on exposed-to-view interior surface for lay-in mounting.

[Provide aluminum border.

][Provide steel border.

][Provide aluminum opposed-blade damper.

][Provide hinged face with 1/4 turn fasteners and aluminum filter track.

]2.2.2.14 Type GR

Provide type GR return grilles, single deflection type with fixed face bars.

Provide grilles installed in vertical surfaces with horizontal face bars set downward at 45 degrees from vertical.

Provide grilles installed in horizontal surfaces with face bars straight and parallel to short dimension.

[Provide a baked enamel finish.

][Provide aluminum construction.

][Provide antismudge rings.

][Provide integral extended surface to fit into module of lay-in ceiling.

]2.2.2.15 Type GCA

Provide type GCA with an individually adjustable, horizontal, curved-blade grilles and a one-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.16 Type GCB

Provide type GCB with an individually adjustable, vertical, curved-blade grilles and a one-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.17 Type GCD

Provide type GCD with an individually adjustable, vertical, curved-blade grilles and a two-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.18 Type GCE

Provide type GCE with an individually adjustable, vertical and horizontal, curved-blade grilles and a three-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.19 Type GCF

Provide type GCF with an individually adjustable, vertical and horizontal, curved-blade grilles and a four-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.20 Type RS

Provide type RS supply register, double-deflection type, with adjustable face bars parallel to short dimension and adjustable rear bars parallel to long dimension with opposed-blade type dampers.

[Provide a baked enamel finish.

][Provide aluminum construction.

][Provide integral extended surface to fit into module of lay-in ceiling.

]2.2.2.21 Type RR

Provide type RR return register, single-deflection type with fixed face bars with opposed-blade dampers.

Provide registers installed in vertical surfaces with horizontal face bars set downward at approximately 45 degrees from vertical.

Provide registers installed in horizontal surfaces with face bars set straight and parallel to short dimension.

[Provide a baked enamel finish.

]2.2.2.22 Type RCA

Provide type RCA with an individually adjustable, horizontal, curved-blade register and a one-way pattern with opposed-blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.23 Type RCB

Provide type RCB with individually adjustable, vertical, curved-blade register and a one-way pattern with opposed blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.24 Type RCC

Provide type RCC with an individually adjustable, horizontal, curved-blade register and a two-way pattern with opposed blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.25 Type RCD

Provide type RCD with an individually adjustable, vertical, curved-blade register and a two-way pattern with opposed blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.26 Type RCE

Provide type RCE with an individually adjustable, vertical and horizontal, curved-blade register and a three-way pattern with opposed-blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.27 Type RCF

Provide type RCF with an individually adjustable, vertical and horizontal, curved-blade register and a four-way pattern with opposed-blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.28 Type TS

Provide type TS supply troffer complete assembly as specified in Section 26 51 00 INTERIOR LIGHTING and as indicated. Install air handling section of unit under this section.

2.2.2.29 Type TR

Provide type TR return troffer conforming to requirements for Type TS supply troffer.

2.2.2.30 Type TSR

Provide type TSR combination supply and return troffer assembly as specified in Section 26 51 00 INTERIOR LIGHTING and as indicated. Install air handling section of unit under this section.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment as indicated and specified and in accordance with manufacturer's recommendations.

[Mount wall-mounted supply registers 6 inches below ceiling.

][Mount wall-mounted return registers 6 inches above the finished floor.

] Submit installation drawings for air-diffusion devices. Indicate on drawings overall physical features, dimensions, ratings, service requirements, and equipment weights.

Unless otherwise indicated, size ductwork drop to diffusers or grilles to match unit collar sizes.

Seal connections between ductwork drops to diffusers or grilles airtight.

Support independently diffusers and grilles for T-bar mounting that exceed weight limit of ceiling suspension system in which they are to be installed.

3.1.1 Operations and Maintenance Manuals

Provide operation and maintenance manuals consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions.

-- End of Section --

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SECTION 23 41 13.00 40

PANEL FILTERS
02/16

PART 1 GENERAL

[Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

] Provide panel filter[s] [system] complete with all components and accessory equipment as specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME AG-1	(2019) Code on Nuclear Air and Gas Treatment

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 14644-1	(2015) Cleanrooms and Associated Controlled Environments Part 1: Classification of Air Cleanliness

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1	(2009) DOC Voluntary Product Standard PS 1-07, Structural Plywood

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-282	(2015; Rev B; Notice 1 2020) Filter Units, Protective Clothing, Gas-Mask Components and Related Products: Performance Test Methods

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50544	(Basic; Notice 2; Notice 3) Radiators, Heating, Steam and Hot Water, Cast Iron

UNDERWRITERS LABORATORIES (UL)

UL 586	(2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 900	(2015) Standard for Air Filter Units

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings

SD-03 Product Data

Air Filters; G[, [____]]

Filter Gages; G[, [____]]

Manometers; G[, [____]]

SD-06 Test Reports

Test Reports

SD-07 Certificates

Air Filters

Filter Gages

Manometers

PART 2 PRODUCTS

2.1 FILTERS

Submit manufacturer's catalog data, including physical characteristics and performance data for panel filter[s] [system].

Submit physical characteristics information and performance data for air filters consisting of use life, system functional flows, safety features, and mechanical automated details. Also submit curves indicating tested and certified equipment responses and performance characteristics.

Provide air filters with a net effective filtering area and a face area to provide the required airflow at the indicated initial pressure-drop.

Provide sufficient clearance for maintenance and operation in and around filter assembly.

Construct filter-holding frames of [extruded aluminum] [type 300 corrosion-resistant steel] [corrosion-resistant coated 16-gage (minimum) steel] [not less than 16-gage galvanized carbon steel conforming to ASTM A653/A653M with not less than 1.25 ounces of zinc per square foot of two-sided surface] [wood-pulp products]. Provide frame assemblies and fasteners constructed of corrosion-resistant metal or carbon steel with a corrosion-resistant finish to preclude surface degradation.

[Make viscous-impingement framed panel filter gaskets from a material inert to filter impregnates, with a minimum thickness after compression of 1/8-inch.

][Provide dry filter gaskets of closed-cell foamed neoprene or urethane elastomer of sufficient hardness to compress to not more than 40 percent of original thickness when filter is in position.

]2.1.1 Filters, Disposable Type

Listed below is the minimum acceptable performance for the air filter:

DIMENSIONS (Inches)	INITIAL RESISTANCE (Inch WG)	ARRESTANCE (Percent)	DUST-HOLDING CAPACITY (Gram/Sq Ft)
14 by 20 by 1	0.04	65	145
16 by 20 by 1	0.04	65	145
16 by 25 by 1	0.04	65	145
20 by 20 by 1	0.04	65	145
20 by 25 by 1	0.04	65	145
16 by 20 by 2	0.08	75	190
16 by 25 by 2	0.08	75	190
20 by 20 by 2	0.08	75	190
20 by 25 by 2	0.08	75	190

For all sizes of filters, ensure the final resistance value is 0.50-inch, with air volume of 1,200 cubic feet per minute, and airflow velocity of 300-feet per minute.

2.1.2 Filters, Cleanable Type

Provide nonwoven synthetic-fabric-type filtering element, supported on rigid pleats of suitable grid material, with a nominal overall depth of [2-inches] [4-inches]. Seal filter element into an enclosing frame of rigid chipboard, providing a unit that will not rack. Verify initial pressure drop at a face velocity of 500 fpm is [0.25] [0.22]-inch wg, with average dust-spot efficiency of [10 percent] [18 percent] and arrestance of [85 percent] [87 percent] when filter is operated to a final pressure drop of 1-inch wg. Verify, under these circumstances, the dust-holding capacity is [45] [70] grams per square foot of face area.

Use test method in accordance with ASHRAE 52.2.

2.1.3 Filters, Replaceable Type

Provide filters conforming to CID A-A-50544, Type I or Type II. Base filter efficiency on ASHRAE 52.2. Efficiency, by definition, is dust-spot efficiency using atmospheric dust. Arrestance is weight efficiency using test dust.[Provide Type III filter arrestance efficiencies in accordance with MIL-STD-282 DOP test.]

Provide each air filter with a permanent corrosion-resistant holding frame and a replaceable factory-assembled filter element. Supply the permanent holding frame with suitable gaskets designed to maintain a positive pressure seal between the frame and the filter element(s).

Design and construct air filters to facilitate field maintenance. Make adjustments and ensure replaceable accessories are readily accessible. Conditions which may be hazardous to personnel or deleterious to equipment are not permitted.

Provide antiallergenic and nontoxic filter element, with no detectable odor, which have no adverse effect on the health of personnel handling or served by the filter element.

Use adhesive coatings on filters with a flashpoint of not less than 325 degrees F conforming to ASTM D92.

[Provide Type I, Grade A filters with 30 percent commercially rated efficiency conforming to UL 900, Class 2, and requirements specified herein. Provide filters, when operated at rated capacity of [_____] cfm, that have an initial pressure drop of not more than [_____]-inch wg, and a final pressure drop not exceeding [_____]-inch wg. Ensure filter initial efficiency is not less than 20 percent, and the average efficiency is not less than 25 percent. Verify dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute), is not less than [_____] at [_____] [600 at 1,500] [1,000 at 2,000] [1,000 at 2,500].

][Provide Type I, Grade B filter with 40 percent commercially rated efficiency conforming to UL 900, Class 2, and requirements specified herein. Provide filters, when operated at rated capacity of [_____] cfm, that have an initial pressure drop of not more than [_____]-inch wg and a final pressure drop not exceeding [_____]-inch wg. Ensure filter initial efficiency is not less than 20 percent, and the average efficiency is not less than 35 percent, with dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute), of not less than [_____] at [_____] [500 at 1,500] [600 at 2,000] [700 at 2,500].

][Provide Type II, Grade C filter with 85 percent commercially rated efficiency [minimum of 58 percent per ASHRAE 52.2 using atmospheric dust] conforming to UL 900, [Class 2] [Class 1] and requirements specified herein. Provide filters, that when operated at rated capacity of [_____] cfm, having an initial pressure drop of not more than [_____]-inch wg, and final pressure drop not exceeding [_____]-inch wg, with an initial filter efficiency of not less than 58 percent, and an average efficiency not less than 76 percent. Verify the dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute) is not less than [_____] at [_____] [300 at 1,500] [400 at 2,000] [470 at 2,500].

][Provide Type II, Grade D filter with 95 percent commercially rated efficiency [minimum of 78 percent per ASHRAE 52.2 using atmospheric dust] conforming to UL 900, [Class 2] [Class 1] and requirements specified herein. Provide filters, that when operated at rated capacity of [_____] cfm, having an initial pressure drop of not more than [_____]-inch wg, and final pressure drop not exceeding [_____]-inch wg. Verify filter initial efficiency is not less than 80 percent, and the average efficiency is not less than 90 percent, a with dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute) of not less than [_____] at [_____] [220 at 1,500] [300 at 2,000] [380 at 2,500].

][Provide Type III, Grade E filter 95 percent rated efficiency [DOP test using 0.2-micrometer particles] conforming to UL 900, [Class 2] [Class 1] and requirements specified herein. Provide filters with an initial pressure drop not exceeding [1.0-inch wg with a face velocity of 325 fpm on 6-inch deep filter] [1.0-inch wg with a face velocity of 500 fpm on 12-inch-deep filter] [[_____] inch wg with a face velocity of [_____] fpm on [_____] inch-deep filter], and a final pressure drop not exceeding [2.0-inches wg with a face velocity of 325 fpm on 6-inch-deep filter] [2.0-inches wg with a face velocity of 500 fpm on 12-inch-deep filter] [[_____] inches wg with a face velocity of [_____] fpm on [_____] inch deep filter].[Verify the filter efficiency is not less than 95 percent as determined in accordance with MIL-STD-282, using a 0.3-micrometer particle of thermally generated DOP smoke.]

][2.1.4 Filters, Automatic Type

Provide automatic renewable filtering element type filters in which a roll of the element is unwound across the airstream by a mechanism regulated by a timer or a differential-pressure control, or a combination of both.

Provide a unit suitable for 120-volt, single-phase, 60-hertz power.

Submit manufacturer established filter performance data established in accordance with ASHRAE 52.2 dynamic loading test procedures. Verify initial resistance does not exceed 0.20-inch wg at an airstream velocity of 500 fpm, and(when operating at its specified rate of airflow) has a dust-holding capacity of 65 grams per square foot when the resistance to airflow is maintained between 0.45 and 0.55-inch wg. Provide filtering element with an average dust-spot efficiency of not less than 20 percent and an arrestance of 85 percent.

Provide a viscous-impingement progressively graded density UL, Class 2, fibrous-glass type filter with a continuous material element. Filter to have a normal depth of 2-inches when clean and not compress more than 1/4-inch when subject to air velocity of 500 fpm. Reinforce element in both length and width. Support element so that no leakage of unfiltered air occurs. Wind dirty element with the dirty surface inward and ensure it re-rolls automatically under tension. Provide each spool of filtering element with guide keys to ensure correct installation, and possessing compressibility that will allow 65-feet to be wound to a maximum of 16-inches in diameter on the used roll. Ensure each roll of filtering element is not less than 65-feet long.

Wind the dirty filtering element and feed the clean element so that no blowoff of collected dirt can occur. Otherwise, contain clean and dirty elements in steel enclosures in reverse-flow units and in horizontal units where the element is wound outside of airstream.

Provide filter widths of uniform size for all project air-handling units.

Provide electrically driven type timer, readily adjustable in the field without special tools. Electrically interlock the timer with the fan motor to start and stop the filter element advancing mechanism, as required, when the fan is operating. Adjust initially such that the pressure-drop through the filter element will be maintained at approximately 0.45-inch wg. If used, the differential-pressure control can adjust to any cut-in and cutout with a differential of 0.05 to 0.10-inch wg. Initially adjust to 0.55-inch cut-in to 0.45-inch wg cutout. Install controls out of the airstream.

Equip master section with a runout switch to stop the feed movement and operate a signal light when the element from one of the sections runs out. Furnish a manual feed-advance switch with each drive unit to advance the element to the end of the roll as required. Locate signal light on the air-handling unit temperature-control panel.

Fabricate filter-supporting structural members of not less than 14-gage mill-galvanized carbon steel for the base and side panels and 16-gage mill-galvanized carbon steel for the top panel. Provide galvanized steel sheet in accordance with ASTM A653/A653M.

]2.1.5 Filters, High-Efficiency Particulate Air (HEPA)

Provide fire-resistant type HEPA filters capable of withstanding a minimum of 90-percent relative humidity determined dynamically at temperatures between 70 and 100 degrees F.

Provide filtering elements conforming to ASME AG-1. Individually certify that each filter has an efficiency of not less than 99.97 percent by a test method other than the DOP test specified in ISO 14644-1. An acceptable method for certification is to remove a filter from a production run prior to testing, then test the five filters before and after the removed filter in accordance with the DOP test (99.97 percent). Successful passing of the test by the five filters before and five filters after the untested filter is the acceptance criteria for the untested filter. Verify the clean filter static pressure drop does not exceed 1.0 inch wg when the filter is tested at rated capacity.

Provide filtering elements containing no holes, cracks, slits, or other visual imperfections, with every splice required in the assembly of a filter pack joined with not less than 1-1/2 inches of fire-retardant adhesive for a continuous coating along the entire width of the element, with filter element made of glass paper with a minimum tensile strength of 3 pounds per inch of width and retain 50 percent of its tensile strength when folded flat upon itself. Verify elongation before rupture is a minimum of 1 percent, and element is water-proofed, retaining 50 percent of its original tensile strength after being immersed in water.

Register the results of test penetration on the frame of the filter unit, legibly and indelibly. Include the test resistance, test flow rate, together with direction of test airflow, manufacturer's name, model number, and serial number of the filter unit.

Provide elements with 3/4-inch plywood frames, Grade A-B EXT-DFPA or better, conforming to NIST PS 1. Treat plywood to exhibit a flame-spread of not more than 30 when tested according to UL 723 or ASTM E84. Countersink flathead wood screws after drilling lead holes. Create a positive seal at corner joints by coating adjoining surfaces with a suitable adhesive having the characteristics specified below. Particle board conforming to the flame-spread requirements specified for plywood may be used in lieu of plywood.

Coat entire inside face of frame members with an adhesive before assembly with filter pack. Following assembly, form a continuous bead of the same adhesive to seal between cut edges of filter pack and edges of abutting frame member on both faces of the filter unit. Ensure filter unit is square to a diagonal tolerance of 1/8-inch.

Provide a resilient and water-resistant adhesive able to withstand a temperature of 250 degrees F for 8 hours after curing. If capable of ignition, provide a self-extinguishing adhesive which meets general operating conditions without change in physical properties and without loss of seal. Ensure the cured adhesive contains no cracks, checks, alligatoring, or separation.

Provide HEPA filters conforming to UL 586.

[Provide with 14-gage [aluminum sheet] [zinc] [aluminum] [cadmium-coated 16-gage steel sheet] frames, with all corner joints given a positive seal by coating adjoining surfaces with a suitable adhesive having the characteristics indicated.

] Provide separators constructed of [aluminum] [_____] that do not contribute to fire, will remain structurally intact under fire exposure, and are not damaged by exposure to the humidity and temperature.

Provide 1/4-inch thick closed cellular construction neoprene gaskets, or gaskets with an elastomer of 20 to 40 Shore A durometer hardness. Attach gasketing firmly and continuously to the frame with rubber-based adhesive.

Assemble filter unit to provide uniformity of materials and construction, surface smoothness and finish, cleanliness, and freedom from protrusions and obvious flaws.

2.2 FILTER GAGES AND MANOMETERS

Provide air-filter gages or manometers for each type filter assembly.

Provide dial-indicator type gages, graduated to read 0 to 2-inches wg, except that gages for HEPA filters are to read0 to 3-inches wg. Provide manometers measuring from minus 0.5 to 3-inches wg, equipped with a built-in indicator bubble. Connect gage or manometer to static-pressure ports of approved design and located so that resistance to airflow will be correctly indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Coordinate filter supports and retention elements to provide a substantial, structurally sound, leakproof installation.

3.1.1 Holding Frame Installation

Provide installation drawings in accordance with referenced standards in this section.

Install gasket [to holding frames on perimeter][caulked to each other][to supplementary steel][to closures with elastomeric compounds recommended by the filter manufacturer]. Prepare substrate in accordance with the elastomer manufacturer's instructions, including the priming of surfaces in areas where the elastomer is not confined.

3.2 FIELD QUALITY CONTROL

Submit test reports in accordance with ASHRAE 52.2.

-- End of Section --

SECTION 23 52 00

HEATING BOILERS
04/08, CHG 5: 11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 801	(2001; R 2008) Industrial Process/Power Generation Fans: Specification Guidelines

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.13/CSA 4.9	(2017; Errata 2018) Gas-Fired Low Pressure Steam and Hot Water Boilers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2021) Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.20	(2017) Metallic Gaskets for Pipe Flanges

ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME CSD-1	(2021) Control and Safety Devices for Automatically Fired Boilers
ASME PTC 10	(1997; R 2014) Performance Test Code on Compressors and Exhausters

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2015) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.2/B2.2M	(2016) Specification for Brazing Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A167	(2011) Standard Specification for

	Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A515/A515M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B828	(2016) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM C27	(1998; R 2008) Fireclay and High-Alumina Refractory Brick
ASTM C34	(2017) Standard Specification for Structural Clay Loadbearing Wall Tile

ASTM C155	(1997; R 2013) Standard Specification for Insulating Firebrick
ASTM C401	(2012) Alumina and Alumina-Silicate Castable Refractories
ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM F876	(2022a; E 2022) Standard Specification for Crosslinked Polyethylene (PEX) Tubing
ASTM F1097	(2017; R 2022) Standard Specification for Mortar, Refractory (High-Temperature, Air-Setting)
ASTM F1139	(1988; R 2019) Steam Traps and Drains

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

CAGI B19.1	(2010) Safety Standard for Compressor Systems

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2016; 14/17) Copper Tube Handbook

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2015) (10th Ed) EJMA Standards

HYDRONICS INSTITUTE DIVISION OF AHRI (HYI)

HI-004	(1995) Radiant Floor Heating
HYI-005	(2008) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and

	Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2020) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2021) National Fuel Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 85	(2019) Boiler and Combustion Systems Hazards Code
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

UNDERWRITERS LABORATORIES (UL)

UL 296	(2017; Reprint Jan 2021) UL Standard for

	Safety Oil Burners
UL 726	(1995; Reprint Oct 2013) Oil-Fired Boiler Assemblies
UL 795	(2016; Reprint May 2022) UL Standard for Safety Commercial-Industrial Gas Heating Equipment
UL 1738	(2020; Reprint Aug 2021) UL Standard for SafetyVenting Systems for Gas-Burning Appliances, Categories II, III and IV
UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Materials and Equipment

[Energy Star label for residential gas fired hot water boiler product; S

][Energy Star label for residential oil fired hot water boiler product; S

] Spare Parts

Water Treatment System

Boiler Water Treatment

Heating System Tests

Fuel System Tests

Unit Heaters

Welding

Qualifications

Field Instructions

Tests

SD-06 Test Reports

Heating System Tests

Fuel System Tests

Water Treatment Testing

SD-07 Certificates

Bolts

Continuous Emissions Monitoring

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G[, [_____]]

Water Treatment System; G[, [_____]]

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.3 QUALITY ASSURANCE

Submit a copy of qualified welding procedures and a list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations. [Boilers and piping shall be welded and brazed in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests, and the tests shall be performed at the work site if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made as a permanent record. Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] [Welding and nondestructive testing procedures for piping are specified in Section 40 05 13.96 WELDING PROCESS PIPING.]

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and no later than 2 months prior to the date of beneficial occupancy. Submit Detail Drawings consisting of equipment layout including installation details and electrical connection diagrams; combustion and safety control diagrams; ductwork layout showing the location of supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of guides and anchors, the load imposed on each support or anchor (not required for radiant floor tubing), and typical support details. Include on the drawings any information required to demonstrate that the system has been coordinated and will properly function as a unit and to show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 years of service.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Submit manufacturer's catalog data included with the detail drawings for the following:

a. Radiant floor heating system including tubing, joints, and manifold for radiant floor heating systems.

b. Data showing model, size, options, etc., that are intended for consideration. Data submitted shall be adequate to demonstrate compliance with contract requirements. Data shall include manufacturer's written installation instructions and manufacturer's recommendations for operation and maintenance clearances for the following:

    (1) Boilers
    (2) Unit Heaters
    (3) Fuel Burning Equipment
    (4) Combustion Control Equipment
    (5) Pumps
    (6) Fittings and Accessories
    (7) Fuel Oil Storage System
    (8) Water Treatment System

2.1.2 Asbestos Prohibition

Asbestos and asbestos-containing products will not be allowed.

2.1.3 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. Also, display an Energy Star label as applicable. Each pressure vessel shall have an approved ASME stamp.

2.1.4 Equipment Guards

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded in accordance with OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed in accordance with Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS].

2.2 BOILERS

Each boiler shall have the output capacity in British thermal units per hour (Btuh) as indicated when fired with the specified fuels. The boiler shall be furnished complete with the [oil] [gas] [combination oil/gas] burning equipment, boiler fittings and trim, automatic controls, [[forced] [induced] draft fan,] [natural draft/atmospheric burner,] electrical wiring, insulation, piping connections, and protective jacket. The boiler shall be completely assembled and tested at the manufacturer's plant. Boiler auxiliaries including fans, motors, drives, and similar equipment shall be provided with at least 10 percent excess capacity to allow for field variations in settings and to compensate for any unforeseen increases in pressure losses in appurtenant piping and ductwork. However, the boiler safety devices shall not be sized for a 10 percent excess capacity. The boiler and its accessories shall be designed and installed to permit ready accessibility for operation, maintenance, and service. Boilers shall be designed, constructed, and equipped in accordance with ASME BPVC SEC IV. Each boiler shall be of the [firetube] [watertube] [cast iron] [condensing] type and designed for [water] [steam] service as specified herein. The boiler capacity shall be based on the ratings shown in HYI-005 or as certified by the American Boiler Manufacturers Association, or American Gas Association.

2.2.1 Firetube Boiler

Boiler shall be self-contained, multipass, packaged type, complete with all accessories, mounted on a structural steel base. When the boilers are operating at maximum output, the heat input rates shall not be greater than 6,700 Btuh per square ft of fireside heating surface.

2.2.2 Watertube Boiler

The boiler shall be a [standard] [finned] [bent or flexible] type of water tube boiler. Boiler shall be self-contained, packaged type, complete with all accessories, mounted on a structural steel base. [The boiler heating surface area for bent or flexible tube boilers shall be at least 4 square feet/boiler horse power. [The heat input rate for finned tube steam boiler or hot water generator shall not be greater than 12,000 Btuh based on internal heating area.]Bent or flexible tube boilers shall be provided with single or multiple downcomers for circulation without the need for exterior pumping. The tubes for bent or flexible tube boilers shall be designed for replacement without requiring welding or rolling of tubes. Any special tools required for bent or flexible tube removal or installation shall be provided with the boiler.]

2.2.3 Cast Iron Boiler

Boiler shall be of the rectangular, sectional type, self-contained, packaged type, complete with accessories, mounted on a structural steel base. Cast iron sections shall be free of leaks under all operating conditions. Access shall be provided to permit cleaning of internal tube surfaces.

2.2.4 Condensing Boiler

Each boiler shall be a self-contained packaged type, complete with accessories, mounted on a structural steel base or a steel base which is integral to the boiler shell. Each boiler shall conform to the commercial design used by the manufacturer and shall permit free thermal expansion without placing undue stress on any part of the boiler. Each boiler which experiences the formation of condensate within the flue gas shall be specifically designed for condensing application. Each boiler shall withstand the corrosive effects of condensate for each part which may be in contact with the condensate at all possible operating conditions. Each boiler shall be provided with a separate air intake, exhaust, and condensate drain. Each boiler shall be designed to withstand the water temperature differentials anticipated at the required operating conditions without experiencing any damage due to thermal shock.

2.2.5 Modular Configuration

Modular boilers shall be of the [cast iron] [and] [condensing] type. Modular boilers shall have the capability of independent operation. Upon failure of any module, the remaining modules shall be capable of operating at their designed capacity. The size of the individual modules shall be as indicated.

2.2.6 Hot Water Heating Boilers

The hot water heating boiler shall be capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity shall be the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency. The boiler design conditions shall be as follows:

a. Boiler design pressure [30] [_____] psig.

b. Operating pressure at boiler outlet [_____] psig.

c. Hot water temperature [160] [180] [_____] degrees F.

d. Temperature differential between boiler discharge and system return [_____] degrees F.

e. Water pressure drop [10] [_____] psig.

f. Outdoor ambient air temperature [_____] degrees F (max), [_____] degrees F (min).

g. Site elevation [_____] feet.

h. Maximum continuous capacity [_____] Btuh.

i. Rated capacity [_____] Btuh.

j. Maximum exhaust stack temperature [_____] degrees F.

k.[Residential gas fired hot water boilers with a capacity less than 300,000 Btu must have an Annual Fuel Utilization Efficiency of at least 90 percent, and must be Energy Star Labeled. Provide proof of Energy Star label for residential gas fired hot water boiler product.][Residential oil fired hot water boilers with a capacity less than

300,000 Btu must have an Annual Fuel Utilization Efficiency of at least 87 percent, and must be Energy Star Labeled. Provide proof of Energy Star label for residential oil fired hot water boiler product.][Hot water boilers with a capacity less than 300,000 Btuh must have an Annual Fuel Utilization Efficiency of at least 80 percent.][Gas fired boilers with a capacity of greater than or equal to 300,000 Btuh and less than or equal to 2,500,000 Btuh must have a thermal efficiency of at least 80 percent when fired at the maximum and minimum ratings allowed by the controls.][Gas fired boilers with a capacity of greater than 2,500,000 Btuh must have a combustion efficiency of at least 82 percent when fired at the maximum and minimum ratings allowed by the controls][Oil fired boilers with a capacity of greater than or equal to 300,000 Btuh and less than or equal to 2,500,000 Btuh must have a thermal efficiency of at least 82 percent when fired at the maximum and minimum ratings allowed by the controls.][Oil fired boilers with a capacity of greater than 2,500,000 Btuh must have a combustion efficiency of at least 84 percent when fired at the maximum and minimum ratings allowed by the controls.]

2.2.7 Steam Heating Boilers

The boiler shall be provided with a water column with gauge glass and fittings including water column and gauge glass drain valves of the straight through type. The steam heating boiler shall be capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity shall be the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency. Design conditions shall be as follows:

a. Boiler design pressure 30 psig.

b. Operating pressure at boiler outlet [_____] psig.

c. Steam temperature 250 degrees F.

d. Feedwater temperature [_____] degrees F.

e. Outdoor ambient air temperature [_____] degrees F (max), [_____] degrees F (min).

f. Site elevation [_____] feet.

g. Maximum continuous capacity [_____] pounds of steam per hour.

h. Rated capacity [_____] pounds of steam per hour.

i. Maximum exhaust stack temperature [_____] degrees F.

j. [Gas fired boilers with a capacity less than 300,000 Btuh shall have an Annual Fuel Utilization Efficiency of at least 75 percent.][Oil fired boilers with a capacity less than 300,000 Btuh must have an Annual Fuel Utilization Efficiency of at least 80 percent.][Gas fired boilers (all, except natural draft) with a capacity of greater than or equal to 300,000 Btuh must have a thermal efficiency of at least 79 percent.][Gas fired natural draft boilers with a capacity greater than or equal to 300,000 Btuh must have a thermal efficiency of at least 77 percent.][Oil fired boilers with a capacity greater than or equal to 300,000 Btuh must have a thermal efficiency of at least 81 percent when fired at the maximum and minimum ratings allowed by the controls.]

2.3 FUEL BURNING EQUIPMENT

Boiler shall be designed to burn [gas] [oil] [combination gas and oil]. Each boiler shall comply with Federal, state, and local emission regulations. As a minimum, the following emission requirements shall be met:

NOx - [[_____] lb/million Btu input] [parts per million (ppm) corrected to 3 percent Oxygen by volume].

SO2 - [[_____] lb/million Btu input] [parts per million (ppm) corrected to 3 percent Oxygen by volume].

Particulate - [[_____] lb/million Btu input] [parts per million (ppm) corrected to 3 percent Oxygen by volume].

2.3.1 Burners

2.3.1.1 Gas and Combination Gas-Oil Fired Burners and Controls

Burners shall be UL approved [mechanical draft burners with all air necessary for combustion supplied by a blower where the operation is coordinated with the burner] [natural draft/atmospheric burners]. Burner shall be provided complete with fuel supply system in conformance with the following safety codes or standards:

a. Gas-fired units with inputs greater than 400,000 Btuh per combustion chamber shall conform to UL 795. [Gas fired units less than 12,500,000 Btuh input shall conform to ANSI Z21.13/CSA 4.9.] [Single and multiple burner gas-fired units greater than or equal to 12,500,000 Btuh input shall conform to NFPA 85.]

b. Combination gas and oil-fired units shall conform to UL 296. [Combination gas and oil-fired units less than 12,500,000 Btuh input shall conform to ASME CSD-1.] [Single and multiple burner combination gas and oil-fired units equal to or greater than 12,500,000 Btuh input shall conform to NFPA 85.]

2.3.1.2 Oil-Fired Burners and Controls

Oil-fired burners and controls for oil-fired units firing No. [_____] oil shall be atomizing, forced-draft type in conformance with UL 726. [Oil-fired units less than 12,500,000 Btuh input shall conform to ASME CSD-1.] [Oil-fired units greater than or equal to 12,500,000 Btuh input shall conform to NFPA 85.]

2.3.1.3 Steam or Air Atomizer

[Steam] [or] [air] atomizer shall be of the inside mix type utilizing [steam] [or] [air] mixing with the oil inside the nozzle. No moving parts shall be required within the atomizer assembly. Unit shall be capable of completely atomizing the oil through a minimum capacity range of 4 to 1 without changing nozzles or sprayer plates and when supplied with [steam] [or] [air] at a maximum pressure of [15] [_____] psig. Capacity of unit shall be adjustable. Unit shall be furnished with a blowout valve so that [steam] [or] [air] may be blown through the oil passages to clear them of any accumulation. A diffuser designed to stabilize the flame shall be mounted near the furnace end of the atomizer in such a position that oil will not strike it.

2.3.1.4 Mechanical pressure atomizer

Mechanical pressure atomizer shall operate solely by the use of oil pressure and shall have no moving parts within the atomizer. Unit shall be capable of completely atomizing the oil through a minimum capacity range of 4 to 1 without changing nozzles or sprayer plates and when furnished with oil at a constant pressure of [_____]. A constant volume of oil shall be supplied to the atomizer. Variable capacity shall be obtained by adjusting control valve. A diffuser provided to stabilize the flame shall be mounted near the furnace end of the atomizer, but in such a position that oil will not strike it.

2.3.2 Draft Fans

Fans conforming to AMCA 801 [forced-draft] [and] [induced-draft] shall be furnished as an integral part of boiler design. Fans shall be centrifugal with [backward-curved blades] [radial-tip blades] or axial flow type. Each fan shall be sized for output volume and static pressure rating sufficient for pressure losses, excess air requirements at the burner, leakages, temperature, and elevation corrections for worst ambient conditions, all at full combustion to meet net-rated output at normal firing conditions, plus an overall excess air volume of 10 percent against a 20 percent static overpressure. Noise levels for fans shall not exceed 85 decibels in any octave band at a 3 foot station. [Forced draft fan bearings shall be air cooled.] [Induced-draft fans shall be designed for handling hot flue gas at the maximum outlet temperature in the boiler. Induced draft fan housings shall be provided with drain holes to accommodate the drainage of condensation. Induced draft fan bearings shall be [air-cooled] [water-cooled]. Induced draft fan scroll sheets and rotor blades shall have protective liners.]

2.3.2.1 Draft Fan Control

[Forced-draft centrifugal fans shall have inlet vane controls or shall have variable speed control where indicated. Inlet vanes shall be suitable for use with combustion control equipment.] [Induced-draft centrifugal fans shall have outlet dampers and shall have variable speed control.] [Induced-draft fans shall have inlet vane controls.] Axial propeller fans shall have variable propeller pitch control.

2.3.2.2 Draft Fan Drives

Fans shall be driven by electric motors. Electric motor shall be [drip proof] [totally enclosed nonventilated] [totally enclosed fan cooled] [totally enclosed fan-cooled, suitable for installation in a Class II, Division 1, Group F, hazardous location conforming to NFPA 70]. [Motor starter shall be [magnetic across-the-line] [reduced voltage start] type with [general purpose] [weather-resistant] [watertight] [dust-tight] [explosion-proof] enclosure and shall be furnished with four auxiliary interlock contacts.]

2.3.3 Draft Damper

Boilers shall be provided with [manual] [automatic] dampers, draft hoods, or barometric dampers as recommended by the boiler manufacturer to maintain proper draft in the boiler. Draft damper shall be provided in a convenient and accessible location in the flue gas outlet from the boiler. Automatic damper shall be arranged for automatic operation by means of a [damper regulator] [furnace draft regulator] [damper motor].

2.3.4 Ductwork

Air ducts connecting the forced-draft fan units with the plenum chamber shall be designed to convey air with a minimum of pressure loss due to friction. Ductwork shall be galvanized sheet metal conforming to ASTM A653/A653M. Ducts shall be straight and smooth on the inside with laps made in direction of air flow. Ducts shall have cross-break with enough center height to assure rigidity in the duct section, shall be angle iron braced, and shall be completely free of vibration. Access and inspection doors shall be provided as indicated and required, with a minimum of one in each section between dampers or items of equipment. Ducts shall be constructed with long radius elbows having a centerline radius 1-1/2 times the duct width, or where the space does not permit the use of long radius elbows, short radius or square elbows with factory-fabricated turning vanes may be used. Duct joints shall be substantially airtight and shall have adequate strength for the service, with 1-1/2 x 1-1/2 x 1/8 inch angles used where required for strength or rigidity. Duct wall thickness shall be 16 gauge (0.0598 inch) for ducts 60 inches or less and 12 gauge (0.1046 inch) for ducts larger than 60 inches in maximum dimension. Additional ductwork shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.4 COMBUSTION CONTROL EQUIPMENT

Combustion control equipment shall be provided as a system by a single manufacturer. Field installed automatic combustion control system shall be installed in accordance with the manufacturer's recommendations and under the direct supervision of a representative of the control manufacturer. [The boiler water temperature shall be controlled by a water temperature controller.] [The boiler pressure shall be controlled by a steam pressure controller.] The equipment shall operate [electronically] [either electrically or pneumatically as applicable]. On multiple boiler installations, each boiler unit shall have a completely independent system of controls responding to the load and to a plant master controller. If recording instruments are provided, a 1 year supply of ink and 400 blank charts for each recorder shall be furnished.

2.4.1 Pneumatic Controls

If pneumatic operation is provided, a regenerant desiccant air dryer unit shall be provided. Boiler shall shut down on loss of control air pressure. Pneumatic control systems shall conform to CAGI B19.1. Air filter regulator sets shall be installed at each control valve and transmitter in the system. The master air filter regulator set on the control panel shall be the dual type where one side can be cleaned and repaired while the other is operating. Exterior control air piping and devices shall be protected from freezing.

2.4.1.1 Air Compressor Unit

The air compressor unit shall be electric-motor driven, polytetrafluoroethylene or carbon ring type automatic air compressor. The compressor unit shall be sized to run not more than 60 percent of the time when all controls are in service. The air compressor unit shall be complete with necessary accessories including automatic pressure control equipment, relief valves, check valves, air filters, moisture traps, and a receiver with ample capacity for emergency operation of the controls for 15 minutes after compressor shutdown. Compressor speed shall not exceed 900 rpm. Motor speed shall not exceed 1750 rpm. The compressor air intake shall be provided with a low drop type air suction filter/silencer suitable for outdoor installation.

2.4.1.2 Air Receiver

The air receiver shall be constructed in accordance with ASME BPVC SEC VIII D1for unfired pressure vessels for 200 psi working pressure, and shall be equipped with inlet and outlet connections, valved drain connection, minimum 6 inch dial pressure gauge, pop safety valves, and regulator connections.

2.4.2 Electrical controls

Electrical control devices shall be rated at [120] [24] volts and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.3 Water Temperature Controller

The controller shall be of sturdy construction and shall be protected against dust and dampness. The thermostatic element shall be inserted in a separable socket installed [in the upper part of the boiler near the water outlet] [in the boiler return piping]. [Fixed position (on-off) and three position (high-low-off) controller shall operate on a 10 degree F differential over an adjustable temperature range of approximately 140 to 220 degrees F.] [Modulating controllers shall control the fuel burning equipment to maintain set boiler water temperature within 2 percent.] [Controller shall be furnished with necessary equipment to automatically adjust the setting to suit the outside weather conditions. The outside air reset controller shall be operated in such a manner that the operating temperatures required by the boiler manufacturer are not compromised.]

2.4.4 Steam Pressure Controller

The controller shall be of sturdy construction and shall be protected against dust and dampness. The sensing elements of the steam controller shall be in direct contact with the steam. [Fixed position (on-off) and three position (high-low-off) type controllers shall operate on a 1 pound differential over a pressure range of 0 to 15 psig.] [Modulating controllers shall automatically maintain, within 2 percent, the desired steam pressure by regulating the burner.]

2.4.5 Boiler Plant Master Controller

A boiler plant master controller, sensitive to a [temperature transmitter in the return water header for the boiler] [steam pressure transmitter in the boiler steam discharge header] shall be furnished to provide anticipatory signals to all boiler controllers. Boiler controllers shall react to anticipatory signals from the plant master controller as necessary in response to the boiler [temperature] [pressure] indication to maintain the preset [temperature] [pressure]. An automatic-manual switch shall be provided to allow the sequence of boiler loading to be varied to distribute equal firing time on all boilers in the plant. The plant master controller shall load the boilers one at a time as the plant load increases.

2.4.6 Boiler Combustion Controls and Positioners

a. [Gas] [Combination gas-oil fired] boiler units shall be provided with [fixed rate (on-off)] [three position (high-low-off)] [modulating] combustion controls with gas pilot or spark ignition. Modulating controls shall be provided with a means for manually controlling the firing rate.

b. Oil fired boiler units shall be provided with [on-off] [high-low-off] [modulating] combustion controls with [direct electric spark ignition system] [spark ignited [No. 2 oil] [natural gas] [liquified petroleum gas] pilot]. Modulating controls shall be provided with a means for manually controlling the firing rate.

c. Modulating control function shall be accomplished using positioning type controls. Air flow ratio and fuel control valve shall be controlled by relative positions of operative levers on a jackshaft responding to a [water temperature controller] [steam pressure controller]. Positioning type combustion control equipment shall include draft controls with synchronized fuel feed and combustion air supply controls, while and shall maintain the proper air/fuel ratio. The desired furnace draft shall be maintained within 0.01 inch of water column.

d. [Fixed rate on-off] [High-low-off] controls for boilers with capacities up to 2,000,000 Btuh shall use a [water temperature controller in a temperature well in direct contact with the water] [steam pressure controller in direct contact with the steam].

2.4.7 Combustion Safety Controls and Equipment

Combustion safety controls and equipment shall be UL listed, microprocessor-based distributed process controller. The system shall include mounting hardware, wiring and cables, and associated equipment. The controller shall be mounted completely wired, programmed, debugged, and tested to perform all of its functions. The controller shall process the signals for complete control and monitoring of the boiler. This shall include maintaining boiler status, starting and stopping all control functions, sequencing control functions and signaling alarm conditions. The program shall be documented and include cross references in description of coils and contacts. Microprocessor shall be able to perform self diagnostics and contain a message center to provide operator with status and failure mode information. Controllers for each boiler shall be mounted on a separate, free standing panel adjacent to the boiler or for packaged boilers on the boiler supporting structure. Control systems and safety devices for automatically fired boilers shall conform to ASME CSD-1. Electrical combustion and safety controls shall be rated at 120 volts, single phase, 60 Hz and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. A 4 inch diameter alarm bell shall be provided and shall be located where indicated or directed. The alarm bell shall ring when the boiler is shut down by any safety control or interlock. Indicating lights shall be provided on the control panel. A red light shall indicate flame failure, and a green light shall indicate that the main fuel valve is open. The following shutdown conditions shall require a manual reset before the boiler can automatically recycle:

a. Flame failure.

b. Failure to establish pilot flame.

c. Failure to establish main flame.

d. [Low-water] [supplementary low-water] cutoff.

e. [High temperature cutoff] [High pressure cutoff].

2.4.7.1 Low-water Cutoff

Low water cutoff shall be float actuated switch or electrically actuated probe type low-water cutoff. Float chamber shall be provided with a blow-down connection. Cutoff shall cause a safety shutdown and sound an alarm when the boiler water level drops below a safe minimum level. A safety shutdown due to low water shall require manual reset before operation can be resumed and shall prevent recycling of the burner. The cutoff shall be in strict accordance to ASME CSD-1.

2.4.7.1.1 Feedwater Regulator with Low-Water Cutoff

Regulator shall be an approved design sized for the application. A regulator shall be provided for each boiler. The feeder shall be so arranged that water will be fed to the boiler automatically when the water level in the boiler drops below a preset point and will actuate the alarm bell when the water level reaches the low danger point. The boiler feeder shall be arranged so that the burner and forced-draft fan will stop whenever the water level drops below a preset danger point. The boiler feeder shall be constructed so that the feedwater valve and seat are isolated from the float chamber to prevent overheating of the feed water and precipitation of scale on either the valve or seat. Each float mechanism, valve, and seat shall be constructed of an approved, durable, corrosion-resistant steel alloy. Valve seats shall be removable and renewable. The regulator shall be equipped with a large, self-cleaning strainer. The drain valve on the regulator shall be the gate or other straight-through type.

2.4.7.1.2 Pump Controller with Low-Water Cutoff

Controller shall be a design approved by the boiler manufacturer. A pump controller shall be provided for each boiler which is used for space heating and process steam loads or long distribution lines. Pump controller shall control the operation of the burner, forced-draft fan, and pump. Pump controller and low-water cutoff shall have a float-operated mercury switch arranged to start and stop the pump at preset boiler water levels. If the water level in the boiler reaches the low danger point, a second mercury switch shall shut down the burner and actuate the alarm bell.

2.4.7.1.3 Supplementary Low-Water Cutoff

Supplementary low-water cutoff of the [electrically operated probe type] [float activated type] shall be provided in addition to the low-water cutoff required above on each boiler. Supplementary low-water cutoff shall be mounted directly in the boiler shell and shall be set below the low-water cutoff required above.

2.4.7.2 Water Flow Interlock

Hot water boiler limit controls shall be provided to include protection for low boiler water flow and high boiler water temperature. The limit controls shall be interlocked with the combustion control system to effect boiler alarm and shutdown. The controls shall not allow boiler startup unless hot water flow is proven.

2.5 PUMPS

2.5.1 Fuel Oil Pumping and Heating Sets

The integrated, shop-fabricated oil pumping and heating set shall be [simplex] [duplex] and be UL approved. Two positive displacement oil meters shall be provided. One meter shall be located on the fuel supply line. The other meter shall be located on the fuel return line. Each set shall include an electric oil heater of adequate capacity to heat the specified fuel oil to ignition temperature at low boiler load until enough [hot water] [steam] is generated to operate the heat exchanger. The electric heater shall be controlled by magnetic starter with a manually-operated On-Off switch in series with a thermostatic control. When oil temperature is raised to proper level and maintained by the [hot water] [steam] heater, the electric heater shall be disconnected automatically by the thermostatic control. Fuel pumps shall be electric-motor-driven. Each pump shall have the capacity of not less than [_____] gpm at a discharge pressure of [_____] psig with a suction lift of 15 feet. A [duplex] [single] filter/basket strainer system shall be installed ahead of the electric oil heater and final discharge filter/strainer system.

2.5.2 Hot Water and Boiler Circulating Pumps

Circulating pumps for hot water shall be electrically driven single-stage centrifugal type and have a capacity not less than indicated. [Boiler circulating pumps shall be supported [on a concrete foundation with a cast iron or structural steel base] [or] [by the piping on which installed] and shall be [closed-coupled shaft] [or] [flexible-coupled shaft]. The boiler circulating pumps shall be [horizontal split case] [vertical split case] type]. [Hot water circulating pumps shall be supported [on a concrete foundation with a cast iron or structural steel base] [or] [by the piping on which installed] and shall have a [closed-coupled shaft] [or] [flexible-coupled shaft]. The hot water circulating pumps shall be [horizontal split case] [vertical split case] type]. The pump shaft shall be constructed of corrosion-resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal, and the housing of close-grained cast iron. Pump seals shall be capable of withstanding 240 degrees F temperature without external cooling. The motor shall have sufficient power for the service required, shall be of a type approved by the manufacturer of the pump, shall be suitable for the available electric service, and shall conform to the requirements of paragraph ELECTRICAL EQUIPMENT. Each pump suction and discharge connection shall be provided with a pressure gauge as specified. The [boiler] [hot water] circulating pump discharge heater shall be provided with a [flow switch] [pressure switch]. [Flow switch unit shall be a self-contained swinging vane type to indicate fluid flow.] [Pressure switch unit shall be a self-contained snap action type to indicate fluid pressure.] Switch shall be a SPDT with 120-volt, 15-ampere rating.

2.5.3 Condensate Pumping Unit

Each pump shall have a capacity not less than that indicated when discharging against the specified pressure. The minimum capacity of the tank shall be as indicated. The condensate pumping unit shall be the [single] [duplex] [horizontal shaft] [vertical shaft] type as indicated. The unit shall consist of [one pump] [two pumps] with electric motor drive, and a single receiver, all mounted on a suitable cast-iron or steel base. The motor may be mounted on the top of the receiving tank. Pump shall be the centrifugal or turbine type, bronze-fitted throughout, with impellers of bronze or other approved corrosion-resisting metal. Pump shall be free from air binding when handling condensate of temperatures up to 200 degrees F. Pump shall be directly connected to suitable drip-proof enclosed motors. Receiver shall be cast iron or not less than 3/16 inch thick black iron or steel and shall be provided with all the necessary reinforced threaded openings, including condensate return, vent, overflow, and pump suction connections. Inlet strainer shall be provided either integral in the tank or separate in the inlet line to the tank. Vent pipe shall be galvanized steel, and the fittings shall be galvanized malleable iron. Vent pipe shall be extended through the roof and shall be properly flashed. The pump, motor, and receiving tank may be mounted on a single base with the receiver piped to the pump suctions. A gate valve and check valve shall be provided in the discharge connection from each pump and a strainer and gate valve shall be provided in the suction line to each pump except where pumps are directly mounted on top of the receiver.

2.5.3.1 Controls for Space Heating Steam Loads Only

An enclosed float switch complete with float mechanisms shall be installed in the head of the receiver. Each condensate pump shall be controlled by a float switch which shall automatically start the motor when the water in the receiving tank reaches the high level and stop the motor when the water reaches the low level. The motors shall be provided with magnetic across-the-line starters equipped with general-purpose enclosures and three-position, "Manual-Off-Automatic" selector switches in the cover. Automatic alternator shall be provided for duplex units.

2.5.3.2 Space Heating and Steam Loads or Distribution Lines

The condensate pump shall be provided with an approved float-actuated valve or water feeder in the cold-water makeup connection either external to or integral with the receiver. Where a de-aerating feedwater heater is not included, the condensate pumping unit shall be controlled automatically by a pump controller with low-water cutout on each boiler. The pump controller and low-water cutout shall have two float-operated mercury switches arranged to start and stop the condensate pump at preset boiler water levels. One switch shall control the operation of the condensate pump by starting the pump when the water in the boiler reaches a preset low level and by stopping the pump when the water in the boiler rises to a preset high level. The second switch shall ring an alarm bell and simultaneously shut down the burner. Relays shall be provided if necessary. A minimum 4 inch alarm bell with bell-ringing transformer shall be installed where directed. A gate valve and a check valve or a stop-check (nonreturn) valve shall be installed in the feed line between the boiler and the pump adjacent to the boiler connection. The condensate pump motor shall be provided with a magnetic, across-the-line starter equipped with thermal-overload protection conforming to the requirements of paragraph ELECTRICAL EQUIPMENT. Where two or more boilers are provided, a pump controller and low-water cutout shall be installed at the normal waterline of each boiler. An automatic feed valve shall be installed in the feed line to each boiler. When any boiler requires water, the pump controller shall open the feed valve by actuating an end switch which, in turn, operates the condensate pump. When the normal water level is restored, the pump controller shall close the feed valve, and the end switch of the valve shall stop the condensate pump.

2.5.3.3 Rating and Testing

The pump manufacturer shall submit a certified test report covering the actual test of the unit and certifying that the equipment complies with the indicated requirements.

2.5.4 Vacuum Pumping Unit

The vacuum pumping unit shall be a combination air removal and condensate return unit consisting of [a single pump, electric motor, and receiving tank] [pumps, electric motors, and other functioning parts in duplicate and a single receiving tank] as indicated. Two interconnected single units will be acceptable in place of a duplex unit. The unit shall be arranged for automatic operation. Where duplicate pumps are used, one pump shall serve as a standby. Where it is standard with the manufacturer, separate pumps may be used for air removal and condensate return if both pumps are mounted on a common receiver. The receiver shall be constructed of cast iron, or of not less than 3/16 inch thick black iron or steel. The pumping unit shall be bronze fitted throughout with bronze shafts or with shafts protected by bronze sleeves. Pumps, motors, and receiver shall be mounted on a single base and provision shall be made for catching the drip from the stuffing boxes. Accessories shall consist of a compound gauge, a pressure gauge inlet strainer, thermometer, water level gauge with stopcocks, adjustable vacuum relief valve, air discharge and condensate discharge check valves, and companion flanges for all flanged connections. The discharge line from each pump shall be provided with a nonslam check valve and a globe valve. Each motor shall have a dripproof-type enclosure. Fully automatic controls shall be provided for each pump motor. Controls shall consist of a float in the receiving tank, a float switch, an adjustable vacuum switch, an automatic, magnetic, across-the-line type starter with general-purpose enclosure, and a three-position selector switch in the cover. The selector switch shall provide for ["Automatic," "Float," "Vacuum,"] ["Automatic," "Float,"] and "Continuous" operation of the pump.

2.6 COLD WATER CONNECTIONS

Connections shall be provided which includes consecutively in line a strainer, reduced pressure principle backflow preventers, and water pressure regulator in that order in the direction of the flow. The reduced pressure principle backflow preventers shall be provided as indicated and in compliance with Section 22 00 00 PLUMBING, GENERAL PURPOSE. Cold water fill connections shall be made to the water supply system as indicated. Necessary pipe, fittings, and valves required for water connections between the boiler and cold water main shall be provided as shown. The pressure regulating valve shall be of a type that will not stick or allow pressure to build up on the low side. The valve shall be set to maintain a terminal pressure of approximately 5 psi in excess of the static head on the system and shall operate within a 2 psi tolerance regardless of cold water supply piping pressure and without objectionable noise under any condition of operation.

2.7 RADIATORS AND CONVECTORS

Radiators, convectors and associated equipment shall be in accordance with Section [23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS] [23 58 00.00 10 CENTRAL STEAM HEATING AND UTILITIES SYSTEMS].

2.8 RADIANT FLOOR HEATING SYSTEMS

The radiant floor heating system shall include all piping, manifolds, valves, pumps, expansion tank, pressure relief valves, and controls to provide a complete and operational heating system.

2.8.1 Tubing

The tubing material shall comply with ASTM F876. The piping shall be provided with a factory applied oxygen barrier with a diffusion rate that does not exceed 0.1 grams per cubic meter per day. The piping shall be rated at 100 psi and 180 degrees F.

2.8.2 Joints

The manifold manufacturer shall be consulted to determine the proper joint for connection of tubing to the manifold. The joints required to connect the tubing to the manifold shall be compression type fittings using crimp rings, a combination of inserts and O-rings, gripper type fittings using a retainer ring and O-rings, or as otherwise recommended by the manifold and tubing manufacturer.

2.8.3 Manifold

The design and construction of the manifold shall be compatible with the tubing manufacture's requirements. The piping manifold material shall be compatible with the piping material. The manifold shall be capable of providing the number of circuits as indicated on the drawings. The manifold shall be suitable for an operating pressure of 100 psi and 180 degrees F. Balancing valves shall be provided for each circuit. Isolation valves shall be provided for each supply and return connection. Each manifold shall be provided with an air vent. The manifold shall allow for the measurement of temperature for each circuit. The manifold shall be provided with all required mounting hardware.

2.9 UNIT HEATERS

Heaters shall be as specified below, and shall have a heating capacity not in excess of 125 percent of the capacity indicated. [Noise level of each unit heater for areas noted shall not exceed the criteria indicated.]

2.9.1 Propeller Fan Heaters

Heaters shall be designed for suspension and arranged for [horizontal] [vertical] discharge of air as indicated. Casings shall be not less than 20 gauge black steel and finished with lacquer or enamel. Suitable [stationary] [rotating air] deflectors shall be provided to assure proper air and heat penetration capacity at floor level based on established design temperature. Suspension from heating pipes will not be permitted. [Fans for vertical discharge type heaters shall operate at speeds not in excess of 1,200 rpm, except that units with 80,000 Btu output capacity or less may operate at speeds up to 1,800 rpm.] [Horizontal discharge type unit heaters shall have discharge or face velocities not in excess of the following]:

Unit Capacity, cfm	Face Velocity, fpm
Up to 1000	800
1,001 to 3,000	900
3001 and over	1,000

2.9.2 Centrifugal Fan Heaters

Heaters shall be arranged for floor or ceiling mounting as indicated. Heating elements and fans shall be housed in steel cabinets of sectionalized steel plates or reinforced with angle-iron frames. Cabinets shall be constructed of not lighter than 18 gauge black steel. Each unit heater shall be provided with a means of diffusing and distributing the air. Fans shall be mounted on a common shaft, with one fan to each air outlet. Fan shaft shall be equipped with self-aligning ball, roller, or sleeve bearings and accessible means of lubrication. Fan shaft may be either directly connected to the driving motor or indirectly connected by adjustable V-belt drive rated at 150 percent of motor capacity. All fans in any one unit heater shall be the same size.

2.9.3 Heating Elements

[Heating coils and radiating fins shall be of suitable nonferrous alloy with [threaded] [brazed] fittings at each end for connecting to external piping. The heating elements shall be free to expand or contract without developing leaks and shall be properly pitched for drainage. The elements shall be tested under a hydrostatic pressure of 200 psig and a certified report of the test shall be submitted to the Contracting Officer.] [Heating coils shall be as specified in Section 23 30 00 HVAC AIR DISTRIBUTION for types indicated.] Coils shall be suitable for use with water up to 250 degrees F.

2.9.4 Motors

Motors shall be provided with NEMA 250 general purpose enclosure. Motors and motor controls shall otherwise be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.9.5 Motor Switches

Motors shall be provided with manual selection switches with "Off," and "Automatic" positions and shall be equipped with thermal overload protection.

2.9.6 Controls

Controls shall be provided as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

2.10 HEATING AND VENTILATING UNITS

Heating and ventilating units and associated equipment shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.11 AIR HANDLING UNITS

Air handling units and associated equipment shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.12 FITTINGS AND ACCESSORIES

Boiler fittings and accessories shall be installed with each boiler in accordance with ASME BPVC SEC IV, unless otherwise specified.

2.12.1 Soot Blowers

Where indicated, each boiler shall be provided with soot blowers using [compressed air] [steam] as the blowing medium. The soot blower system shall be the automatic sequencing and intermittent puff type. The soot blower units shall be sequenced automatically using successive steps by their controller, each step involving no more than a 10 psi drop in air pressure at the receiver. After one unit is operated in successive steps through its cycle, the controller shall shift the operation to the second soot blower unit, and so on, until all units on that boiler have been operated, after which the controller shall be shut down automatically by the sequence controls. The soot blower heads shall have elements of suitable material for the highest temperatures encountered in the boiler. The sequence timer shall have provision for manual selection of the soot blower units to be used. Soot blower system for oil fired boilers shall conform to NFPA 85.

2.12.1.1 Air Compressor Unit

The air compressor unit shall conform to ASME PTC 10 except as specified otherwise. Compressor speed shall not exceed 900 rpm. Motor speed shall not exceed 1750 rpm. The service air requirements shall be as indicated with receivers sized as indicated. The units shall be suitable for heavy-duty service (soot blowing). The compressors shall be simplex type, single-stage, double-acting, with water-jacketed cylinder, fitted with intake and discharge valves of the lightweight feather, disc or plate type, and shall be provided with necessary controls, water-cooled aftercooler, moisture separator, drive, receiver, relief valves, and cooling water controls as required. The compressor air intake shall be provided with an air suction filter/silencer suitable for outdoor installation. The filter shall have a collection efficiency of 99 percent of particles larger than 10 microns. The filter body and media shall withstand a pressure of 125 psi. The aftercooler shall be the shell-and-tube type designed for air flow through the tubes with steel shell internal baffle plates. The cooling capacity of the after cooler shall be sized for the total capacity of the compressor. The moisture separator shall be provided with an automatic water discharge trap and level gauge. Cooling water controls for regulating compressor cylinder water temperature and after-cooler water temperature shall be thermostatic valve type and shall be installed with a three-valve bypass in the water outlet lines ahead of open sight drain funnels. The compressor shall be equipped with adjustable, pressure type unloader controls suitable for continuous compressor operation.

2.12.1.2 Air Receiver

The air receiver shall be a vertical type constructed in accordance with ASME BPVC SEC VIII D1 for unfired pressure vessels for 200 psi working pressure, and shall be equipped with flanged inlet and outlet connections, valved drain connection, minimum 6 inch dial pressure gauge, pop safety valves, and regulator connections.

2.12.2 Continuous Emissions Monitoring

a. Continuous Emissions Monitoring System (CEMS) equipment shall be provided as a system by a single manufacturer. A CEMS, meeting the requirements of applicable federal, State of [_____] and local regulations, shall be provided for each boiler in accordance with manufacturer's recommendations and under the direct supervision of the CEMS equipment manufacturer. Before acceptance of the installation, the Contracting Officer shall be furnished a written test report which provides documentation that the CEMS equipment passed factory and field certification test required by federal, state, and local regulations. Submit written certification by the boiler manufacturer that each boiler furnished complies with Federal, state, and local regulations for emissions. The certification shall also include a description of applicable emission regulations. If any boiler is exempt from the emission regulations, the certification shall indicate the reason for the exemption.

b. The reported data shall include [sulfur dioxide (SO2)] [oxides of nitrogen (NOX)] [carbon dioxide (CO2)] [and] [particulate matter (PM)] and other information required by Federal, state, and local regulations. SO2 reporting shall be based on [analyzer measurement] [fuel flow and percent sulfur calculation]. Nitrous oxides, carbon dioxide and particulate matter reporting shall be based on analyzers.

c. The CEMS equipment shall include the central processing unit, printer, hard disk drive, and floppy disk drive. The floppy disk drive shall function as a recorder. The manufacturer shall provide the software to generate the required reports in a format acceptable to the Federal, state and local regulatory agencies. The operator interface to the CEMS equipment shall be via CRT screen.

2.12.2.1 Gaseous Emission Monitors

Extractive or in situ gaseous monitors shall be provided. A combination of extractive and in situ monitors is not acceptable. Gas monitors shall include automatic calibration checks. An alarm horn and annunciator shall be provided to alarm when any monitor parameter is out of range or a gaseous monitor malfunctions. The surfaces that are exposed to the corrosive gas of the boiler shall be constructed of noncorrosive materials such as 316 SS, teflon or hastelloy.

a. In situ monitor shall be mounted on the ductwork at the location [shown on the plans] [recommended by the manufacturer]. The situ system shall not be affected by the presence of particulate matter in the flue gas.

b. Extractive systems shall be [wet] [dry] [diluted]. Analyzing equipment for the extractive system shall be located in a walk-in cabinet. The equipment shall be arranged to provide access for maintenance. Extractive system sampling between the probes and the analyzers shall be heat traced to maintain the temperature recommended by the manufacturer when the ambient temperature is [_____] degrees F. Probes shall be mounted on the ductwork at the location [shown on the plans] [recommended by the manufacturer].

2.12.2.2 Flue Gas Flow Monitor

Flue gas flow monitor shall utilize the pitot tube principle to measure the flow. The probe shall be an across-the-duct-average pitot tube and shall be designed and located to obtain representative measurement. Differential pressure transmitters shall be used to sense the difference between the static and total pressure of the flowing gas steam. Calibrations shall be stable. Lines shall be arranged to prevent collection of condensate. A purge system shall be provided as required to keep the pitot pressure taps clear.

2.12.2.3 Particulate Matter Monitor

Particulate matter (opacity) monitor based on the principle of transmissometry shall be provided. The transmissometer shall include automatic simulation of zero opacity and upscale check of calibration while the boiler is in service without dismounting the unit. The calibration check shall include analyzer internal circuitry and electronic circuitry. An alarm horn and annunciator shall be provided to annunciate excess opacity and any system malfunction. Units shall be provided with fans to keep the sending and receiving lenses pressurized and blown clean at all times.

2.12.2.4 Wiring

The CEMS equipment shall be provided with plug-in prefabricated cable for interconnection between components. Power supply to the equipment shall be 2-wire, 120 volt nominal or less, 60 Hz, with one side grounded. Electrical devices shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.12.3 Tankless Water Heater

A seamless copper immersion type tankless water heater of the specified capacity shall be installed in the boiler. The heater shall be equipped with an approved water-tempering valve which shall be set to supply hot water at approximately 140 degrees F. Instead of the immersion type coil, an approved external shell and tube type or plate type heat exchanger may be installed as specified in Section 23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS.

2.12.4 Conventional Breeching and Stacks

2.12.4.1 Breeching

Each boiler shall be connected to the stack or flue by breeching constructed of black steel sheets not less than 0.0478 inch thick nor less than thickness of stack, whichever is larger. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. The clear distance between any portion of the breeching surface and any combustible material shall not be less than that specified in NFPA 211. Joints and seams shall be securely fastened and made airtight. Suitable hinged and gasketed cleanouts shall be provided, which will permit cleaning the entire smoke connection without dismantling. Flexible-type expansion joints shall be provided as required and shall not require packing.

2.12.4.2 Stacks

[Individual stub stacks shall extend above the roof to the heights indicated. Individual stub stacks shall be [20] [_____] feet in height when assembled on the boiler and measured from the ground line. Stack section shall be sheet steel having a thickness of not less than 0.0972 inch.]

[Prefabricated double wall stacks system shall extend above the roof to the height indicated. The stacks shall be [20] [_____] feet in height when assembled on the boiler and measured from the ground line. The inner stack shall be [304 stainless steel] [316 stainless steel] having a thickness of not less than 0.035 inch. The outer stack shall be sheet steel having a thickness of not less than 0.025 inch. A method of maintaining concentricity between the inner and outer stacks shall be incorporated. The joints between the stack sections shall be sealed to prevent flue gas leakage.] A 0.3125 inch diameter hole shall be provided in the stack not greater than 6 inches from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Each stack shall be provided complete with rain hood. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.12.5 Direct Vents

Direct venting shall be used for condensing type boilers. Both the air intake and exhaust vents shall be sized and located as indicated on the drawings and as recommended by the boiler manufacturer. A separate combustion air intake vent and exhaust vent shall be provided for each boiler.

2.12.5.1 Combustion Air Intake Vent

The combustion air intake piping shall be constructed of Schedule 40 PVC in accordance with ASTM D1784. The vent shall be suitable for the temperature at the boiler combustion air intake connection point. Each intake shall be provided complete with bird screen.

2.12.5.2 Exhaust Vent

The exhaust vent piping shall be constructed of Schedule 40 CPVC or stainless steel conforming to UL 1738 and the boiler manufacturer's recommendations. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. The exhaust vent shall be suitable for the maximum anticipated boiler exhaust temperature and shall withstand the corrosive effects of the condensate. A 0.3125 inch diameter hole shall be provided in the stack not greater than 6 inches from the boiler flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Each exhaust stack shall be provided complete with bird screen.

2.12.6 Expansion Tank

The hot water pressurization system shall include a diaphragm-type expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The only air in the system shall be the permanent sealed-in air cushion contained in the diaphragm-type tank. The sizes shall be as indicated. The expansion tank shall be welded steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of [125] [_____] psi and precharged to the minimum operating pressure. The tank's air chamber shall be fitted with an air charging valve and pressure gauge. The tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The tank shall have lifting rings and a drain connection. All components shall be suitable for a maximum operating temperature of 250 degrees F.

2.12.7 Air Separator

External air separation tank shall be steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of [125] [_____] psi. The capacity of the air separation tank indicated is minimum.

2.12.8 Filters

Filters shall conform to ASHRAE 52.2.

2.12.9 Foundation (Setting) Materials

2.12.9.1 Firebrick

Firebrick shall be ASTM C27 class as recommended by boiler manufacturer.

2.12.9.2 Tile

Tile shall be ASTM C34, Grade LBX.

2.12.9.3 Insulating Brick

Insulating brick shall comply with ASTM C155.

2.12.9.4 Refractory Mortar

Refractory mortar shall comply with ASTM F1097.

2.12.9.5 Castable Refractories

Castable refractories shall be ASTM C401. The minimum modulus of rupture for transverse strength shall be not less than 600 psi after being heat soaked for 5 hours or more at a temperature in excess of 2500 degrees F.

2.12.10 Steel Sheets

2.12.10.1 Galvanized Steel

Galvanized steel shall be ASTM A653/A653M.

2.12.10.2 Uncoated Steel

Uncoated steel shall be composition, condition, and finish best suited to the intended use.

2.12.11 Gaskets

Gaskets shall be nonasbestos material in accordance with ASME B16.20, full face or self-centering type. The gaskets shall be of the spiral wound type with graphite filler material.

2.12.12 Steel Pipe and Fittings

2.12.12.1 Steel Pipe

Steel pipe shall be ASTM A53/A53M, Type E or S, Grade A or B, black steel, standard weight.

2.12.12.2 Steel Pipe Fittings

Fittings shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.12.12.3 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns, etc. shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A105/A105M. Flanges for high temperature water systems shall be serrated or raised-face type. Blind flange material shall conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A193/A193M. Submit written certification by the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification.

2.12.12.4 Welded Fittings

Welded fittings shall conform to ASTM A234/A234M with WPA marking. Buttwelded fittings shall conform to ASME B16.9, and socket-welded fittings shall conform to ASME B16.11.

2.12.12.5 Cast-Iron Fittings

Fittings shall be ASME B16.4, Class 125, type required to match connecting piping.

2.12.12.6 Malleable-Iron Fittings

Fittings shall be ASME B16.3, type as required to match connecting piping.

2.12.12.7 Unions

Unions shall be ASME B16.39, Class 150.

2.12.12.8 Threads

Pipe threads shall conform to ASME B1.20.1.

2.12.12.9 Grooved Mechanical fittings

Joints and fittings shall be designed for not less than[125 psig] [_____] service and shall be the product of the same manufacturer. Fitting and coupling houses shall be ductile iron conforming to ASTM A536. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D2000 for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183.

2.12.13 Copper Tubing and Fittings

2.12.13.1 Copper Tubing

Tubing shall be ASTM B88, Type K or L. Adapters for copper tubing shall be brass or bronze for brazed fittings.

2.12.13.2 Solder-Joint Pressure Fittings

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 and ASTM B828.

2.12.13.3 Flared Fittings

Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62.

2.12.13.4 Adapters

Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.12.13.5 Threaded Fittings

Cast bronze threaded fittings shall conform to ASME B16.15.

2.12.13.6 Brazing Material

Brazing material shall conform to AWS A5.8/A5.8M.

2.12.13.7 Brazing Flux

Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides, and contain fluorides. Silver brazing materials shall be in accordance with AWS A5.8/A5.8M.

2.12.13.8 Solder Material

Solder metal shall conform to ASTM B32 95-5 tin-antimony.

2.12.13.9 Solder Flux

Flux shall be either liquid or paste form, non-corrosive and conform to ASTM B813.

2.12.13.10 Grooved Mechanical Fittings

Joints and fittings shall be designed for not less than [125 psig] [_____] service and shall be the product of the same manufacturer. Fitting and coupling houses shall be ductile iron conforming to ASTM A536. Gaskets shall be molded synthetic rubber with central cavity, pressure responsible configuration and shall conform to ASTM D2000, for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183.

2.12.14 Dielectric Waterways and Flanges

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall include dielectric unions to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.12.15 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 125 psi or 150 psi service. Connectors shall be installed where indicated. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. Materials used and the configuration shall be suitable for the pressure, vacuum, and temperature medium. The flexible section shall be suitable for service intended and may have threaded, welded, soldered, flanged, or socket ends. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.12.16 Pipe Supports

Pipe supports shall conform to MSS SP-58.

2.12.17 Pipe Expansion

2.12.17.1 Expansion Loops

Expansion loops and offsets shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loops and offsets shall be cold-sprung and installed where indicated. Pipe guides and anchors shall be provided as indicated.

2.12.17.2 Expansion Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the transverse indicated. The joints shall be designed for a [hot water] [steam] working pressure not less than [_____] psig and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. End connection shall be flanged. Anchor bases or support bases shall be provided as indicated or required. Sliding surfaces and water wetted surfaces shall be chromium plated or fabricated of corrosion resistant steel. Initial setting shall be made in accordance with the manufacturer's recommendations to compensate for an ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall not be more than 5 feet from expansion joint, except in lines 4 inches or smaller guides shall be installed not more than 2 feet from the joint. Service outlets shall be provided where indicated.

2.12.17.2.1 Bellows-Type joint

Bellows-type joints shall be flexible, guided expansion joints. The expansion element shall be stabilized corrosion resistant steel. Bellows-type expansion joints shall conform to the applicable requirements of EJMA Stds and ASME B31.1 with internal lines. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but shall not be less than 150 psig.

2.12.17.2.2 Flexible Ball Joint

Flexible ball joints shall be constructed of alloys as appropriate for the service intended. The joints shall be threaded, grooved, flanged, or welded end as required and shall be capable of absorbing the normal operating axial, lateral, or angular movements or combination thereof. Balls and sockets shall be polished, chromium-plated when materials are not of corrosion-resistant steel. The ball type joint shall be designed and constructed in accordance with ASME B31.1 and EJMA Stds. Flanges shall conform to the diameter and drilling of ASME B16.5. Molded gaskets shall be suitable for the service intended.

2.12.17.2.3 Slip Type Expansion Joint

Slip type expansion joints shall be EJMA Stds and ASME B31.1, Class 1 or 2. Type II joints shall be suitable for repacking under full line pressure.

2.12.18 Valves

Valves shall be Class 125 and shall be suitable for the application. Grooved ends in accordance with AWWA C606 may be used for water service only. Valves in nonboiler external piping shall meet the material, fabrication and operating requirements of ASME B31.1. The connection type of all valves shall match the same type of connection required for the piping on which installed.

2.12.18.1 Gate Valves

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 bronze rising stem, threaded, solder, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70 cast iron bronze trim, outside screw and yoke, flanged, or threaded ends.

2.12.18.2 Globe Valves

Globe valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Globe valves 3 inches and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.3 Check Valves

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Check valves 3 inches and larger shall conform to MSS SP-71, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.4 Angle Valves

Angle valves 2-1/2 inches and smaller shall conform to MSS SP-80 bronze, threaded, soldered, or flanged ends. Angle valves 3 inches and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.5 Ball Valves

Ball valves 1/2 inch and larger shall conform to [MSS SP-72] [or] [MSS SP-110], ductile iron or bronze, threaded, soldered, or flanged ends.

2.12.18.6 Plug Valves

Plug valves 2 inch and larger shall conform to MSS SP-78. Plug valves smaller than 2 inch shall conform to ASME B16.34.

2.12.18.7 Grooved End Valves

Valves with grooved ends in accordance with AWWA C606 may be used if the valve manufacturer certifies that their performance meets the requirements of the standards indicated for each type of valve.

2.12.18.8 Balancing Valves

Balancing valves shall have meter connections with positive shutoff valves. An integral pointer shall register the degree of valve opening. Valves shall be calibrated so that flow rate can be determined when valve opening in degrees and pressure differential across valve is known. Each balancing valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation. Valves shall be suitable for 250 degrees F temperature and working pressure of the pipe in which installed. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential. One portable differential meter shall be furnished. The meter suitable for the operating pressure specified shall be complete with hoses, vent, and shutoff valves, and carrying case. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.

2.12.18.9 Automatic Flow Control Valves

In lieu of the specified balancing valves, automatic flow control valves may be provided to maintain constant flow and shall be designed to be sensitive to pressure differential across the valve to provide the required opening. Valves shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valves shall control the flow within 5 percent of the tag rating. Valves shall be suitable for the maximum operating pressure of 125 psi or 150 percent of the system operating pressure, whichever is greater. Where the available system pressure is not adequate to provide the minimum pressure differential that still allows flow control, the system pump head capability shall be increased. Valves shall be suitable for 250 degrees F temperature service. Valve materials shall be same as specified for the heating system check, globe, angle, and gate valves. Valve operator shall be the electric motor type[or pneumatic type as applicable]. Valve operator shall be capable of positive shutoff against the system pump head. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the automatic flow control valve. A portable meter shall be provided with accessory kit as recommended for the project by the automatic valve manufacturer.

2.12.18.10 Butterfly Valves

Butterfly valves shall be 2-flange type or lug wafer type, and shall be bubbletight at 150 psig. Valve bodies shall be cast iron, malleable iron, or steel. ASTM A167, Type 404 or Type 316, corrosion resisting steel stems, bronze, or corrosion resisting steel discs, and synthetic rubber seats shall be provided. Valves smaller than 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

2.12.18.11 Drain valves

Drain valves shall be provided at each drain point of blowdown as recommended by the boiler manufacturer. Piping shall conform to ASME BPVC SEC IV and ASTM A53/A53M.

2.12.18.12 Safety Valves

Safety valves shall have steel bodies and shall be equipped with corrosion-resistant trim and valve seats. The valves shall be properly guided and shall be positive closing so that no leakage can occur. Adjustment of the desired back-pressure shall cover the range between 2 and 10 psig. The adjustment shall be made externally, and any shafts extending through the valve body shall be provided with adjustable stuffing boxes having renewable packing. Boiler safety valves of proper size and of the required number, in accordance with ASME BPVC SEC IV, shall be installed so that the discharge will be through piping extended [to the blowoff tank] [to a location as indicated]. [Each discharge pipe for steam service shall be provided with a drip pan elbow to prevent accumulation of water on the valve. A slip joint shall be provided between drip pan elbow and riser.] [Each discharge pipe for hot water service shall be pitched away from the valve seat.]

2.12.19 Strainers

Basket and "Y" type strainers shall be the same size as the pipelines in which they are installed. The strainer bodies shall be heavy and durable, fabricated of cast iron, and shall have bottoms drilled and tapped with a gate valve attached for blowdown purposes. Strainers shall be designed for [_____] psig service and [_____] degrees F. The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment screen. The screen shall be made of 22 gauge thick [brass sheet] [monel] [corrosion-resistant steel] with small perforations numbering not less than 400/square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.12.20 Pressure Gauges

Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 3-1/2 inches. A pressure gauge shall be provided for each boiler in a visible location on the boiler. Pressure gauges shall be provided with readings in psi. Pressure gauges shall have an indicating pressure range that is related to the operating pressure of the fluid in accordance with the following table:

Operating Pressure (psi)	Pressure Range (psi)
76-150	0-200
16-75	0-100
2-15	0-30 (retard)

2.12.21 Thermometers

Thermometers shall be provided with wells and separable corrosion-resistant steel sockets. Mercury shall not be used in thermometers. Thermometers for [inlet water and outlet water for each hot water boiler] [the feedwater for each steam boiler] shall be provided in a visible location on the boiler. Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a minimum 9 inch scale. The operating range of the thermometers shall be 32-212 degrees F. The thermometers shall be provided with readings in degrees F.

2.12.22 Air Vents

2.12.22.1 Manual Air Vents

Manual air vents shall be brass or bronze valves or cocks suitable for the pressure rating of the piping system and furnished with threaded plugs or caps.

2.12.22.2 Automatic Air Vents

Automatic air vents shall be 3/4 inch quick-venting float and vacuum air valves. Each air vent valve shall have a large port permitting the expulsion of the air without developing excessive back pressure, a noncollapsible metal float which will close the valve and prevent the loss of water from the system, an air seal that will effectively close and prevent the re-entry of air into the system when subatmospheric pressures prevail therein, and a thermostatic member that will close the port against the passage of steam from the system. The name of the manufacturer shall be clearly stamped on the outside of each valve. The air vent valve shall be suitable for the pressure rating of the piping system.

2.12.23 Steam Traps

2.12.23.1 Thermostatic Traps

Thermostatic traps shall conform to the requirements of ASTM F1139 and shall be installed in the return connection from each radiator and elsewhere as indicated. Drip traps for mains, risers, and similar lines shall be installed with a cooling leg of 5 feet of uncovered 3/4 inch pipe. The capacity of traps shall be based on a pressure differential of 2 psi. The traps shall be designed for a steam working pressure of 15 psig but shall operate with a supply pressure of approximately 2 psig. The traps shall be angle or straight-through pattern with union inlet connections as indicated. The trap bodies and covers shall be brass. Valve mechanisms and seats shall be monel, stainless steel or hard bronze and shall be removable for servicing or replacement.

2.12.23.2 Float-and-Thermostatic Traps

Float-and-thermostatic traps shall conform to the requirements of ASTM F1139 and be designed for a steam working pressure of 15 psig but shall operate with a supply pressure of approximately 5 psig. The trap capacity shall be based on a pressure differential of 2 psig. Each float-and-thermostatic trap shall have a cast iron body and shall be provided with a hard bronze, monel, or corrosion-resisting steel valve seat and mechanism, an open- or closed-type float of brass or equally corrosion-resistant metal, and a corrosion-resisting steel thermostatic air vent, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.12.23.3 Inverted Bucket Traps

Inverted bucket traps shall conform to the requirements of ASTM F1139 and be designed for a steam working pressure of 15 psig but shall operate with a supply pressure of approximately 5 psig. Each trap shall have a cast iron body and shall have a corrosion-resistant steel valve and seat and a brass or corrosion-resistant steel bucket, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.13 ELECTRICAL EQUIPMENT

Electric motor-driven equipment shall be provided complete with motors, motor starters, and necessary control devices. Electrical equipment, motor control devices, motor efficiencies and wiring shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motors which are not an integral part of a packaged boiler and which are integral in size shall be the premium efficiency type in accordance with NEMA MG 1. Motors which are an integral part of the packaged boiler shall be the highest efficiency available by the manufacturer of the packaged boiler. Motor starters shall be provided complete with properly sized thermal overload protections and other appurtenances necessary for the motor control specified. Starters shall be furnished in [general purpose][watertight][explosion-proof, Class I, division I] enclosures. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices but not shown shall be provided.

2.13.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 1/2 hp and larger shall be three-phase, unless otherwise indicated. Motors shall be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating on the motor.

2.13.2 Motor Controls

Motor controllers shall be provided complete with properly sized thermal overload protection. Manual or automatic control and protective or signal devices required for the operation specified and any wiring required to such devices shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Solid state variable speed controllers shall be utilized for fractional through 10 hp ratings. Adjustable frequency drives shall be used for larger motors.

2.14 INSULATION

Shop and field-applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.15 TOOLS

Special tools shall be furnished. Special tools shall include uncommon tools necessary for the operation and maintenance of boilers, burners, pumps, fans, controls, meters, special piping systems, and other equipment. Small hand tools shall be furnished within a suitable cabinet, mounted where directed.

2.15.1 Breeching Cleaner

A cleaner shall be provided to clean the breeching. The cleaner shall have a jointed handle of sufficient length to clean the breeching without dismantling.

2.15.2 Tube Cleaner

If a watertube boiler is being furnished, a water-driven tube cleaner with three rotary cutters and rotary wire brush complete with the necessary length of armored water hose, valves, and other appurtenances necessary for operation shall be provided. Tube cleaner and rotary brush shall be provided for each size of water tube in the boiler, with one extra set of cutters for each size cleaner. Necessary valves and fittings shall be provided to permit ready connection of the cleaner hose to a high-pressure pump for cold water supply to operate the cleaner.

2.15.3 Tube Brush

If a firetube boiler is being furnished, a tube brush, with steel bristles and jointed handle of sufficient length to clean full length of firetubes, shall be provided.

2.15.4 Wrenches

Wrenches shall be provided as required for specialty fittings such as manholes, handholes, and cleanouts. One set of extra gaskets shall be provided for all manholes and handholes, for pump barrels, and other similar items of equipment. Gaskets shall be packaged and properly identified.

2.16 FUEL OIL STORAGE SYSTEM

The fuel oil storage system shall be as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS unless noted otherwise. A [helical wound coil constructed of 1 inch seamless steel tubing] [platecoil suction bell heater constructed of carbon steel not lighter than 14 gauge] shall be provided in each tank for No. 6 fuel oil and installed around the suction end of the oil line. The coil in each tank shall have capacity to heat the fuel oil from [_____] to [_____] degrees F, during the maximum demand of all oil burners connected to the tank. The coil shall utilize [steam at [_____] psig] [hot water at [_____] degrees F] as the heating medium. The heating coil inlet and outlet connections and the fuel-oil suction and return piping connections shall be attached to the same tank manway cover. An additional manhole located above the heater shall be provided for removal of the heater as a unit.

2.17 BOILER WATER TREATMENT

Submit [six] [_____] complete copies of the proposed water treatment plan. The plan shall include a layout, control scheme, a list of the existing water conditions including the items listed in this paragraph, a list of all chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals. The water treatment system shall be capable of feeding chemicals and bleeding the system to prevent corrosion and scale within the boiler and piping distribution system. Submit [6] [_____] complete copies of operating and maintenance manuals for the step-by-step water treatment procedures, including procedures for testing the water quality. The water shall be treated to maintain the conditions recommended by the boiler manufacturer. Chemicals shall meet required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. The services of a company regularly engaged in the treatment of boilers shall be used to determine the correct chemicals and concentrations required for water treatment. The company shall maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Filming amines and proprietary chemicals shall not be used. The water treatment chemicals shall remain stable throughout the operating temperature range of the system and shall be compatible with pump seals and other elements of the system.

2.17.1 MakeUp Water Analysis

The makeup water conditions reported as prescribed in ASTM D596 are as follows:

Date of Sample	[_____]
Temperature	[_____] degrees F
Silica (SiO2)	[_____] ppm (mg/1)
Insoluble	[_____] ppm (mg/1)
Iron and Aluminum Oxides	[_____] ppm (mg/1)
Calcium (Ca)	[_____] ppm (mg/1)
Magnesium (Mg)	[_____] ppm (mg/1)
Sodium and Potassium (Na and K)	[_____] ppm (mg/1)
Carbonate (HCO3)	[_____] ppm (mg/1)

Sulfate (SO4)	[_____] ppm (mg/1)
Chloride (C1)	[_____] ppm (mg/1)
Nitrate (NO3)	[_____] ppm (mg/1)
Turbidity	[_____] ntu
pH	[_____]
Residual Chlorine	[_____] ppm (mg/1)
Total Alkalinity	[_____] epm (meq/1)
Noncarbonate Hardness	[_____] epm (meq/1)
Total Hardness	[_____] epm (meq/1)
Dissolved Solids	[_____] ppm (mg/1)
Fluorine	[_____] ppm (mg/1)
Conductivity	[_____] micro-mho/cm

2.17.2 Boiler Water Limits

The boiler manufacturer shall be consulted for the determination of the boiler water chemical composition limits. The boiler water limits shall be as follows unless dictated differently by the boiler manufacturer's recommendations:

[

Causticity	20-200 ppm
Total Alkalinity (CACO3)	900-1200 ppm
Phosphate	30-60 ppm
Tanin	Medium
Dissolved Solids	3000-5000 ppm
Suspended Solids	300 ppm Max
Sodium Sulfite	20-40 ppm Max
Silica	Less than 150 ppm
Dissolved Oxygen	Less than 7 ppm
Iron	10 ppm
pH (Condensate)	7 - 8

][

Sodium Sulfite	20-40 ppm
Hardness	Less than 2 ppm
pH	9.3 - 9.9

]

2.17.3 Water Softening System

The water softening system shall be as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.17.4 Chemical Feed Pumps

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The capacity of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of the pumps shall be not less than 1.5 times the pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.17.5 Tanks

The tanks shall be constructed of [high density polyethylene] [stainless steel] with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.17.6 Injection Assemblies

An injection assembly shall be provided at each chemical injection point located along the boiler piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the water line.

2.17.7 Water Meter

The water meter shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the makeup water line, as indicated.

2.17.8 Water Treatment Control Panel

The control panel shall be a NEMA 12, single door, wall-mounted box conforming with NEMA 250. The panel shall be constructed of [steel] [stainless steel] with a hinged door and lock. The panel shall contain, as a minimum, the following functions identified with a laminated plastic nameplate:

a. Main power switch and indicating light

b. MAN-OFF-AUTO selector switch

c. Indicating lamp for blow down

d. Indicating lamp for each chemical feed pump

e. Indicating lamp for the water softener

2.17.9 Sequence of Operation

The flow rate of chemical addition shall be based upon [metering the makeup water.] [a manual setting.] The boiler shall be provided with [continuous blowdown.] [automatic blowdown based upon conductivity or boiler load.] The required rate of chemical feed and boiler blowdown shall be determined by the water treatment company.

2.17.10 Chemical Shot Feeder

A shot feeder shall be provided as indicated. Size and capacity of feeder shall be based upon local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.17.11 Chemical Piping

The piping and fittings shall be constructed of [schedule 80 PVC] [steel] [stainless steel].

2.17.12 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.17.13 Glycol Feed System

Design the Glycol feed system to automatically maintain the desired glycol content of the closed water recirculation system(s). Each system shall consist of the following components:

2.17.13.1 Supply Tank and Stand

Include a 50 gallon cross lined polyethylene tank and steel support stand. The tank shall have a cover and bottom outlet fitting for pump suction. Equip the tank stand with a pump mounting platform and support for the control panel and level switch.

2.17.13.2 Glycol Pump

Rotary gear type of bronze construction with a capacity of 1.8 gpm at 40 psi. The pump shall have a 1/3 horsepower, 1/115V/60hz motor and internal pressure relief. Provide the pump with a discharge check valve and shutoff valve.

2.17.13.3 Pressure Switch

The pressure switch shall be adjustable over the range of 3 - 15 psi with a 6 psi differential and have contacts rated for 115V.

2.17.13.4 Level Switch

Equipped with N/O and N/C contacts to activate upon sensing a low level condition.

2.17.13.5 Control Panel

The control panel shall be installed in a NEMA 1 enclosure with terminal strip and shall include a red low level alarm light, low level alarm bell and silence button, full voltage motor starter for the glycol pump, and a Hand-Off-Auto selector switch.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work or ordering any materials.

3.2 ERECTION OF BOILER AND AUXILIARY EQUIPMENT

Boiler and auxiliary equipment shall be installed in accordance with manufacturer's written instructions. Proper provision shall be made for expansion and contraction between boiler foundation and floor. This joint shall be packed with suitable nonasbestos rope and filled with suitable compound that will not become soft at a temperature of 100 degrees F. Boilers and firing equipment shall be supported from the foundations by structural steel completely independent of all brickwork. Boiler supports shall permit free expansion and contraction of each portion of the boiler without placing undue stress on any part of the boiler or setting. Boiler breeching shall be as indicated with full provision for expansion and contraction between all interconnected components.

3.3 PIPING INSTALLATION

Unless otherwise specified, nonboiler external pipe and fittings shall conform to the requirements of ASME B31.1. Pipe installed shall be cut accurately to suit field conditions, shall be installed without springing or forcing, and shall properly clear windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes shall be free of burrs, oil, grease and other foreign material and shall be installed to permit free expansion and contraction without damaging the building structure, pipe, pipe joints, or pipe supports. Changes in direction shall be made with fittings, except that bending of pipe 4 inches and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Vent pipes shall be carried through the roof as directed and shall be properly flashed. Unless otherwise indicated, horizontal supply mains shall pitch down in the direction of flow with a grade of not less than 1 inch in 40 feet. Open ends of pipelines and equipment shall be properly capped or plugged during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified shall be uncoated. Unless otherwise specified or shown, final connections to equipment shall be made with malleable-iron unions for steel pipe 2-1/2 inches or less in diameter and with flanges for pipe 3 inches or more in diameter. Unions for copper pipe or tubing shall be brass or bronze. Reducing fittings shall be used for changes in pipe sizes. In horizontal hot water lines, reducing fittings shall be eccentric type to maintain the top of the lines at the same level to prevent air binding.

3.3.1 Hot Water Piping and Fittings

Pipe shall be black steel or copper tubing. Fittings for steel piping shall be black malleable iron or cast iron to suit piping. Fittings adjacent to valves shall suit valve material. Grooved mechanical fittings will not be allowed for water temperatures above 230 degrees F.

3.3.2 Vent Piping and Fittings

Vent piping shall be black steel. Fittings shall be black malleable iron or cast iron to suit piping.

3.3.3 Gauge Piping

Piping shall be copper tubing.

3.3.4 Steam Piping and Fittings

Piping shall be black steel. Fittings shall be black, malleable iron, cast iron or steel. Fittings adjacent to valves shall suit valves specified. Grooved mechanical fittings will not be allowed for steam piping.

3.3.5 Condensate Return Pipe and Fittings

Piping shall be black steel. Fittings shall be malleable iron, cast iron, or steel. Grooved mechanical fittings will not be allowed for condensate piping.

3.3.6 Joints

Joints between sections of steel pipe and between steel pipe and fittings shall be threaded, grooved, flanged or welded as indicated or specified. Except as otherwise specified, fittings 1 inch and smaller shall be threaded; fittings 1-1/4 inches and up to but not including 3 inches shall be either threaded, grooved, or welded; and fittings 3 inches and larger shall be either flanged, grooved, or welded. Pipe and fittings 1-1/4 inches and larger installed in inaccessible conduit or trenches beneath concrete floor slabs shall be welded. Connections to equipment shall be made with black malleable-iron unions for pipe 2-1/2 inches or smaller in diameter and with flanges for pipe 3 inchesor larger in diameter. Joints between sections of copper tubing or pipe shall be flared, soldered, or brazed.

3.3.6.1 Threaded Joints

Threaded joints shall be made with tapered threads properly cut and shall be made perfectly tight with a stiff mixture of graphite and oil or with polytetrafluoroethylene tape applied to the male threads only and in no case to the fittings.

3.3.6.2 Welded Joints

Welded joints shall be in accordance with paragraph GENERAL REQUIREMENTS unless otherwise specified. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitation. Branch outlet fittings, where used, shall be forged, flared for improved flow characteristics where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Socket weld joints shall be assembled so that the space between the end of the pipe and the bottom of the socket is no less than 1/16 inch and no more than 1/8 inch.

3.3.6.3 Grooved Mechanical Joints

Grooved mechanical joints may be provided for hot water systems in lieu of unions, welded, flanged, or screwed piping connections in low temperature hot water systems where the temperature of the circulating medium does not exceed 230 degrees F. Grooves shall be prepared according to the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations. Mechanical joints shall use rigid mechanical pipe couplings, except at equipment connections. At equipment connections, flexible couplings may be used. Coupling shall be of the bolted type for use with grooved end pipes, fittings, valves, and strainers. Couplings shall be self-centering and shall engage in a watertight couple.

3.3.6.4 Flared and Brazed Copper Pipe and Tubing

Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Brazed joints shall be made in conformance with AWS B2.2/B2.2M and CDA A4015 with flux. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver or a silver brazing filler metal. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided in all branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Flared or brazed copper tubing to pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing.

3.3.6.5 Soldered Joints

Soldered joints shall be made with flux and are only acceptable for lines 2 inches and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015.

3.3.6.6 Copper Tube Extracted Joint

An extruded mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.3.7 Flanges and Unions

Flanges shall be faced true, provided with 1/16 inch thick gaskets, and made square and tight. Where steel flanges mate with cast-iron flanged fittings, valves, or equipment, they shall be provided with flat faces and full face gaskets. Union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Dielectric pipe unions shall be provided between ferrous and nonferrous piping to prevent galvanic corrosion. The dielectric unions shall have metal connections on both ends. The ends shall be threaded, flanged, or brazed to match adjacent piping. The metal parts of the union shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Gaskets, flanges, and unions shall be installed in accordance with manufacturer's recommendations.

3.3.8 Branch Connections

3.3.8.1 Branch Connections for Hot Water Systems

Branches from the main shall pitch up or down as shown to prevent air entrapment. Connections shall ensure unrestricted circulation, eliminate air pockets, and permit complete drainage of the system. Branches shall pitch with a grade of not less than 1 inch in 10 feet. When indicated, special flow fittings shall be installed on the mains to bypass portions of the water through each radiator. Special flow fittings shall be standard catalog products and shall be installed as recommended by the manufacturer.

3.3.8.2 Branch Connections for Steam Systems

Branches shall be taken from the supply mains at an angle of 45 degrees above the horizontal, unless otherwise indicated. The branches from return mains shall be taken from the top or sides, unless indicated otherwise. Branches shall pitch up from the mains toward the undripped risers or radiator connections with a grade of not less than 1 inch in 10 feet. Connections to ensure unrestricted circulation, eliminate air pockets, and permit the complete drainage of the system.

3.3.9 Steam Connections to Equipment

Steam supply and return connections shall be provided as shown. Connections shall be made with malleable-iron unions or with steel flanges, to match equipment. Valves and traps shall be installed in accordance with the manufacturer's recommendations. The size of the supply and return pipes to each piece of equipment shall not be smaller than the outlets on the equipment.

3.3.10 Steam Risers

The location of risers is approximate. The exact locations of the risers shall be approved. Downfeed risers shall terminate in a dirt pocket and shall be dripped through a trap to the return line.

3.3.11 Air Vents for Steam Systems

Automatic balanced pressure thermostatic air vents shall be installed at the ends of the steam lines and where shown on the drawings. The vents shall be rated for 125 psi steam service. The outlet of the vent shall be routed to a point designated by the Contracting Officer's Representative. The inlet line shall have a gate valve or ball valve.

3.3.12 Flared, Brazed, and Soldered Copper Pipe and Tubing

Copper tubing shall be flared, brazed, or soldered. Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided on branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing. Brazed joints shall be made in conformance with CDA A4015. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver, or a silver brazing filler metal. Soldered joints shall be made with flux and are only acceptable for lines 2 inches or smaller. Soldered joints shall conform to ASME B31.5 and shall be in accordance with CDA A4015.

3.3.13 Copper Tube Extracted Joint

An extracted mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.3.14 Supports

Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. Threaded rods which are used for support shall not be formed or bent. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.3.14.1 Seismic Requirements for Supports and Structural Bracing

Piping and attached valves shall be supported and braced to resist seismic loads as specified in Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT [and][as shown on the drawings]. Structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, shall be provided in this section. Material used for supports shall be as specified in Section 05 12 00 STRUCTURAL STEEL.

3.3.14.2 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58, except as modified herein.

3.3.14.2.1 Types 5, 12, and 26

Use of Types 5, 12, and 26 is prohibited.

3.3.14.2.2 Type 3

Type 3 shall not be used on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe, if the clamp bottom does not extend through the insulation, and if the top clamp attachment does not contact the insulation during pipe movement.

3.3.14.2.3 Type 18

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

3.3.14.2.4 Type 19 and 23 C-Clamps

Torque Type 19 and 23 C-clamps in accordance with MSS SP-58 and have both locknuts and retaining devices furnished by the manufacturer. Field fabricated C-clamp bodies or retaining devices are not acceptable.

3.3.14.2.5 Type 20 Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.3.14.2.6 Type 24

Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.3.14.2.7 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-58 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves.

3.3.14.2.8 Vertical Pipe Support

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.

3.3.14.2.9 Type 35 Guides

Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

a. Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger, a Type 39 saddle may be welded to the pipe and freely rested on a steel plate. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rested on a steel slide plate.

b. Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.

3.3.14.2.10 Horizontal Insulated Pipe

Except for Type 3, pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation.

3.3.14.2.11 Piping in Trenches

Support piping in trenches as indicated.

3.3.14.2.12 Structural Steel Attachments

Structural steel attachments and brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material and installation shall be as specified under Section 05 12 00 STRUCTURAL STEEL. Pipe hanger loads suspended from steel joist between panel points shall not exceed 50 pounds. Loads exceeding 50 pounds shall be suspended from panel points.

3.3.14.3 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support member shall not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run. The clips or clamps shall be rigidly attached to the common base member. A clearance of 1/8 inch shall be provided between the pipe insulation and the clip or clamp for piping which may be subjected to thermal expansion.

3.3.15 Anchors

Anchors shall be provided where necessary to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results, using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

3.3.16 Valves

Valves shall be installed where indicated, specified, and required for functioning and servicing of the systems. Valves shall be safely accessible. Swing check valves shall be installed upright in horizontal lines and in vertical lines only when flow is in the upward direction. Gate and globe valves shall be installed with stems horizontal or above. Valves to be brazed shall be disassembled prior to brazing and all packing removed. After brazing, the valves shall be allowed to cool before reassembling.

3.3.17 Pipe Sleeves

Pipe passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. A waterproofing clamping flange shall be installed as indicated where membranes are involved. Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof. Sleeves through walls shall be cut flush with wall surface. Sleeves through floors shall [be cut flush with floor surface] [extend above top surface of floor a sufficient distance to allow proper flashing or finishing]. Sleeves through roofs shall extend above the top surface of roof at least 6 inches for proper flashing or finishing. Unless otherwise indicated, sleeves shall be sized to provide a minimum clearance of 1/4 inch between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in waterproofing membrane floors, bearing walls, and wet areas shall be galvanized steel pipe or cast-iron pipe. Sleeves in nonbearing walls, floors, or ceilings may be galvanized steel pipe, cast-iron pipe, or galvanized sheet metal with lock-type longitudinal seam. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls shall be sealed as indicated and specified in Section 07 92 00 JOINT SEALANTS. Metal jackets shall be provided over insulation passing through exterior walls, firewalls, fire partitions, floors, or roofs.

a. Metal jackets shall not be thinner than 0.006 inch thick aluminum, if corrugated, and 0.016 inch thick aluminum, if smooth.

b. Secure metal jackets with aluminum or stainless steel bands not less than 3/8 inch wide and not more than 8 inches apart. When penetrating roofs and before fitting the metal jacket into place, a 1/2 inch wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum height of 36 inches above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the back-up material to a minimum distance of 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 12 inches above material to a minimum distance of 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 12 inches above the floor; when passing through walls above grade, the jacket shall extend at least 4 inches beyond each side of the wall.

3.3.17.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, pipes passing through waterproofing membranes shall be provided with a 4 pound lead flashing or a 16 ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall set over the membrane in a troweled coating of bituminous cement. The flashing shall extend above the roof or floor a minimum of 10 inches. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 10 inches in diameter which pass through waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

3.3.17.2 Optional Modular Mechanical Sealing Assembly

At the option of the Contractor, a modular mechanical type sealing assembly may be installed in the annular space between the sleeve and conduit or pipe in lieu of a waterproofing clamping flange and caulking and sealing specified above. The seals shall include interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion-protected carbon steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved.

3.3.17.3 Optional Counterflashing

As alternates to caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may consist of standard roof coupling for threaded pipe up to 6 inches in diameter, lead flashing sleeve for dry vents with the sleeve turned down into the pipe to form a waterproof joint, or a tack-welded or banded-metal rain shield around the pipe, sealed as indicated.

3.3.17.4 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.3.18 Balancing Valves

Balancing valves shall be installed as indicated.

3.3.19 Thermometer Wells

Provide a thermometer well in each return line for each circuit in multicircuit systems.

3.3.20 Air Vents

Install air vents in piping at all system high points. The vent shall remain open until water rises in the tank or pipe to a predetermined level at which time it shall close tight. An overflow pipe from the vent shall be run to a point designated by the Contracting Officer's representative. The inlet to the air vent shall have a gate valve or ball valve.

3.3.21 Escutcheons

Provide escutcheons at all finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be chromium-plated iron or chromium-plated brass, either one-piece or split pattern, held in place by internal spring tension or setscrews.

3.3.22 Drains

A drain connection with a 1 inch gate valve or 3/4 inch hose bib shall be installed at the lowest point in the return main near the boiler. In addition, threaded drain connections with threaded cap or plug shall be installed on the heat exchanger coil on each unit heater or unit ventilator and wherever required for thorough draining of the system.

3.3.23 Strainer Blow-Down Piping

Strainer blow-down connections shall be fitted with a black steel blow-down pipeline routed to an accessible location and provided with a blow-down valve.

3.3.24 Direct Venting for Combustion Intake Air and Exhaust Air

The intake air and exhaust vents shall be installed in accordance with NFPA 54 and boiler manufacturer's recommendations. The exhaust vent shall be sloped 1/4 inch/ft toward the boiler's flue gas condensate collection point.

3.4 GAS FUEL SYSTEM

Gas piping, fittings, valves, regulators, tests, cleaning, and adjustments shall be in accordance with the Section 23 11 20 FACILITY GAS PIPING. Submit proposed test schedules for the heating system and fuel system tests, at least 2 weeks prior to the start of related testing. NFPA 54 shall be complied with unless otherwise specified. Burners, pilots, and all accessories shall be listed in UL FLAMMABLE & COMBUSTIBLE. The fuel system shall be provided with a gas tight, manually operated, UL listed stop valve at the gas-supply connections, a gas strainer, a pressure regulator, pressure gauges, a burner-control valve, a safety shutoff valve suitable for size of burner and sequence of operation, and other components required for safe, efficient, and reliable operation as specified. Approved permanent and ready facilities to permit periodic valve leakage tests on the safety shutoff valve or valves shall be provided.

3.5 FUEL OIL SYSTEM

Fuel oil system shall be installed in accordance with NFPA 31, unless otherwise indicated.

3.5.1 Piping and Storage Tank

Fuel oil piping and storage tanks shall be installed in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS, unless indicated otherwise.

3.5.2 Fuel-Oil Storage Tank Heating-Coil Piping

Supply and return piping and fittings for the heating coil shall be installed in accordance with paragraph PIPING INSTALLATION. The [hot water] [steam] supply line to the heating coil shall be provided with an automatic temperature-control valve, a strainer and a three-valve bypass. The return line from the coil shall be provided with a [check valve] [steam trap] and a block valve.

3.5.3 Automatic Safety Shutoff Valve

Oil supply line to each oil burner shall be equipped with an automatically operated valve designed to shut off the oil supply in case of fire in the immediate vicinity of the burner. The valve shall be thermoelectrically actuated or thermomechanically actuated type and shall be located immediately downstream of the manual shutoff valve at the day tank inside of the building. If a day tank is not used, the automatic safety valve shall be located immediately downstream of the building shutoff devices where oil supply line enters the building. A thermoelectrical or thermomechanical detection device shall be located over the oil burner to activate the valve. A fire shutoff valve may be combined with other automatic shutoff devices if listed in UL FLAMMABLE & COMBUSTIBLE.

3.5.4 Earthwork

Excavation and backfilling for tanks and piping shall be as specified in Section 31 00 00 EARTHWORK.

3.6 RADIANT FLOOR HEATING SYSTEM

The radiant floor heating system shall be installed in accordance with HI-004, unless otherwise indicated by the tubing manufacturer's installation instructions. During the installation, all tubing shall be plugged on each end to prevent foreign materials from entering the tubing. All tubing shall be checked for abrasions prior to installation. Tubing with excessive abrasions that damage the oxygen barrier coating will not be acceptable. Tubing with any abrasion that is greater than 10 percent of the minimum wall thickness will not be acceptable. All tubing embedded or concealed by the floor shall be installed without joints. The bending radius of the tubing shall not exceed the values recommended by the tubing manufacturer. The tubing shall be installed in such a manner as to evenly distribute the heat across the floor. Tubing shall not be placed near heat sensitive materials such as water closet seals. Isolation valves shall be installed on each side of each tubing manifold. The manifold and fittings shall be accessible for maintenance. After the system is filled with water or glycol, all air shall be vented from the system. After the system is allowed to stabilize at the operating temperatures of the heating fluid, the system shall be vented again.

3.6.1 Concrete Slab construction

In areas where tubing must cross expansion joints, control joints, or other crack control measures, the tubing shall be installed below the joints. The tubing shall be fastened to the reinforcing steel in accordance with the tubing manufacturer's recommendations. The tubing shall be pressurized prior to and during the concrete pour to ensure system integrity.

3.6.2 Wooden Floor Construction

Tubing shall be fastened to the wood subflooring in accordance with the drawings and the tubing manufacturer's recommendations. The method of attaching the tubing to the flooring shall not cause abrasions on the tubing.

3.6.3 Penetrations to Fire Rated Assemblies

Where pipe pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.7 COLOR CODE MARKING AND FIELD PAINTING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS. Ferrous metal not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09 90 00 PAINTS AND COATINGS. Exposed pipe covering shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

3.8 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified to supervise the installing, adjusting, and testing of the equipment.

3.9 TEST OF BACKFLOW PREVENTION ASSEMBLIES

Backflow prevention assemblies shall be tested in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.10 HEATING SYSTEM TESTS

Submit the Qualifications of the firms in charge of installation and testing as specified. Submit a statement from the firms proposed to prepare submittals and perform installation and testing, demonstrating successful completion of similar services of at least five projects of similar size or scope, at least 2 weeks prior to the submittal of any other item required by this section. Before any covering is installed on pipe or heating equipment, the entire heating system's piping, fittings, and terminal heating units shall be hydrostatically tested and proved tight at a pressure of 1.5 times the design working pressure, but not less than 100 psi. Submit proposed test procedures for the heating system tests and fuel system tests, at least 2 weeks prior to the start of related testing.

a. Before pressurizing system for test, items or equipment (e.g., vessels, pumps, instruments, controls, relief valves) rated for pressures below the test pressure shall be blanked off or replaced with spool pieces.

b. Before balancing and final operating test, test blanks and spool pieces shall be removed; and protected instruments and equipment shall be reconnected. With equipment items protected, the system shall be pressurized to test pressure. Pressure shall be held for a period of time sufficient to inspect all welds, joints, and connections for leaks, but not less than 2 hours. No loss of pressure will be allowed. Leaks shall be repaired and repaired joints shall be retested.

c. Repair joints shall not be allowed under the floor for floor radiant heating systems. If a leak occurs in tubing located under the floor in radiant heating systems, the entire zone that is leaking shall be replaced. If any repair is made above the floor for floor radiant heating systems, access shall be provided for the installed joint. Caulking of joints shall not be permitted.

d. System shall be drained and after instruments and equipment are reconnected, the system shall be refilled with service medium and maximum operating pressure applied. The pressure shall be held while inspecting these joints and connections for leaks. The leaks shall be repaired and the repaired joints retested.

Upon completion of hydrostatic tests and before acceptance of the installation, submit test reports for the heating system tests. Upon completion of testing complete with results, balance the heating system in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and operating tests required to demonstrate satisfactory functional and operational efficiency. The operating test shall cover a period of at least 24 hours for each system, and shall include, as a minimum, the following specific information in a report, together with conclusions as to the adequacy of the system:

a. Certification of balancing.

b. Time, date, and duration of test.

c. Outside and inside dry bulb temperatures.

d. [Temperature of hot water supply leaving boiler] [Steam pressure].

e. Temperature of [heating return water from system at] [condensate feed to] boiler inlet.

f. Quantity of water feed to boiler.

g. Boiler make, type, serial number, design pressure, and rated capacity.

h. Fuel burner make, model, and rated capacity; ammeter and voltmeter readings for burner motor.

i. [Circulating] [Condensate] [Vacuum] pump make, model, and rated capacity, and ammeter and voltmeter readings for pump motor during operation.

j. Flue-gas temperature at boiler outlet.

k. Percent carbon dioxide in flue-gas.

l. Grade or type and calorific value of fuel.

m. Draft at boiler flue-gas exit.

n. Draft or pressure in furnace.

o. Quantity of water circulated.

p. Quantity of fuel consumed.

q. Stack emission pollutants concentration.

Indicating instruments shall be read at half-hour intervals unless otherwise directed. Furnish all instruments, equipment, and personnel required for the tests and balancing. Obtain necessary natural gas, water and electricity as specified in the [SPECIAL CONTRACT REQUIREMENTS][Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS] Provide necessary quantities of propane gas or No. [_____] fuel oil when propane gas or fuel oil is require for testing. Operating tests shall demonstrate that fuel burners and combustion and safety controls meet the requirements of [ASME CSD-1] [ANSI Z21.13/CSA 4.9] [NFPA 85]

3.10.1 Water Treatment Testing

The boiler water shall be analyzed [prior to the acceptance of the facility] [a minimum of once a month for a period of 1 year] by the water treatment company. Submit a water quality test report identifying the chemical composition of the boiler water. The report shall include a comparison of the condition of the boiler water with the manufacturer's recommended conditions. Any required corrective action shall be documented within the report. The test report shall identify the condition of the boiler at the completion of 1 year of service. The report shall include a comparison of the condition of the boiler with the manufacturer's recommended operating conditions. The analysis shall include the following information recorded in accordance with ASTM D596.

Date of Sample	[_____]
Temperature	[_____] degrees F
Silica (SiO2)	[_____] ppm (mg/1)
Insoluble	[_____] ppm (mg/1)
Iron and Aluminum Oxides	[_____] ppm (mg/1)
Calcium (Ca)	[_____] ppm (mg/1)
Magnesium (Mg)	[_____] ppm (mg/1)
Sodium and Potassium (Na and K)	[_____] ppm (mg/1)
Carbonate (HCO3)	[_____] ppm (mg/1)
Sulfate (SO4)	[_____] ppm (mg/1)
Chloride (C1)	[_____] ppm (mg/1)
Nitrate (NO3)	[_____] ppm (mg/1)
Turbidity	[_____] ntu
pH	[_____]
Residual Chlorine	[_____] ppm (mg/1)

Total Alkalinity	[_____] epm (meq/1)
Noncarbonate Hardness	[_____] epm (meq/1)
Total Hardness	[_____] epm (meq/1)
Dissolved Solids	[_____] ppm (mg/1)
Fluorine	[_____] ppm (mg/1)
Conductivity	[_____] micro-mho/cm

If the boiler water is not in conformance with the boiler manufacturer's recommendations, the water treatment company shall take corrective action.

3.10.2 Boiler/Piping Test

At the conclusion of the 1 year period, the boiler and condensate piping shall be inspected for problems due to corrosion and scale. If the boiler is found not to conform to the manufacturer's recommendations, and the water treatment company recommendations have been followed, the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations. If corrosion is found within the condensate piping, proper repairs shall be made by the water treatment company.

3.11 CLEANING

3.11.1 Boilers and Piping

After the hydrostatic tests have been made and before the system is balanced and operating tests are performed, the boilers and piping shall be thoroughly cleaned by filling the system with a solution consisting of either 1 pound of caustic soda or 1 pound of trisodium phosphate per 50 gallons of water. The proper safety precautions shall be observed in the handling and use of these chemicals. The water shall be heated to approximately 150 degrees F and the solution circulated in the system for a period of 48 hours. The system shall then be drained and thoroughly flushed out with fresh water. Strainers and valves shall be thoroughly cleaned. Prior to operating tests, air shall be removed from all water systems by operating the air vents.

3.11.2 Heating Units

Inside space heating equipment, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for fans that are operated during construction, and new provide filters after construction dirt has been removed from the building, and the ducts, plenum, casings, and other items specified have been vacuum cleaned. Perform and document that proper "Indoor Air Quality During Construction" procedures have been followed; provide documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.12 FIELD TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of [_____] hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests.

a. The field instructions shall cover all of the items contained in the approved operation and maintenance manuals, as well as demonstrations of routine maintenance operations and boiler safety devices.

b. Submit system layout diagrams that show the layout of equipment, piping, and ductwork and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system, framed under glass or laminated plastic, at least 2 weeks prior to the start of related testing. After approval, these items shall be posted where directed.

c. Submit [six] [_____] complete operation and maintenance instructions listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, simplified wiring and control diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization shall be capable of providing [4] [_____] hour onsite response to a service call on an emergency basis.

d. Notify the Contracting Officer at least 14 days prior to date of proposed conduction of the training course.

3.13 FUEL SYSTEM TESTS

Submit test reports for the fuel system tests, upon completion of testing complete with results.

3.13.1 Fuel Oil System Test

The fuel oil system shall be tested in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

3.13.2 Gas System Test

The gas fuel system shall be tested in accordance with the test procedures outlined in NFPA 54.

-- End of Section --

SECTION 23 54 19

BUILDING HEATING SYSTEMS, WARM AIR
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 430	(2009) Central-Station Air-Handling Units
AHRI 640	(2017) Performance Rating of Commercial and Industrial Humidifiers

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 611	(2014) Voluntary Specification for Anodized Architectural Aluminum

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.47/CSA 2.3	(2021) Gas-Fired Central Furnaces
ANSI Z21.66/CGA 6.14	(2015; R 2020) Automatic Vent Damper Devices for Use with Gas-Fired Appliances
ANSI Z83.4/CSA 3.7	(2017) Non-Recirculating Direct Gas-Fired Heating and Forced Ventilation Appliances for Commercial and Industrial Application
ANSI Z83.8/CSA 2.6	(2016; R 2021) Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and

Gas-Fired Duct Furnaces

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ASTM INTERNATIONAL (ASTM)

ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A269/A269M	(2015; R 2019) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

CSA GROUP (CSA)

CSA Directory	(updated continuously online) Product Index

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code
ICC IMC	(2018) International Mechanical Code
ICC IPC	(2018) International Plumbing Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA DC 3	(2013) Residential Controls - Electrical Wall-Mounted Room Thermostats
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2020) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2021) National Fuel Gas Code
NFPA 58	(2020; TIA 20-1; TIA 20-2; TIA 20-3) Liquefied Petroleum Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2021) Standard for the Installation of Warm Air Heating and Air Conditioning Systems
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

UNDERWRITERS LABORATORIES (UL)

UL 296	(2017; Reprint Jan 2021) UL Standard for Safety Oil Burners
UL 441	(2016; Reprint Jul 2016) UL Standard for SafetyGas Vents
UL 499	(2014; Reprint Jun 2022) UL Standard for Safety Electric Heating Appliances
UL 641	(2010; Reprint Apr 2018) UL Standard for Safety Type L Low-Temperature Venting Systems
UL 727	(2018) UL Standard for Safety Oil-Fired Central Furnaces
UL 900	(2015) Standard for Air Filter Units
UL 1738	(2020; Reprint Aug 2021) UL Standard for SafetyVenting Systems for Gas-Burning

	Appliances, Categories II, III and IV
UL 1995	(2015) UL Standard for Safety Heating and Cooling Equipment

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit data packages in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor Qualifications; G[, [_____]]

SD-02 Shop Drawings

Equipment Layouts

SD-03 Product Data

Self-Contained Furnaces; G[, [_____]]

[Energy Star Label for Residential Gas Fired Furnace Product; S

][Energy Star Label for Residential Oil-Fired Furnace Product; S

] Vent Connections; G[, [_____]]

Controls; G[, [_____]]

Dampers; G[, [_____]]

Air Filters; G[, [_____]]

Humidifiers; G[, [_____]]

Duct Furnace; G[, [_____]]

[Heating and Ventilating Units; G[, [_____]]

][Heating Only Makeup Air Units; G[, [_____]]

] System Diagrams; G[, [_____]]

SD-06 Test Reports

Field Acceptance Test Plans and Test Reports; G[, [_____]]

Field Acceptance Testing; G[, [_____]]

Test Reports; G[, [_____]]

SD-08 Manufacturer's Instructions

Self-Contained Furnaces - Installation Instructions; G[, [_____]]

Vent Connections - Installation Instructions; G[, [_____]]

Controls - Installation Instructions; G[, [_____]]

Dampers - Installation Instructions; G[, [_____]]

Air Filters - Installation Instructions; G[, [_____]]

Humidifiers - Installation Instructions; G[, [_____]]

Duct Furnace - Installation Instructions; G[, [_____]]

[Heating and Ventilating Units - Installation Instructions; G[, [_____]]

][Heating Only Makeup Air Units - Installation Instructions; G[, [_____]]

] SD-10 Operation and Maintenance Data

Self-Contained Furnaces, Data Package 3; G[, [_____]]

Vent Connections, Data Package 3; G[, [_____]]

Controls, Data Package 3; G[, [_____]]

Dampers, Data Package 3; G[, [_____]]

Humidifiers, Data Package 3; G[, [_____]]

[Duct Furnace, Data Package 3; ; G[, [_____]]

][Heating and Ventilating Units, Data Package 3; G[, [_____]]

][Heating Only Makeup Air Units, Data Package 3; G[, [_____]]

] SD-11 Closeout Submittals

Field Training

Indoor Air Quality During Construction; S

1.3 QUALITY CONTROL

1.3.1 Installing Contractor Qualifications

Submit contractor qualifications demonstrating successful completion of similar services by the mechanical contractor on at least five projects of similar award amount and scope with equipment submittal.

1.3.2 Service Contractor Qualifications

The submitted equipment must be supported by manufacturer-approved service organization[s]. Provide service organization names and locations along with the Operation and Maintenance submittal. The service organization[s] must have an office within [_____][50][100] miles of the site with factory certified technicians, spare parts inventory and all necessary test and diagnostic equipment for the installed system. The service organization must be able to render service to the equipment on both a regular and emergency basis during the warranty period of the contract as determined by the Contracting Officer.

Spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than [_____] months prior to the date of beneficial occupancy. The data must include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 12 months operation, and a list of the parts recommended by the manufacturer to be replaced after [1][and][3] year(s) of service.

1.3.3 Modification to Reference

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.3.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions must be considered mandatory, the word "should" is interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." For government owned property, references to the "owner" must be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" must be interpreted to mean the "lessor." References to the "permit holder" must be interpreted to mean the "Contractor."

1.3.3.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.3.4 Equipment Layouts

Submit Equipment Layouts showing equipment assembly and installation details with electrical, ductwork layout, supports, utility connections, and details. Include any information required to demonstrate that the system has been coordinated and functions properly as designed.

1.3.5 System Diagrams

Proposed system diagrams, must be submitted, approved and posted prior to start of related testing. System diagrams that show the layout of equipment and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system must be framed under glass or laminated plastic. After approval, these items must be posted where directed.

1.4 DELIVERY STORAGE AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 ACCESSIBILITY

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors. Access door must be adequately sized for removal and replacement. Installation must provide both manufacturer and code required clearances.

PART 2 PRODUCTS

Provide warm air heating system, including equipment, equipment, materials, installation, workmanship, fabrication, assembly, erection, inspection, examination, and testing in accordance with the applicable requirements contained in ICC IBC, ICC IMC, ICC IPC, NFPA 90A or NFPA 90B, and [NFPA 31][NFPA 54] [NFPA 58] as modified and supplemented by this specification section and accompanying drawings.

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate equipment that has been in satisfactory use at least [1][_____] year[s] prior to bid opening.

2.1.2 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products and materials must have a local supplier within [_____][50][100] miles of the site. Standard products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

2.1.3 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

2.1.4 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. As applicable, affix an Energy Star label to the product.

2.1.5 Bearings

Motor bearings must be fitted with grease supply fittings and grease relief to outside of the enclosure.

2.2 ELECTRICAL WORK

Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

2.2.1 Motors

a. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Provide premium efficiency type integral size motors in accordance with NEMA MG 1.

b. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.

c. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered interval between start and stop. Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.

d. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

2.3 AIR SYSTEMS EQUIPMENT

2.3.1 Ductwork and Accessories

Ductwork and accessories must be as specified in Section 23 30 00 HVAC AIR DISTRIBUTION.

2.3.2 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans must not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly. Indirectly connected motors must use V-belt drives designed for not less than [150][140][120] percent of the connected driving capacity. Provide variable pitch motor sheaves for 15 hp and below, and fixed pitch as defined by AHRI Guideline D (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated.

2.3.3 Air Filters

Air Filters must be listed in accordance with requirements of UL 900.

2.3.4 Replaceable Media Filters

The air flow capacity of the filter must be based on net filter face velocity not exceeding [300][_____] feet per minute, with initial resistance of [0.13][_____] inches water gauge. Minimum Efficiency Reporting Value (MERV) must be not less than [_____] when tested according to ASHRAE 52.2.

2.4 GAS-FIRED COMPONENTS

2.4.1 Gas-Burning Components

Gas-burning equipment must include the gas burners, ignition equipment, gas-control valve, gas piping, gas-pressure regulating valve, when applicable, and accessories necessary for a fully automatic system that is listed in CSA Directory. Gas-fired units equipped with programming controls must be furnished both with high and with low gas supply pressure switches in the fuel supply piping.[Provide Energy Star labeled equipment for high efficiency furnaces installed in residential applications (input less than 225 MBtuh). Provide proof of Energy Star label for residential gas fired furnace product.]

2.4.2 Gas Burners

The gas burners must include ignition equipment, gas-control valve, gas piping, gas-pressure regulating valve, gas shut-off cocks,[combustion air blower,] when applicable, and accessories necessary for a fully automatic system that conforms to ANSI Z21.47/CSA 2.3 and NFPA 54.

Do not provide manually ignited type burners. Burners must always return to low fire for ignition. Provide control system for [on-off][high-low-off][modulated]operation. Provide interrupted type ignition systems for burners with input capacities over 400,000 Btu's per hour.

2.4.3 Ignition System

Ignition systems must be of the [direct spark][hot surface][or][interrupted intermittent]type with automatic electric ignition. The pilots must be of the electrically-ignited proven type. Continuous pilots will not be permitted. Burner must be designed in accordance with NFPA 54 and located so that parts are protected against overheating. Provisions must be made in the burner housing for inspection of the pilot flame.

2.4.4 Fuel-Gas Supply System

Fuel-gas supply system must be as specified in Section 23 11 20 FACILITY GAS PIPING.

2.5 OIL-BURNING COMPONENTS

2.5.1 Oil-Burning Components

The equipment must include the oil burner motor, ignition equipment safety devices, and accessories necessary for a full automatic system that conforms to UL 296. Oil-fired units equipped with programming controls must be furnished with low oil-pressure switches in the fuel supply piping. Oil-fired units not equipped with programming controls must be equipped with a delayed opening or shutoff valve. The valve must automatically delay delivery of oil to the burner until such time as the combustion air fan and, when applicable, the induced draft fan are operated at rated speed.[Provide Energy Star labeled equipment for high efficiency furnaces installed in residential applications (input less than 225 MBtuh). Provide proof of Energy Star label for residential oil burning furnace product.]

2.5.2 Ignition System

Ignition systems for oil-fired units must be of the [direct-electrical spark type][or][interrupted type]in accordance with UL 296.

2.5.3 Fuel-Oil Systems

Fuel oil systems must conform to Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.6 VENT CONNECTIONS

Flue vent connections must be furnished as indicated. Provide a[draft regulator of the barometric-type for oil-fired draft control][draft hood for atmospheric gas-fired draft control]. Flue vent connections, including pipe and fittings, must conform to NFPA 211 and must be galvanized sheet steel having a nominal thickness not less than that required by NFPA 211. The weight of zinc-coating must not be less than 1.25 ounces per square foot commercial. If the standard flue connection on the furnace is other than the size specified for the furnace pipe, provide a suitable adapter. Provide suitable cleanouts to permit cleaning of the entire flue connection without dismantling.[Provide a resilient mount induced draft fan with an integral sail switch to sense flow, in the exhaust system.][Provide double-wall metal chimneys.]

A 0.3125 inch diameter hole must be provided in the vent stack not greater than 6 inches from the furnace flue outlet for sampling of the exit gases. A method must be provided to seal the hole to prevent exhaust gases from entering the indoor space when samples are not being taken. Each exhaust stack must be provided complete with bird screen and rain hood.

2.6.1 Gas-Fired Units

Vent piping must be in accordance with UL 441,[Type B][Type BW]. Vent must conform to NFPA 211 and NFPA 54. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are unacceptable for vent piping of combustion gases.

2.6.2 Oil-Fired Units

Vent piping must be in accordance with UL 641, Type L. Vent must conform to NFPA 211. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are unacceptable for vent piping of combustion gases.

2.6.3 Vents for High Efficiency Furnaces

Direct venting must be used for condensing type furnaces. Both the air intake and exhaust vents must be sized and located as indicated on the drawings and as recommended by the furnace manufacturer. A separate combustion air intake vent and exhaust must be provided for each furnace. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are unacceptable for vent piping of combustion gases.

2.6.3.1 Combustion Air Intake Vent

The combustion air intake piping must be constructed of Schedule 40 PVC in accordance with ASTM D1784. The vent must be suitable for the temperature at the furnace combustion air intake connection point. Each intake must be provided complete with bird screen[and rain hood].

2.6.3.2 Exhaust Vent

The exhaust vent piping must be constructed of Schedule 40 CPVC or stainless steel in accordance with UL 1738 and the furnace manufacturer's recommendations. The exhaust vent must be suitable for the maximum anticipated furnace exhaust temperature and must withstand the corrosive effects of the condensate.

2.6.4 Automatic Vent Dampers

Automatic vent dampers must be provided in the vents of all gas burning equipment that uses indoor air for combustion. Vent dampers must conform to ANSI Z21.66/CGA 6.14.

2.6.5 Condensate Neutralization Kit

Factory-supplied condensate trap[with condensate trip sensor], high capacity condensate receiver prefilled with appropriate medium.

2.7 CONTROLS

2.7.1 Thermostat

Provide wall mounted, low voltage type conforming to NEMA DC 3 with an operating range from 55 to 90 degrees F. Housing must have [concealed setpoint dials][, covers with allen head screws][, aspirator type wall box with flushplate and locking screws][, built-in concealed thermometers][, exposed adjustment covers with visible thermometers].[Provide clear, lockable with key thermostat cover.] The mounting plate or base must be made of thermal insulating material or must support the thermal element not less than 1/4 inch from the wall. The control unit of the thermostat must consist of a temperature sensing element, control switch, and anticipating heater. The control switch must be a hermetically-sealed switch. Thermostat must have provisions for calibrating the unit to the accuracy specified in NEMA DC 3. The design must preclude calibration adjustment with ordinary tools, such as screwdriver or pliers. Unless otherwise specified, a system selector switch having "heat" and "off" positions, and a fan selector switch having "auto" and "on" positions must be provided integral to or mounted on a sub-base of the thermostat. Mercury must not be allowed in switches and thermometers.

2.7.2 Carbon Monoxide Detection

Provide Carbon Monoxide Detector(s) and monitoring system for all installations.

Carbon monoxide detection systems must conform to Sections 28 31 60 INTERIOR FIRE ALARM SYSTEM, NON-ADDRESSABLE, 28 31 66 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, NON-ADDRESSABLE, 28 31 70 INTERIOR FIRE ALARM SYSTEM, ADDRESSABLE, and 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE.

[2.7.3 OPTIONAL CONTROLS

On units with input capacities over 400,000 Btu/hr, [electronic][electrical] controls may be provided for regulation of temperature and operation of power operators.

]2.7.4 Cybersecurity

Control systems must conform to Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.8 SELF CONTAINED FURNACES

Provide manufacturer's standard, self-contained, indirect, [oil][and][gas]-fired, forced-air, furnaces conforming to[UL 727][ANSI Z21.47/CSA 2.3]. Furnace and furnace components must be completely factory-assembled and must consist of a[n] [aluminized][stainless] steel heat exchanger; burner; centrifugal blower, a sheet metal cabinet-type casing with provisions for duct, vibration isolators, and all required operating, limit, and safety controls. Furnace casing must be [galvanized sheet steel with factory painting as specified in paragraph FACTORY PAINTING][or][corrosion-resisting sheet steel conforming to ASTM A167, type 316][or][aluminum with factory painting as specified in paragraph FACTORY PAINTING]. Dissimilar materials must be separated by appropriate means to avoid creation of galvanic cells. Furnace casing must be factory insulated and be compatible with the operating temperatures. Furnace must be provided with removable service panels which allow access to all internal components requiring cleaning, servicing, or adjustment. Provide a 24 volt control transformers, high temperature limit, and fan time delay relay.

Provide [upflow, high-boy][upflow, low-boy][downflow][horizontal flow][duct mounted]style designed to supply heated air through a duct system.[Provide cooling evaporator coil module with cabinet suitable for use with furnace.]

2.8.1 Gas-Fired Unit

Gas-fired furnace must be the [conventional][high efficiency, condensing]type in accordance with ANSI Z21.47/CSA 2.3. Furnace design must be certified by the AMERICAN GAS ASSOCIATION LABORATORIES (AGA). Furnace must have a minimum certified Annual Fuel Utilization Efficiency (AFUE) of [_____] percent . Furnace must be suitable for burning [natural][propane]gas ([_____] Btu's per cubic foot), [combination [natural][propane]gas ([_____] Btu's per cubic foot)][and [light oil (Grade 2)]].[Provide Energy Star labeled equipment for high efficiency furnaces installed in residential applications (input less than 225 MBtuh). Provide proof of Energy Star label for residential gas fired furnace product.]

2.8.2 Oil-Fired Unit

Oil-fired furnace must be in accordance with UL 727 and have a minimum certified Annual Fuel Utilization Efficiency (AFUE) of [_____] percent. Equipment must be suitable for burning [[No. 2][No. 4] oil][,][combination [natural][propane] gas ([_____] Btu's per cubic foot) [and [No. 2][No. 4] oil]].[Provide Energy Star labeled equipment for high efficiency furnaces installed in residential applications (input less than 65.9 kW 225 MBtuh). Provide proof of Energy Star label for residential oil-fired furnace product.]

2.9 HUMIDIFIERS

2.9.1 Steam Spray Type

Steam spray humidifiers must be AHRI 640 rated, ARI labeled, and must inject steam directly into the [surrounding air][or][air stream] as indicated.[Single grid humidifiers must consist of a stainless steel distribution grid with pipe connection on one end and cap on the other end. Automatic steam control valves and condensate traps must be field-installed.][Enclosed grid must be housed in a copper enclosure with a build-in condensate drain connection. Exposed grid must be wick wrapped.][Package type steam spray humidifiers must be equipped to trap out and to re-evaporate condensate and to supply dry steam to a single distribution grid. Grid must be steam jacketed and condensate drained. Unit must trap excess condensate to return system. Package type steam spray humidifiers must have modulating electric, electronic, or pneumatic steam control valve, as indicated.] Unit must have internal drain water tempering to 140 degrees F. Steam spray humidifiers must be rated for humidifying capacity in pounds of steam per hour and at steam pressure as indicated.

2.9.2 Steam Diffuser Type

Diffuser units must be of a design that will separate any condensate from steam supply and provide positive drain of condensate to waste and supply dry steam only to air stream. Humidifiers may be installed on single or multiple units. All materials must be[noncorrosive materials][Type 300 stainless steel].

[2.9.3 Ultrasonic Type

Humidifiers must be AHRI 640 rated and ARI labeled and be of the ultrasonic type permitted herein, and of the manufacturer's standard catalog product. The ultrasonic type must introduce moisture into the air stream in the form of 1 micron water droplets. The ultrasonic unit must be installed in the ductwork. The humidifiers must consume less than 100 btu per lb/hr of water introduced to the air stream. Water with a total dissolved solids level of less than 5 ppm must be supplied to the humidifier. The piezoelectric transducers must be capable of a minimum of 10,000 hours of continuous operation. Provide a manual on-off switch [remotely located][or][integral with the humidifier]. Unit must have an internal solenoid valve for drain command from the internal controller and must automatically drain if the humidifier is idle for 72 hours. Humidifier must be designed for easy maintenance and must not require removing or disconnecting sheet metal duct work for ordinary cleaning and service procedure. Humidistat must be furnished by the humidifier manufacturer and must be factory calibrated in percent relative humidity.

]2.9.4 Electrode Steam Humidifier

Provide steam electrode humidifiers to generate steam from potable water. Unit must utilize an electrode steam cylinder. The cylinder must be replaceable assembly that complies with UL 499. Unit cabinet must be sheet metal enclosure with baked enamel finish and must be hinged or feature a removable access door. The cabinet must feature integral control panel. Unit must have internal drain water tempering to 140 degrees F and a drain pump system complete with integral pump discharge check valve, integral float switch, reservoir, and pump motor assembly. Provide unit with supply domestic water backflow preventer.

2.9.4.1 Unit Mounted Distribution Manifold

Provide unit mounted manifold with integral fan to discharge vapor directly into occupied space.

2.9.4.2 Remote Mount Blower Pack

Provide remote mount blower pack with integral fan to discharge vapor directly into occupied space. Steam must be constructed of 316 stainless steel. The steam line must have a constant slope (minimum upslope of 10 degrees or minimum downslope of 2 degrees), and have no restrictions in the line.

2.9.5 Gas Fired Steam Humidifier

Provide natural gas-fired humidifier to generate steam from potable water. Unit cabinet must be sheet metal enclosure with baked enamel finish and must be hinged or feature a removable access door. Insulated humidifier tank must ensure safe surface temperature. The cabinet must feature integral control panel. Unit must feature at Category IV sealed combustion condensing appliance featuring a stainless steel combustion chamber/heat exchanger. The burner must be capable of no less than 5:1 modulation with an overall efficiency of 90 percent. Humidifier is to feature variable speed blower, modulating gas valve, precision water fill and is to have internal safeties. Unit must have internal drain water tempering to 140 degrees F[and a drain pump system complete with integral pump discharge check valve, integral float switch, reservoir, and pump motor assembly]. Provide unit with supply domestic water backflow preventer.

2.9.5.1 Duct Mounted Manifold

Provide remote duct mounted stainless steel humidifier manifold. Distributor must be sized to have a maximum absorption length of ten feet. Provide type 316 stainless steel tubing and fittings for steam and steam condensate in accordance ASTM A269/A269M. Pipe must be suitable for 150 percent of humidifier steam pressure and temperature. Pipe insulation must be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Installation of steam and steam condensate between humidifier and manifold in accordance with manufacturer's requirements. Unit installation and venting must comply with NFPA 54. Intake air and flue vent must be per paragraph VENT CONNECTIONS and must be stainless steel. Intake and flue must be installed per humidifier manufacturers recommendations.

2.9.6 Operation

Humidifier must be controlled by a manually adjustable humidistat[located in occupied spaces][with sensing bulb in[return][supply]]. Humidifier must operate when the furnace operates.

2.10 DUCT FURNACE

Duct furnace must be in accordance with ANSI Z83.8/CSA 2.6. Furnace must be [power][gravity]-vented type. Furnace must have automatic ignition. Furnace must employ metered combustion air with enclosed draft diverter (no open flue collar). Furnace heat exchangers must be [aluminized steel][or][stainless steel]. Furnace must have minimum steady state thermal efficiency of 80 percent at maximum rated capacity and 75 percent at minimum rated capacity that is provided and allowed by the controls. Furnace must be provided with a [space][discharge air] thermostat which controls the unit's burner.

2.11 [HEATING AND VENTILATING UNITS][HEATING ONLY MAKEUP AIR UNITS]

Units must be equipped for and adjusted to burn [natural][liquified petroleum][dual fuel natural/liquified petroleum] gas. Each heater must be provided with a gas pressure regulator that will satisfactorily limit the main gas burner supply pressure. Heaters must have an intermittent or interrupted electrically ignited pilot or a direct electric ignition system. Safety controls must conform to the ANSI standard specified for each heater. Mounting brackets and hardware must be furnished by the heater manufacturer and must be factory finished to match the supported equipment.

[Provide [single-zone draw-through type][or][single-zone blow-through type][or]units as indicated. Units must include fan(s), coils, airtight insulated casing,[prefilters,][secondary filter sections,][and][diffuser sections where indicated,][air blender,][adjustable V-belt drives, belt guards for externally mounted motors,][directly driven motors,] access sections where indicated,[mixing box,][combination sectional filter-mixing box,][[pan][drysteam][spray type] humidifier,] vibration-isolators, and appurtenances required for specified operation . Provide vibration isolators as indicated. Physical dimensions of each air handling unit must be suitable to fit space allotted to the unit with the capacity indicated. Provide unit that is rated in accordance with AHRI 430.

]2.11.1 [Direct Fired Heating and Ventilating Units][Heating Only Makeup Air Units]

Units must be in accordance with ANSI Z83.4/CSA 3.7. Direct fired [heating and ventilating units][heating only makeup air units] use outdoor air[and return air] directly ducted to the heater. The products of combustion generated by the heater are released into the air stream being heated. Heaters must be equipped with[motorized [inlet][, return][and][outlet]][backdraft] dampers,[discharge air diffuser,][duct collar,][air filters,][mixing box][and][bird screen]. Gas control valve must be [single-stage][two stage][modulating] type. Maximum air temperature rise during minimum burner fire must be 5 degrees F. Fan must be [single-speed][two speed, with low speed approximately two-thirds of high speed][variable speed]. Motorized [inlet][and][outlet] dampers must be closed when the unit is shut down. Dampers must be interlocked to prevent burner operation when dampers are closed. Heaters must be provided with a [space][discharge air] thermostat, a low limit air stream thermostat, and an ambient air thermostat. The [space][discharge air] thermostat must control the gas control valve. The low limit air stream thermostat must shut down the entire unit if the discharge air temperature drops below the [space][discharge] thermostat setting. The ambient air thermostat must shut down the burner if the outdoor air exceeds the [discharge][space] thermostat setting.

2.11.2 Indirect Fired [Heating and Ventilating Units][Heating Only Makeup Air Units]

Units must be in accordance with ANSI and CSA Standards. Indirect fired [heating and ventilating units][heating only makeup air units] use heat exchanger to isolate products of combustion generated by the heaters from the air stream being heated. Heaters must be equipped with[motorized [inlet,] [return,][and][outlet]] [backdraft] dampers,[discharge air diffuser,][duct collar,][air filters,][mixing box,][and][bird screen]. Gas control valve must be [single-stage][two stage][modulating] type. Maximum air temperature rise during minimum burner fire must be 5 degrees F. Fan must be [single-speed][two speed, with low speed approximately two-thirds of high speed][variable speed]. Motorized [inlet][and][outlet] dampers must be closed when the unit is shut down. Dampers must be interlocked to prevent burner operation when dampers are closed. Heaters must be provided with a [space][discharge air] thermostat, a low limit air stream thermostat, and an ambient air thermostat. The [space][discharge air] thermostat must control the gas control valve. The low limit air stream thermostat must shut down the entire unit if the discharge air temperature drops below the [space][discharge] thermostat setting. The ambient air thermostat must shut down the burner if the outdoor air exceeds the [discharge][space] thermostat setting.

2.11.3 Coils

Provide fin-and-tube type coils constructed of seamless [copper][red brass] tubes and [aluminum][or][copper] fins mechanically bonded or soldered to the tubes.[Provide copper tube wall thickness that is a minimum of [0.016][0.020][0.024] inches.][Provide red brass tube wall thickness that is a minimum of [0.035] [0.049] inches.][Provide aluminum fins that are [0.0055][0.0075] inch minimum thickness.][Provide copper fins that are 0.0045 inch minimum thickness.] Provide casing and tube support sheets that are not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Mount coils for counterflow service. Rate and certify coils to meet the requirements of AHRI 410.[Provide factory applied phenolic, vinyl, or epoxy/electrodeposition coating uniformly applied to all coil surfaces without material bridging between fins. Provide complete coil encapsulation and a uniform dry film thickness of 0.8 - 1.2 mils on all surface areas including fin edges. Coating must have a corrosion durability through testing of no less than 5000 hours salt spray per ASTM B117.]

2.11.3.1 Water Coils

Install water coils with a pitch of not less than 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans. Pressure test coils in accordance with UL 1995.

2.11.3.2 Steam Heating Coils

Construct steam coils from cast semisteel, welded steel or copper headers, and [red brass][copper] tubes. Construct headers from cast iron, welded steel or copper. Provide fin tube and header section that float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide each coil with a field or factory installed vacuum breaker. Provide single-tube type coils with tubes not less than 1/2 inch outside diameter, except for steam preheat coils. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent. Pressure test coils in accordance with UL 1995.

2.11.3.3 Electric Heating Coil

Provide an electric duct heater coil in accordance with UL 1995 and NFPA 70. Provide duct- or unit-mounted coil. Provide [nickel chromium resistor, single stage, strip][nickel chromium resistor, single stage, strip or stainless steel, fin tubular] type coil. Provide coil with a built-in or surface-mounted high-limit thermostat interlocked electrically so that the coil cannot be energized unless the fan is energized. Provide galvanized steel or aluminum coil casing and support brackets. Mount coil to eliminate noise from expansion and contraction and for complete accessibility for service.

2.11.4 Unit Casing

Casing must be insulated [single][double] wall panels constructed of minimum 18-gage [galvanized sheet steel with factory painting as specified in paragraph FACTORY PAINTING][or][corrosion-resisting sheet steel conforming to ASTM A167, type 316][or][aluminum with factory painting as specified in paragraph FACTORY PAINTING]. Reinforce casing with [angles][a formed structural metal frame] and provided with easily removable panels located for access to all parts of the equipment. Ensure that the casing and insulation are designed to limit noise and vibration within acceptable levels. Outdoor heaters must be weatherized. Dissimilar materials must be separated by appropriate means to avoid creation of galvanic cells.

2.11.5 Fans

Fan must be [centrifugal][airfoil][backward curve][mixed flow][plenum] type. Statically and dynamically balance fan and motor. Fan ratings are to be determined in accordance with AMCA 210. Motor must be heavy-duty, permanently lubricated type with [belt-drive][direct-drive]. Provide fan assembly with internal vibration isolation.

2.12 FACTORY PAINTING

Equipment painting must be factory or shop applied, and must be as specified herein, and provided under each individual section.

2.12.1 Factory Painting of Indoor Equipment

Indoor Equipment must be coated with a manufacturer's factory-applied finish that meets the following requirements:

a. The finish system designed for the equipment must have been tested in accordance with Federal Test Method Standard No. 141 (Method 6061) and passed the 125-hour salt-spray fog test of that standard. The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the successful test specimens.

b. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to working temperatures above 120 degrees F, the factory painting system must be designed for service at the finished surface's working temperature and must meet the test requirements specified above for Federal Test Method Standard No. 141 when the finished surface temperature is at the service working temperature.

[2.12.2 Factory Painting of Outdoor Equipment

Outdoor equipment must be coated with a manufacturer's factory-applied finish that meets the following requirements:

a. The finish system designed for the equipment must have been tested in accordance with Federal Test Method Standard No. 141 (Method 6061) and passed the 500-hour salt-spray fog test of that standard. The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the successful test specimens.

b. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to working temperatures above 120 degrees F, the factory painting system must be designed for service at the finished surface's working temperature and must meet the test requirements specified above for Federal Test Method Standard No. 141 when the finished surface temperature is at the service working temperature.

][2.12.3 Factory Painting of Exterior Equipment in Corrosion Prone Locations

a. Galvanized Steel: Provide three-part coating system Epoxy Primer / Waterborne Light Industrial Coating as specified in Section 09 90 00 PAINTS AND COATINGS.

b. Type 316 or Duplex Stainless Steel: No requirement for factory painting.

c. Aluminum: Provide either coating or anodized finish that meets the following requirements:

(1) Coating Provide three-part coating system Waterborne Light Industrial Coating as specified in Section 09 90 00 PAINTS AND COATINGS.

(2) Anodized finish: Clean exposed aluminum surfaces and provide an anodized finish conforming to AA DAF45 and AAMA 611. Finish must be Architectural Class I (0.7 mil or thicker), designation AA-M10-C22-[A41, clear (natural)][A42, integral color][A44, electrolytically deposited color] anodized.

]2.12.4 Shop Applied Painting of Equipment

Shop applied painting must meet same requirements as factory painting. Field retouch only if approved by the Contracting Officer. Otherwise, return equipment to the factory for refinishing.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

The warm air heating system installation must be in accordance with the manufacturer's written instructions and be in compliance with the requirements contained in ICC IBC, ICC IMC, ICC IPC, NFPA 90A or NFPA 90B, and[NFPA 31][NFPA 54][NFPA 58].

Combustion air supply and ventilation must be in accordance with[NFPA 31][NFPA 54][NFPA 58]. Systems and equipment include:

a. Self-contained furnaces - Installation Instructions

[b. Vent connections - Installation Instructions

][c. Controls - Installation Instructions

][d. Dampers - Installation Instructions

][e. Air filters - Installation Instructions

][f. Humidifiers - Installation Instructions

][g. Duct Furnace - Installation Instructions

][h. Heating and Ventilating Units - Installation Instructions

][i. Heating Only Makeup Air Units - Installation Instructions

][3.2.1 Seismic

[Provide vibration isolation, seismic bracing and sound data as specified in Sections 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL and 23 05 48.19 [SEISMIC] BRACING FOR HVAC.][Provide seismic bracing as specified in Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC.]

][3.2.2 Anti-Terrorism

Provide outdoor air intakes, relief air, and exhaust openings with low leakage dampers that are automatically closed when the emergency air distribution shutoff switch is activated. Exterior wall penetrations for outdoor air intakes must be a minimum of 10 feet above grade. Emergency air distribution shutoff switches must clearly labeled and located in an accessible location. Switch must be mushroom type pushbutton with plastic clear cover.[If shutting down an exhaust system will violate building or fire codes or create an unsafe condition, then the exhaust system may continue to operate.]

Mount all overhead utilities and other fixtures weighing 31 pounds or more (excluding distributed systems such as piping networks that collectively exceed that weight) using either rigid or flexible systems to minimize the likelihood that they will fall and injure building occupants. Design all equipment mountings to resist forces of 0.5 times the equipment weight in any horizontal direction and 1.5 times the equipment weight in the downward direction. Requirement must does not preclude the need to design equipment mountings for forces required by other criteria such as seismic standards.

]3.2.3 Furnaces

Foundations, settings, or suspensions for mounting equipment and accessories including supports, vibration isolators, stands, guides, anchors, clamps, and brackets must be provided. Foundations and suspension for equipment must conform to the recommendations of the manufacturer, unless otherwise indicated on drawings. Anchor bolts and sleeves must be set accurately using properly constructed templates. Anchor bolts, when embedded in concrete, must be provided with welded-on plates on the head end and guarded against damage until equipment is installed. Equipment bases must be leveled, using jacks or steel wedges, and when resting on concrete must be neatly grouted-in with a non-shrinking type of grout. Equipment must be located as indicated and in such a manner that working space is available for all necessary servicing, such as shaft removal, replacing, or adjusting drives, motors, or shaft seals, air filters, access to automatic controls, humidifiers, and lubrication. Electrical isolation must be provided between dissimilar metals for the purpose of minimizing galvanic corrosion. The interior of cabinets or casings must be cleaned before completion of installation. The furnace must be connected to the vent or chimney with the specified connectors, draft regulators, draft loads, and induced draft fans, as applicable, in accordance with NFPA 211.

3.2.4 Automatic Vent Dampers

Automatic vent dampers must be installed in accordance with ANSI Z21.66/CGA 6.14.

3.2.5 Humidifiers

Humidifiers must be installed in accordance with manufacturer's instructions and in an arrangement that will permit access and ease of maintenance. Provide water piping, drain, manual shut-off valve, and solenoid valves when required for type of humidifier furnished and install in accordance with the ICC IPC and paragraph SYSTEM DESCRIPTION. Drain lines must be provided for humidifiers and must be piped to drains shown. Humidifiers installed in a bypass arrangement must be provided with an integral damper that can be conveniently operated to regulate or shut off flow through the humidifier. To permit humidifier operation, a manual ON-OFF switch must be provided near the humidifier. The ON-OFF switch may be integral with the humidifier. Provide an access door in the ductwork located two feet downstream of the humidifier for verifying operation and inspecting the ductwork. When humidifier is installed in glass fiber ductwork, ductwork must be adequately reinforced to support the humidifier.[For reservoir or re-circulating type humidifier, the automatic bleed must be connected to the humidifier drain.]

3.2.6 Access Panels

Access panels must be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels must be of sufficient size and so located that the concealed items may be serviced and maintained or completely removed for replacement. Access panels must be as specified in[Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS][Section 05 51 33 METAL LADDERS][Section 05 52 00 METAL RAILINGS][Section 05 51 00 METAL STAIRS].

3.2.7 Flexible Connectors

Pre-insulated flexible connectors and flexible duct must be attached to other components in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, must be of the type recommended by the connector or duct manufacturer and must be provided at the intervals recommended.

3.2.8 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation must be packed as specified in Section 07 84 00 FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space must be packed as specified in Section 07 92 00 JOINT SEALANTS.

3.2.9 Ductwork

Ductwork and accessories must be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.2.10 Air Filters

Air filters must be installed[in heater casings][in return air ducts at furnaces][in return air grilles]. Fans or blowers must not be operated until filters are installed. After completion of tests and before the building is accepted by the Government, the Contractor must[provide a new second set of replaceable filters, where utilized][clean the permanent type filters]. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, [new filters were provided and installed][the permanent filters were cleaned].

3.2.11 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, temporary dust control protection must be provided. The distribution system (supply and return) must be protected with temporary seal-offs at all inlets and outlets at the end of each day's work. Temporary protection must remain in place until system is ready for startup.

3.2.12 Insulation

Thickness and application of insulation materials for ductwork and equipment must be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.13 Duct Test Holes

Holes with closures or threaded holes with plugs must be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, must be provided where the ducts are insulated.

3.2.14 Condensate Collection and Disposal

For high efficient, condensing type units provide condensate collection system consisting of p-traps, acid neutralizers,[condensate pump,] and corrosion resistant piping. Provide drains for heating unit and exhaust vents. All condensate must be captured and appropriately treated prior to entering sanitary system or discharging to outdoors. Install system in accordance manufacturer's installation instructions, ICC IMC and ICC IPC requirements. Provide piping as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Provide [dedicated collection system per heating unit][combined collection system serving multiple heating units].

3.2.15 Fuel-Oil System

Fuel oil systems must be installed in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

3.2.16 Fuel-Gas Supply System

Fuel-gas supply system must be installed in accordance with Section 23 11 20 FACILITY GAS PIPING.

3.3 FIELD PAINTING

Finish painting of items only primed at the factory or surfaces not specifically noted otherwise, are specified in paragraph SYSTEM DESCRIPTION.

3.4 CLEANING

Ducts, plenums, and casings must be thoroughly cleaned of all debris and blown free of all small particles of rubbish and dust and then must be vacuum cleaned before installing outlet faces. Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters must be provided prior to startup of all fans that are operated during construction, and new filters must be installed after all construction dirt has been removed from the building, the ducts, plenums, casings, and other items specified have been vacuum cleaned, and after completion of all tests. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. All equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.5 FIELD QUALITY CONTROL

Inspect equipment when it is delivered to the job site. The right is reserved to inspect any equipment at the plant of the manufacturer, during or after manufacture. Inspect and repair all refractory after installation and prior to startup. Continually inspect equipment during installation, after installation, and during the tests. Upon completion and prior to acceptance, perform tests and furnish all necessary equipment and materials required for the tests as specified herein to demonstrate that warm air heating system is in compliance with contract requirements. Make all tests under the direction of the[Contracting Officer][Contractor Quality Control representative]. Read all indicating instruments no less frequently than at half-hour intervals.

3.6 TESTS

Upon completion and prior to acceptance of the installation, furnish all equipment, instruments, materials, labor, and supervision required for the tests as specified. Submit proposed test procedures for ductwork leak and performance tests, at least 2 weeks prior to the start of related testing.

a. Obtain necessary natural gas, water and electricity as specified in [the SPECIAL CONTRACT REQUIREMENTS][Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS]. Provide necessary quantities of propane gas or No. [_____] fuel oil when propane gas or fuel oil is require for testing.

b. Defects disclosed by the tests must be rectified. Tests must be made under the direction and subject to the approval of the Contracting Officer. All indicating instruments must be read at 1/2-hour intervals unless otherwise directed by the Contracting Officer. Submit proposed System Diagrams, at least 2 weeks prior to start of related testing.

c. System diagrams that show the layout of equipment and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system must be framed under glass or laminated plastic. After approval, these items must be posted where directed.

d. Submit test reports for the ductwork leak test and the performance tests in booklet form, upon completion of testing. Reports must document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

3.7 TESTING, ADJUSTING, AND BALANCING

[Testing, adjusting, and balancing requirements are specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Testing, adjusting, and balancing must begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

][Perform in accordance with SMACNA 1780, Chapter VII, "Air System TAB Procedures," to achieve and confirm compliance with drawings and specifications; prepare complete report of final test results.

]3.7.1 Firing Tests

a. Test combustion controls and equipment with[each] specified fuel at 100 percent rated load. Demonstrate satisfactory smoke-count numbers and combustion efficiency. Maintain firing for at least 4 hours[, and where high-low-off combustion controls are provided, operate the furnace for one hour at low fire and 3 hours at high fire]. During tests, verify proper operation of controls. Adjust burners for maximum efficiency using Orsat or similar apparatus.

b. Record temperature rises across heat exchangers.

c. Minimum requirements for satisfactory combustion efficiency must be [10.0 percent carbon dioxide for oil burners][and][8.5 percent carbon dioxide for gas burners].[Minimum temperatures of flue gas at the stack must be 100 degrees F above the flue-gas dew points.] The observed smoke at all firing rates during the prescribed tests must not exceed that indicated by a number 2 spot for the burners firing a distillate fuel or gas and a number 4 spot for burners firing a residual type fuel on the Shell-Bacharach scale.

[3.7.2 Operating Test

Perform the following operating tests to demonstrate satisfactory [furnace][and][humidifier] operation. Check burner safety controls by simulating flame failure in accordance with the manufacturer's instructions. Operate furnace for a period sufficient to make the following observations and record the following data but in no case less than one hour. These tests may be run concurrent with fire tests specified below to the extent practical. Demonstrate satisfactory operation of all heat-regulating controls and safety controls.[Observe the humidifier for satisfactory operation and check humidifier drain to insure proper drainage.][Record humidity of air entering and leaving the humidifier during steady state furnace operation.] Record temperature rise across the heat exchanger under all firing rates after equilibrium conditions have been reached at each firing rate. Record ammeter and voltmeter readings for the [furnace motor][,][circulating blower motor][,][induced draft fan motor][,][and][humidifier motor].

]3.7.3 Performance Tests

After testing, adjusting, and balancing has been completed as specified, each system must be tested as a whole to see all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments must be conducted by an experienced engineer. Tests must cover a period of not less than [_____] days for each system and must demonstrate that the entire system is functioning according to the specifications. Coincidental chart recordings must be made at points indicated on the drawings for the duration of the time period and must record the temperature at space thermostats or space sensors,[the humidity at the humidistat(s) location(s),] and the outdoor air temperature[and humidity] in an immediately adjacent shaded and weather protected outdoor area.

3.8 FIELD ACCEPTANCE PROCEDURES

3.8.1 Field Acceptance Test Plans and Test Reports

a. Manufacturer's Test Plans: Within [120] [_____] calendar days after contract award, submit the Field Acceptance Test Plan. Field acceptance test plans must developed by the furnace manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the furnaces prior to commencement of field testing of the furnaces. The approved field acceptance test plans must be the plan and procedures followed for the field acceptance tests of the furnaces and resultant test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of furnace controls which interlock and interface with controls factory prewired or external controls for the equipment provided under Section [23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS].

c. Prerequisite testing: Equipment for which performance testing is dependent upon the completion of the work covered by Section [23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC][SMACNA 1780] must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer. Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Manufacturer must furnish with each test procedure a description of acceptable results that have been verified.

f. Job specific: Each test plan must be job specific and must address the particular item of equipment and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such temperature control valves, or pressure control valves.

3.8.2 Field Acceptance Testing

a. Equipment Requiring Test Reports: Each self-contained furnace must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting field acceptance test report submitted for approval.

b. Manufacturer's recommended testing: Conduct the manufacturer's recommend field testing in compliance with the approved test plan.[Furnish a factory trained field representative authorized by and to represent the equipment manufacturer throughout the complete execution of the field acceptance testing.]

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed must result in the test period being started again and run for the required duration. For the duration of each test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables. Submit test logs for each test period.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director and the QC manager. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.9 FIELD TRAINING

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of [_____] hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals, manufacturer’s troubleshooting and repair manuals, as well as demonstrations of routine maintenance operations. Submit the proposed On-site Training schedule concurrently with the Operation and Maintenance Manuals, manufacturer's troubleshooting and repair manuals, and at least 14 days prior to conducting the training course.

3.10 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work. Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

-- End of Section --

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SECTION 23 57 10.00 10

FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS
11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2021) Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2015) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A515/A515M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B251/B251M	(2017) Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube
ASTM B265	(2020a) Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate
ASTM B333	(2003; R 2018) Standard Specification for Nickel-Molybdenum Alloy Plate, Sheet, and Strip
ASTM B395/B395M	(2018) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM B424	(2019; E 2020) Standard Specification for Ni-Fe-Cr-Mo-Cu Alloy (UNS N08825 and UNS N08221, and UNS N06845) Plate, Sheet, and Strip
ASTM B650	(1995; R 2018) Standard Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
ASTM B687	(1999; R 2016) Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper

	and Copper Alloy Tube
ASTM B828	(2016) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1384	(2005; R 2019) Corrosion Test for Engine Coolants in Glassware
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2015) (10th Ed) EJMA Standards

HYDRONICS INSTITUTE DIVISION OF AHRI (HYI)

HYI-005	(2008) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

PLUMBING-HEATING-COOLING CONTRACTORS ASSOCIATION (PHCC)

NAPHCC NSPC	(2015) National Standard Plumbing Code Illustrated

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heating System

SD-03 Product Data

Spare Parts

Welding

Framed Instructions

SD-06 Test Reports

Testing and Cleaning

Water Treatment Testing

SD-07 Certificates

Bolts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

1.3 QUALITY ASSURANCE

Procedures and welders must be qualified in accordance with the code under which the welding is specified to be accomplished.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and excessive temperature variation; and dirt, dust, or other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the related submittals and not later than [_____] months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment must be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

Place a plate on each major item of equipment having the manufacturer's name, address, type or style, model or serial number, and catalog number secured to the item of equipment.

2.1.3 Equipment Guards and Access

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact in accordance with OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard must be properly guarded or covered with insulation of a type specified. [Catwalks, operating platforms, ladders, and guardrails must be provided where shown and must be constructed in accordance with Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS].]

2.1.4 Asbestos Prohibition

Asbestos and asbestos-containing products will not be accepted.

2.1.5 Electrical Work

Provide electrical motor driven equipment specified complete with motors, motor starters, and controls. Electric equipment (including motor efficiencies), and wiring must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide integral size motors of the premium efficiency type in accordance with NEMA MG 1. Electrical characteristics must be as specified or indicated. Provide motor starters complete with thermal overload protection and other appurtenances necessary for the motor control specified. Each motor must be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring, conduit, and connection to power required for controls and devices but not shown must be provided.

2.2 PIPING, TUBING, AND FITTINGS

2.2.1 General

Piping, tubing, and fittings must be as follows:

a. Low temperature water piping must be black steel or copper tubing with cast iron, malleable iron or steel, solder-joint, flared-tube or grooved mechanical joint fittings.

b. Steam pipe must be black steel with malleable iron or steel fittings.

c. Condensate return piping must be black steel Schedule 80 with cast iron or malleable iron, Class 250 minimum.

d. High temperature water piping must be black steel, Schedule 40.

e. Vent piping must be black steel, Schedule 40, with black malleable iron fittings.

2.2.2 Steel Pipe

Pipe must conform to ASTM A53/A53M or ASTM A106/A106M, Grade A or B, black steel, Schedule 40, unless otherwise specified. Steel pipe to be bent must be ASTM A53/A53M, Grade A, standard, or Grade B, extra strong weight. Steam pipe must be ASTM A53/A53M Grade A.

2.2.3 High Temperature Water Piping

Piping must be Type S for 1-1/2 inches and smaller, Type S or Type E for pipe 2 inches and larger, schedule 40 steel conforming to ASTM A53/A53M, Grade B; or to ASTM A106/A106M, Grade B.

2.2.4 Gauge Piping

Piping must be copper tubing for [steam] [and] [low temperature water]. [Use black steel, ASTM A106/A106M, seamless, Grade A pipe for high temperature.]

2.2.5 Copper Tubing

Tubing must conform to ASTM B88, ASTM B88M, Type K or L. Tubing for compressed air tubing must conform to ASTM B251/B251M.

2.2.6 High Temperature Water Fittings

Fittings must be steel welding fittings conforming in physical and chemical properties to ASTM A234/A234M. Buttwelding fittings must conform to ASME B16.9. Socket welded fittings must conform to ASME B16.1. Screwed fittings, when required, must be black forged steel, 2000-pound class, conforming to ASME B16.11. Flanges must be serrated or raised-faced type.

2.2.7 Malleable Iron Pipe Fittings

Fittings must conform to ASME B16.3, type required to match adjacent piping.

2.2.8 Cast Iron Pipe Fittings

Fittings must conform to ASME B16.1 or ASME B16.4 type required to match adjacent piping.

2.2.9 Steel Pipe Fittings

Fittings must have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.2.9.1 Welded Fittings

Welded fittings must conform to ASTM A234/A234M with WPA marking. Butt welded fittings must conform to ASME B16.9, and socket welded fittings must conform to ASME B16.11.

2.2.9.2 Grooved Mechanical Fittings

Standard fittings must be of malleable iron conforming to ASTM A47/A47M, Grade 32510, or ductile iron conforming to ASTM A536, Grade 65-45-12. Fittings may also be constructed of steel, conforming to ASTM A106/A106M, Grade B or ASTM A53/A53M.

2.2.9.3 Grooved Mechanical Pipe Joints

Pipe joints must conform to AWWA C606. Grooved mechanical joint fittings must be full flow factory manufactured forged steel fittings. Fittings, couplings, gaskets, and pipe grooving tool or grooved end pipe must be products of the same manufacturer. Mechanical pipe couplings must be of the bolted type and must consist of a housing fabricated in two or more parts, a synthetic rubber gasket, and nuts and bolts to secure unit together. Housings must be of malleable iron conforming to ASTM A47/A47M, Grade 32510 or ductile iron conforming to ASTM A536, Grade 65-45-12. Coupling nuts and bolts must be of steel and conform to ASTM A183. Submit written certification that the bolts furnished comply with the requirements of this specification, provided by the bolt manufacturer. The certification must include illustrations of product-required markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification. Gaskets must be of molded synthetic rubber, Type [EPDM] [Buna-N] with central cavity, pressure responsive configuration and must conform to ASTM D2000.

2.2.10 Joints and Fittings for Copper Tubing

Wrought copper and bronze fittings must conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy fittings must conform to ASME B16.18 and ASTM B828. Flared fittings must conform to ASME B16.26 and ASTM B62. Adaptors may be used for connecting tubing to flanges and threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Cast bronze threaded fittings must conform to ASME B16.15. Grooved mechanical joints and fittings must be designed for not less than 125 psig service and must be the product of the same manufacturer. Grooved fitting and mechanical coupling housing must be ductile iron conforming to ASTM A536. Gaskets for use in grooved joints must be molded synthetic polymer of pressure responsive design and must conform to ASTM D2000 for circulating medium up to 230 degrees F. Grooved joints must conform to AWWA C606. Coupling nuts and and bolts for use in grooved joints must be steel and must conform to ASTM A183.

2.2.11 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns., etc. must be in accordance with ASME B16.5 class 150 and must have the manufacturers trademark affixed in accordance with MSS SP-25. Flange material must conform to ASTM A105/A105M. Flanges for high temperature water systems must be serrated or raised-face type. Blind flange material must conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts must be high strength or intermediate strength with material conforming to ASTM A193/A193M.

2.2.12 Pipe Threads

Pipe threads must conform to ASME B1.20.1.

2.2.13 Nipples

Nipples must conform to ASTM A733 or ASTM B687, standard weight.

2.2.14 Unions

Unions must conform to ASME B16.39, type to match adjacent piping.

2.2.15 Adapters

Adapters for copper tubing must be brass or bronze for soldered fittings.

2.2.16 Dielectric Waterways

Dielectric waterways must conform to the tensile strength and dimensional requirements specified in ASME B16.39. Waterways must have metal connections on both ends to match adjacent piping. Metal parts of dielectric waterways must be separated so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Dielectric waterways must have temperature and pressure rating equal to or greater than that specified for the connecting piping. Dielectric waterways must be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges must meet the performance requirements described herein for dielectric waterways.

2.2.17 Grooved Mechanical Joints

Rigid grooved pipe joints may be provided in lieu of unions, welded, flanges or screwed piping connections at chilled water pumps and allied equipment, and on aboveground pipelines in serviceable locations, if the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved joints will not be permitted, except as vibration isolators adjacent to mechanical equipment. Rigid grooved joints must incorporate an angle bolt pad design which maintains metal-to-metal contact with equal amount of pad offset of housings upon installation to insure positive rigid clamping of the pipe. Designs which can only clamp on the bottom of the groove or which utilize gripping teeth or jaws, or which use misaligned housing bolt holes, or which require a torque wrench or torque specifications, will not be permitted. Rigid grooved pipe couplings must be used with grooved end pipes, fittings, valves and strainers. Rigid couplings must be designed for not less than 125 psi service and appropriate for static head plus the pumping head, and must provide a water-tight joint. Grooved fittings and couplings, and grooving tools must be provided from the same manufacturer. Segmentally welded elbows must not be used. Grooves must be prepared in accordance with the coupling manufacturer's latest published standards. Grooving must be performed by qualified grooving operators having demonstrated proper grooving procedures in accordance with the tool manufacturer's recommendations. The Contracting Officer must be notified 24 hours in advance of test to demonstrate operator's capability, and the test must be performed at the work site, if practical, or at a site agreed upon. The operator must demonstrate the ability to properly adjust the grooving tool, groove the pipe, and verify the groove dimensions in accordance with the coupling manufacturer's specifications.

2.2.18 Flexible Pipe Connectors

Flexible pipe connectors must be designed for 125 psi or 150 psi service as appropriate for the static head plus the system head, and 250 degrees F. Connectors must be installed where indicated. The flexible section must be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. Materials used and the configuration must be suitable for the pressure, vacuum, temperature, and circulating medium. The flexible section may have threaded, welded, soldered, flanged, grooved, or socket ends. Flanged assemblies must be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors must be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, must be provided when recommended by the manufacturer. Provide covers to protect the bellows where indicated.

2.3 MATERIALS AND ACCESSORIES

2.3.1 Iron and Steel Sheets

2.3.1.1 Galvanized Iron and Steel

Galvanized iron and steel must conform to ASTM A653/A653M, with general requirements conforming to ASTM A653/A653M. Gauge numbers specified are Manufacturer's Standard Gauge.

2.3.1.2 Uncoated (Black) Steel

Uncoated (black) steel must conform to ASTM A653/A653M, composition, condition, and finish best suited to the intended use. Gauge numbers specified refer to Manufacturer's Standard Gauge.

2.3.2 Solder

Solder must conform to ASTM B32. Solder and flux must be lead free. Solder flux must be liquid or paste form, non-corrosive and conform to ASTM B813.

2.3.3 Solder, Silver

Silver solder must conform to AWS A5.8/A5.8M.

2.3.4 Thermometers

Mercury must not be used in thermometers. Thermometers must have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9 inch scale, and thermometers must have rigid stems with straight, angular, or inclined pattern.

2.3.5 Gauges

Provide gauges conforming to ASME B40.100.

2.3.6 Gaskets for Flanges

Composition gaskets must conform to ASME B16.21. Gaskets must be nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type. Gaskets must contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). NBR binder must be used for hydrocarbon service. Gaskets must be suitable for pressure and temperatures of piping system.

2.3.7 Polyethylene Tubing

Low-density virgin polyethylene must conform to ASTM D1248, Type I, Category 5, Class B or C.

2.3.8 Bellows-Type Joints

Joints must be flexible, guided expansion joints. Expansion element must be of stainless steel. Bellows-type expansion joints must be in accordance with the applicable requirements of EJMA Stds and ASME B31.1 with internal liners.

2.3.9 Expansion Joints

Expansion joints must provide for either single or double slip of connected pipes, as required or indicated, and for not less than the traverse indicated. Joints must be designed for hot water working pressure not less than [_____] psig and must be in accordance with applicable requirements of EJMA Stds and ASME B31.1. Joints must be designed for packing injection under full line pressure. End connections must be flanged or beveled for welding as indicated. Provide joints with anchor base where required or indicated. Where adjoining pipe is carbon steel, the sliding slip must be seamless steel plated with a minimum of 2 mils of hard chrome conforming to ASTM B650. Joint components must be fabricated from material equivalent to that of the pipeline. Initial settings must be made in accordance with manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides must be installed as recommended by joint manufacturer, but in any case must not be more than 5 feet from expansion joint except for lines 4 inches or smaller, guides must be installed not more than 2 feet from the joint. Provide service outlets where indicated.

2.3.10 Flexible Ball Joints

Flexible ball joints must be constructed of alloys as appropriate for the service intended. Where so indicated, the ball joint must be designed for packing injection under full line pressure to contain leakage. Joint ends must be threaded (to 2 inches only), grooved, flanged or beveled for welding as indicated or required and must be capable of absorbing a minimum of 15-degree angular flex and 360-degree rotation. Balls and sockets must be of equivalent material as the adjoining pipeline. Exterior spherical surface of carbon steel balls must be plated with 2 mils of hard chrome conforming to ASTM B650. Ball type joints must be designed and constructed in accordance with ASME B31.1 and ASME BPVC SEC VIII D1, where applicable. Flanges where required must conform to ASME B16.5. Gaskets and compression seals must be compatible with the service intended.

2.3.11 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports must conform to MSS SP-58.

2.4 VALVES FOR LOW TEMPERATURE WATER HEATING AND STEAM SYSTEMS

2.4.1 Check Valves

Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Type 3 or 4, Class 125. Sizes 3 inches through 24 inches, cast iron must conform to MSS SP-71, Type III or IV, Class 125.

2.4.2 Globe Valves

Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Type 1, 2 or 3, Class 125. Sizes 3 inches through 12 inches, cast iron must conform to MSS SP-85, Type III, Class 125.

2.4.3 Angle Valves

Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Type 1, 2 or 3, Class 125. Sizes 3 inches through 12 inches, cast iron must conform to MSS SP-85, Type III, Class 125.

2.4.4 Gate Valves

Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Type 1 or 2, Class 125. Sizes 3 inches through 48 inches, cast iron must conform to MSS SP-70, Type I, Class 125, Design OT or OF (OS&Y), bronze trim.

2.4.5 Air Vents

Provide air vents at all piping high points in water systems, with block valve in inlet and internal check valve to allow air vent to be isolated for cleaning and inspection. Outlet connection must be piped to nearest open site or suitable drain, or terminated 12 inches above finished grade. Pressure rating of air vent must match pressure rating of piping system. Body and cover must be cast iron or semi-steel with stainless steel or copper float and stainless steel or bronze internal parts. Air vents installed in piping in chase walls or other inaccessible places must be provided with an access panel.

2.4.6 Balancing Valves

Balancing valves must have meter connections with positive shutoff valves. An integral pointer must register degree of valve opening. Valves must be calibrated so that flow in gpm can be determined when valve opening in degrees and pressure differential across valve is known. Each balancing valve must be constructed with internal seals to prevent leakage and must be supplied with preformed insulation. Valves must be suitable for 250 degrees F temperature and working pressure of the pipe in which installed. Valve bodies must be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions must be provided with quick connecting hose fittings for a portable meter to measure the pressure differential. One portable differential meter must be furnished. The meter suitable for the operating pressure specified must be complete with hoses, vent, and shutoff valves and carrying case. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing. Provide plug valves and ball valves 8 inches or larger with manual gear operators with position indicators.

2.4.7 Gravity Flow Control Valves

Ends must be soldered, threaded, or flanged type as applicable, and designed for easy cleaning without disconnecting piping. Valves for copper tubing must be bronze. Valves must prevent flow due to gravity when circulators are off.

2.4.8 Radiator Valves

Automatic thermostatic radiator valves must be self-contained [direct sensor] [remote sensor] [wall thermostat] controlled nonelectric temperature control valves. Valve bodies must be constructed of chrome plated brass and must be angle or straight pattern as indicated, with threaded or brazed end connections. Valve disc must be of ethylene propylene or composition material. Thermostatic operators must be a modulating type consisting of a sensing unit counter balanced by a spring setting.

2.5 VALVES FOR HIGH AND MEDIUM TEMPERATURE WATER SYSTEMS

2.5.1 Check Valves

Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Class 300
Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Class 300
minimum. Sizes 3 inches through 24 inches, steel must conform to ASME B16.34, Class 300 minimum, flanged ends, swing disc; water, oil gas or steam service to 850 degrees F.

2.5.2 Globe Valves

Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Type 1, 2 or 3, Class 300 minimum. Sizes 3 inches through 24 inches, steel must conform to ASME B16.34, Class 300 minimum, flanged ends; water, oil, gas, or steam service to 850 degrees F.

2.5.3 Angle Valves

Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Type 1, 2 or 3, Class 300 minimum. Sizes 3 inches through 24 inches, steel must conform to ASME B16.34, Class 300 minimum, flanged ends; water, oil, gas, or steam service to 850 degrees F.

2.5.4 Gate Valves

Sizes 2-1/2 inches and less, bronze must conform to MSS SP-80, Type 1, or 2, Class 300 minimum. Sizes 3 inches through 24 inches, steel must conform to ASME B16.34, Class 300 minimum, flanged ends; water, oil, gas or steam service to 850 degrees F. Gate must be split wedge (double disc) type.

2.6 COLD WATER CONNECTIONS

Connections must be provided which include consecutively in line a strainer, backflow prevention device, and water pressure regulator. The backflow prevention device must be provided as indicated and in compliance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.6.1 Strainers

Basket or Y-type strainers must be the same size as the pipelines in which they are installed. Strainer bodies must be rated for [125] [250] pound service, with bottoms drilled and plugged. Bodies must have arrows cast on the sides to indicate the direction of flow. Each strainer must be equipped with a removable cover and sediment basket. Basket must not be less than 22 gauge and must have perforations to provide a net free area through the basket of at least four times that of the entering pipe.

2.6.2 Pressure Regulating Valve

Valve must be a type that will not stick nor allow pressure to build up on the low side. Valve must be set to maintain a terminal pressure approximately 5 psi in excess of the static head on the system and must operate within a 20 psi variation regardless of initial pressure and without objectionable noise under any condition of operation.

2.7 FLASH TANK

Tank must be sized and installed as indicated, and must be of welded construction utilizing black steel sheets not less than 11 gauge. Provide tank with a handhole and with tapping for the condensate returns, drip lines, vent line, and condensate discharge line to the condensate receiver. Discharge line must be equipped with a float trap. Tank must be ASME rated for [_____] psig in accordance with ASME BPVC SEC VIII D1.

2.8 EXPANSION TANK

Pressurization system must include a replaceable diaphragm-type captive air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. The only air in the system must be the permanent sealed-in air cushion contained in the diaphragm-type tank. Sizes must be as indicated. Expansion tank must be welded steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of [125] [_____] psig and precharged to the minimum operating pressure. Tank air chamber must be fitted with an air charging valve. Tank must be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations.

2.9 AIR SEPARATOR TANK

External air separation tank must be steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of [125] [_____] psi. The capacity of the air separation tank indicated is minimum.

2.10 STEAM TRAPS

2.10.1 Float Traps

Capacity, working pressure, and differential pressure of the traps must be as indicated.

2.10.2 Float-and-Thermostatic Traps

Traps must be designed for a steam working pressure of approximately 15 psig, but must operate with a supply pressure of approximately 5 psig. The capacity of the traps must be as indicated. Trap capacity must be based on a pressure differential of 1/4 psi. Provide each float-and-thermostatic trap a hard bronze, monel, or stainless steel valve seat and mechanism and brass float, all of which can be removed easily for inspection or replacement without disturbing the piping connections. Inlet to each trap must have a cast iron strainer, either an integral part of the trap or a separate item of equipment.

2.10.3 Bucket Traps

Traps must be inverted or vertical bucket type with automatic air discharge. Traps must be designed for a working pressure of 150 psig, but must operate under a steam supply pressure of approximately 40 to 100 psig as required. Each trap must have a heavy body and cap of fine-grained, gray cast iron. The bucket must be made of brass; the mechanism of hard bronze; the valve and seat of stainless or monel; or each of equivalent material. Traps must be tested hydrostatically under a pressure of 200 psig. Traps must have capacities as indicated when operating under the specified working conditions. A strainer must be installed in the suction connection of each trap. Impact operated traps, impulse-operated traps, or thermodynamic traps with continuous discharge may be installed in lieu of bucket traps, subject to approval. Thermostatic traps designed for a steam working pressure suitable for the application may be furnished in lieu of the traps specified above. Thermostatic traps must be equipped with valves and seats of stainless steel or monel metal, and must have capacities based on a pressure differential not in excess of the following:

Steam Working Pressure, psi	Differential, psi
25-50	20
90-100	80

2.11 HEAT EXCHANGERS

Heat exchangers must be multiple pass shell and U-tube type or plate and frame type as indicated, to provide low temperature hot water for the heating system when supplied with [steam] [or] [high temperature hot water] [or] [medium temperature hot water] at the temperatures and pressures indicated. Temperature and pressure for plate and frame exchangers must not exceed 280 degrees F and 280 psig for medium temperature hot water, or 280 degrees F and 35 psig for steam. Temperature and pressure for shell and U-tube exchangers must not exceed 338 degrees F and 100 psig for steam or 430 degrees F and 400 psig for high temperature hot water. Exchangers must be constructed in accordance with ASME BPVC SEC VIII D1 and certified with ASME stamp secured to unit. U-tube bundles must be completely removable for cleaning and tube replacement and must be free to expand with shell. Shells must be of seamless steel pipe or welded steel construction and tubes must be seamless tubing as specified below unless otherwise indicated. Tube connections to plates must be leakproof. Provide saddles or cradles to mount shell and U-tube exchangers. Frames of plate and frame type exchangers must be fabricated of carbon steel and finished with baked epoxy enamel. Design fouling factor must be [_____].

2.11.1 Steam Heat Exchangers, Shell and U-Tube Type

Exchangers must operate with steam in shell and low temperature water in tubes. Shell and tube sides must be designed for 150 psig working pressure and factory tested at 300 psig. Steam, water, condensate, and vacuum and pressure relief valve connections must be located in accordance with the manufacturer's standard practice. Connections larger than 3 inches must be ASME 150 pound flanged. Water pressure loss through clean tubes must not exceed 6 psi and water velocity must not exceed 6 fps unless otherwise indicated. Minimum water velocity in tubes must be not less than 1 fps and assure turbulent flow. Tubes must be seamless copper or copper alloy, constructed in accordance with ASTM B75/B75M or ASTM B395/B395M, suitable for the temperatures and pressures specified. Tubes must be not less than 3/4 inch unless otherwise indicated. Maximum steam inlet nozzle velocity must not exceed 6000 fpm.

2.11.2 High Temperature Water Heat Exchangers, Shell and U-tube Type

Exchangers must operate with low temperature water in shell and high temperature water in tubes. Shell side must be designed for 150 psig working pressure and factory tested at 300 psig. Tubes must be designed for 400 psig working pressure and an operating temperature of 450 degrees F. High and low temperature water and pressure relief connections must be located in accordance with the manufacturer's standard practice. Water connections larger than 3 inches must be ASME 600 pound flanged for high temperature water, and ASME 150 pound flanged for low temperature water. Water pressure loss through clean tubes must not exceed 6 psig unless otherwise indicated. Minimum water velocity in tubes must be 1 fps and assure turbulent flow. Tubes must be cupronickel or inhibited admiralty, constructed in accordance with ASTM B395/B395M, suitable for the temperatures and pressures specified. Tubes must be not less than 3/4 inch unless otherwise indicated.

2.11.3 Steam Heat Exchangers, Plate and Frame Type

Plates, frames and gaskets must be designed for a working pressure of 300 psig and factory tested at 450 psig. Steam, low temperature water, condensate, and vacuum and pressure relief valve connections must be located in accordance with the manufacturer's standard practice. Connections larger than 3 inches must be ASME 150 pound flanged. Water pressure drop through clean plates and headers must not exceed [_____] psig at the flow rates and temperatures indicated. Plates must be designed to assure turbulent flow at a minimum rate of [_____] gpm through any 2 plate segment. Plates must be corrugated [Type 304 stainless steel] [Type 316 stainless steel] [nickel-iron-chromium alloy conforming to ASTM B424] [nickel-molybdenum alloy conforming to ASTM B333] [titanium alloy conforming to ASTM B265]. Plate thickness must be not less than [_____] inch.

2.11.4 Medium Temperature Water Heat Exchangers, Plate and Frame Type

Plates, frames and gaskets must be designed for a working pressure of 300 psig and factory tested at 450 psig. Medium temperature water, low temperature water, and pressure relief valve connections must be located in accordance with the manufacturer's standard practice. Connections larger than 3 inches must be ASME 300 pound flanged. Water pressure drop through clean plates and headers must not exceed [_____] psi at the flow rates and temperatures indicated. Plates must be designed to assure turbulent flow at a minimum rate of [_____] gpm through any 2 plate segment. Plates must be corrugated [Type 304 stainless steel] [Type 316 stainless steel] [nickel-iron-chromium alloy conforming to ASTM B424] [nickel-molybdenum alloy conforming to ASTM B333] [titanium alloy conforming to ASTM B265]. Plate thickness must be not less than [_____] inch.

2.12 SYSTEM EQUIPMENT AND ACCESSORIES

2.12.1 Circulating Pumps

Pumps for hot water must be of the single-stage centrifugal type, electrically driven. Pumps must be supported [on a concrete foundation] [or] [by the piping on which installed] [as indicated]. Pumps must be either integrally mounted with the motor or direct-connected by means of a flexible-shaft coupling on a cast iron, or steel sub-base. Pump housing must be of close grained cast iron. Shaft must be carbon or alloy steel, turned and ground. Shaft seal must be mechanical-seal or stuffing-box type. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve must be bronze. Bearings must be ball-, roller-, or oil-lubricated, bronze-sleeve type, and must be sealed or isolated to prevent loss of oil or entrance of dirt or water. Motor must be of a type approved by the manufacturer of the pump.

2.12.2 Condensate Pumping Unit

Pump must have a minimum capacity, as indicated, of [_____] gpm when discharging against the specified pressure. The minimum capacity of the tank must be [_____] gallons. Condensate pumping unit must be of the [single] [duplex], [horizontal-shaft] [vertical-shaft] type, as indicated. Unit must consist of [one pump] [two pumps], [one electric motor] [two electric motors] and a single receiver. Pumps must be centrifugal or turbine type, bronze-fitted throughout with impellers of bronze or other corrosion-resistant metal. Pumps must be free from air-binding when handling condensate with temperatures up to 200 degrees F. Pumps must be connected directly to dripproof enclosed motors. Receiver must be cast iron and must be provided with condensate return, vent, overflow, and pump suction connections, and water level indicator and automatic air vent. Inlet strainer must be provided in the inlet line to the tank. Vent pipe must be galvanized steel, and fittings must be galvanized malleable iron. Vent pipe must be installed as indicated or directed. Vent piping must be flashed as specified. Pump, motor, and receiving tank may be mounted on a single base with the receiver piped to the pumps suctions. Provide a gate valve and check valve in the discharge connection from each pump.

2.12.2.1 Controls

Install enclosed float switches complete with float mechanisms in the head of the receiver. The condensate pump must be controlled automatically by means of the [respective] float switch that will automatically start the motor when the water in the receiving tank reaches the high level and stop the motor when the water reaches the low level. Provide motors with magnetic across-the-line starters equipped with general purpose enclosure and Automatic-Manual-Off selector switch in the cover.

2.12.2.2 Factory Testing

Submit a certificate of compliance from the pump manufacturer covering the actual test of the unit and certifying that the equipment complies with the indicated requirements.

2.12.3 Pressure Gauges and Thermometers

Provide gauges for each heat exchanger and piping as indicated. Provide a thermometer and pressure gauge on the high temperature water supply and return mains. Thermometers must be separable socket type.

2.12.4 Vacuum Relief Valve

Install a vacuum relief valve on the shell of each shell and U-tube steam heat exchanger and on the factory supplied steam inlet nozzle of each plate and frame heat exchanger. On shutoff of steam supply and condensing of steam, the vacuum relief valve must automatically admit air to the heat exchanger.

2.12.5 Pressure Relief Valves

Provide one or more pressure relief valves for each heat exchanger in accordance with ASME BPVC SEC VIII D1. The aggregate relieving capacity of the relief valves must be not less than that required by the above code. Discharge from the valves must be installed as indicated. Pressure relief valves for steam heat exchangers must be located on the low temperature water supply coming from near the heat exchanger as indicated. Relief valves for high temperature water heat exchanger must be installed on the heat exchanger shell.

2.12.6 Drains

Install a drain connection with 3/4 inch hose bib at the lowest point in the low temperature water return main near the heat exchanger. In addition, install threaded drain connections with threaded cap or plug wherever required for thorough draining of the low temperature water system.

2.12.7 Strainers

Basket or Y-type strainer-body connections must be the same size as the pipe lines in which the connections are installed. The bodies must have arrows clearly cast on the sides to indicate the direction of flow. Each strainer must be equipped with an easily removable cover and sediment basket. The body or bottom opening must be equipped with nipple and gate valve for blowdown. The basket for steam systems must be of not less than 0.025 inch thick stainless steel, or monel with small perforations of sufficient number to provide a net free area through the basket of at least 2.5 times that of the entering pipe. The flow must be into the basket and out through the perforations. [For high temperature water systems, only cast steel bodies must be used.] [The strainer bodies for steam systems must be of cast steel or gray cast iron with bottoms drilled and plugged.]

2.13 INSULATION

Shop and field applied insulation must be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.14 FACTORY PAINTED EXPOSED SPACE HEATING EQUIPMENT

Radiator and convector enclosures must be coated with the manufacturer's standard rust inhibiting primer for painting in the field as specified in Section 09 90 00 PAINTS AND COATINGS. All other exposed heating equipment must be painted at the factory with the manufacturer's standard primer and enamel finish.

2.15 RADIATORS AND CONVECTORS

The radiator and convector must be the type and size indicated. The supply and return connections must be the same size. Cast iron radiators and nonferrous convectors must be tested hydrostatically at the factory and proved tight under a pressure of not less than [30 psig][[_____] psig] or 150 percent of the system operating pressure, whichever is greater. Furnish a certified report of these tests in accordance with paragraph SUBMITTALS.

2.15.1 Cast Iron Radiators

Cast iron radiators must be gray cast iron, free from sandholes and other defects. The sections must be connected with malleable iron nipples not less than 0.09 inch thick at any point. Cast iron radiators must be the legless type mounted on the walls by means of hangers as specified. Adjustable radiator hangers must be secured to the wall and must hold the radiators near both ends, at both top and bottom, in such a manner that the radiators cannot be removed without the use of tools. Not less than two bolts must be used to secure each hanger to the wall. Necessary angles, bolts, bearing plates, toggles, radiator grips, and other parts required for complete installation of the radiators must be provided.

2.15.2 Extended-Surface, Steel, or Nonferrous Tube-Type Radiators

Radiators must consist of metal fins permanently bonded to steel or nonferrous pipe cores, with threaded or sweat fittings at each end for connecting to external piping. Radiators must have capacities not less than those indicated, determined in accordance with HYI-005. Radiators must be equipped with [expanded-metal cover grilles fabricated from black steel sheets not less than 16 gauge, secured either directly to the radiators or to independent brackets.] [solid-front, slotted horizontal-top cover grilles fabricated from black steel sheets not less than 18 gauge, secured either directly to the radiators or to independent brackets.] [solid-front, slotted sloping-top cover grilles fabricated from black steel sheets not less than 16 gauge, independently secured to masonry with brackets.]

2.15.3 Convectors

Convectors must be constructed of cast iron or of nonferrous alloys, and must be installed where indicated. Capacity of convectors must be as indicated. Overall space requirements for convectors must not be greater than the space provided. Convectors must be complete with heating elements and enclosing cabinets having bottom recirculating opening, manual control damper and top supply grille. Convector cabinets must be constructed of black sheet steel not less than 20 gauge.

2.15.4 Radiators and Convectors Control

[The space temperature must be maintained automatically by regulating water flow to the radiators and convectors by the self contained, automatic thermostatic radiator control valves.] [Provide controls as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.]

2.16 UNIT HEATERS

Heaters must be as specified below, and must have a heating capacity not in excess of 125 percent of the capacity indicated. [Noise level of each unit heater for areas noted must not exceed the criteria indicated.]

2.16.1 Propeller Fan Heaters

Heaters must be designed for suspension and arranged for [horizontal] [vertical] discharge of air as indicated. Casings must be not less than 20 gauge black steel and finished with lacquer or enamel. Suitable [stationary] [rotating air] deflectors must be provided to assure proper air and heat penetration capacity at floor level based on established design temperature. Suspension from heating pipes will not be permitted. [Fans for vertical discharge type heaters must operate at speeds not in excess of 1,200 rpm, except that units with 80,000 Btu output capacity or less may operate at speeds up to 1,800 rpm.] [Horizontal discharge type unit heaters must have discharge or face velocities not in excess of the following:

Unit Capacity, cfm	Face Velocity, fpm
Up to 1000	800
1001	900
3001 and over	1000

]

2.16.2 Centrifugal Fan Heaters

Heaters must be arranged for floor or ceiling mounting as indicated. Heating elements and fans must be housed in steel cabinets of sectionalized steel plates or reinforced with angle-iron frames. Cabinets must be constructed of not lighter than 18 gauge black steel. Provide each unit heater with a means of diffusing and distributing the air. Fans must be mounted on a common shaft, with one fan to each air outlet. Fan shaft must be equipped with self-aligning ball, roller, or sleeve bearings and accessible means of lubrication. Fan shaft may be either directly connected to the driving motor or indirectly connected by adjustable V-belt drive rated at 150 percent of motor capacity. All fans in any one unit heater must be the same size.

2.16.3 Heating Elements

[Heating coils and radiating fins must be of suitable nonferrous alloy with [threaded] [brazed] fittings at each end for connecting to external piping. The heating elements must be free to expand or contract without developing leaks and must be properly pitched for drainage. The elements must be tested under a hydrostatic pressure of 200 psig and a certified report of the test must be submitted to the Contracting Officer.] [Heating coils must be as specified in Section 23 30 00 HVAC AIR DISTRIBUTION for types indicated.] Coils must be suitable for use with water up to 250 degrees F.

2.16.4 Motors

Provide motors with NEMA 250 general purpose enclosure. Motors and motor controls must otherwise be as specified in Section 26 20 00 INTERIOR

DISTRIBUTION SYSTEM.

2.16.5 Motor Switches

Provide motors with manual selection switches with "Off," and "Automatic" positions and must be equipped with thermal overload protection.

2.16.6 Controls

Provide controls as specified in 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

2.17 HEATING AND VENTILATING UNITS

Heating and ventilating units must be as specified in Section 23 30 00 HVAC AIR DISTRIBUTION.

2.18 WATER TREATMENT SYSTEM

The water treatment system must be capable of [manually] [automatically] feeding chemicals into the heating system to prevent corrosion and scale within the heat exchanger and piping system. Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Also show on the drawings complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show on the drawings proposed layout and anchorage of equipment and appurtenances and equipment relationship to other parts of the work including clearances for maintenance and operation. All water treatment equipment and chemicals must be furnished and installed by a water treatment company regularly engaged in the installation of water treatment equipment and the provision of water treatment chemicals based upon water condition analyses. The water treatment company must provide a water sample analysis taken from the building site, each month for one year.

2.18.1 Chemical Shot Feeder

Provide a shot feeder indicated. Size and capacity of feeder must be based upon local requirements and water analysis. The feeder must be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping. All materials of construction must be compatible with the chemicals being used.

2.18.2 Make Up Water Analysis

The make up water conditions reported as prescribed in ASTM D596 are as follows:

Date of Sample	[_____]
Temperature	[_____] degrees F
Silica (SiO2)	[_____] ppm (mg/1)
Insoluble	[_____] ppm (mg/1)

Iron and Aluminum Oxides	[_____] ppm (mg/1)
Calcium (Ca)	[_____] ppm (mg/1)
Magnesium (Mg)	[_____] ppm (mg/1)
Sodium and Potassium (Na and K)	[_____] ppm (mg/1)
Carbonate (HCO3)	[_____] ppm (mg/1)
Sulfate (SO4)	[_____] ppm (mg/1)
Chloride (C1)	[_____] ppm (mg/1)
Nitrate (NO3)	[_____] ppm (mg/1)
Turbidity	[_____] unit
pH	[_____]
Residual Chlorine	[_____] ppm (mg/1)
Total Alkalinity	[_____] ppm (mg/1)
Noncarbonate Hardness	[_____] epm (mg/1)
Total Hardness	[_____] epm (mg/1)
Dissolved Solids	[_____] ppm (mg/1)
Fluorine	[_____] ppm (mg/1)
Conductivity	[_____] microsiemens/cm

2.18.3 Chemicals

The chemical company must provide pretreatment chemicals that will remove and permit flushing of mill scale, oil, grease, and other foreign matter from the water heating system. The chemical company must also provide all treatment chemicals required for the initial fill of the system and for a period of one year of operation. The chemical company must determine the correct chemicals and concentrations required for the water treatment. The chemicals must not be proprietary and must meet required federal, state, and local environmental regulations for the treatment of heating water systems and discharge to the sanitary sewer. The chemicals must remain stable throughout the operating temperature range of the system, and must be compatible with pump seals and other elements of the system.

2.18.4 Glycol Solutions

Provide a [_____] percent concentration by volume of industrial grade [ethylene] [propylene] glycol. The glycol must be tested in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. The glycol must contain corrosion inhibitors. Silicate based inhibitors must not be used. The solution must be compatible with pump seals, other elements of the system, and all water treatment chemicals used within the system.

2.18.5 Test Kits

Provide all required test kits and reagents for determining the proper water conditions.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install all work as indicated and in accordance with the manufacturer's diagrams and recommendations.

3.3 COLOR CODE MARKING AND FIELD PAINTING

Color code marking, field painting of exposed pipe, and field painting of factory primed equipment must be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.4 WELDING

Submit [_____] copies of qualified procedures and list of names and identification symbols of qualified welders and welding operators, prior to welding operations. [Piping must be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders must be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer must be notified 24 hours in advance of tests and the tests must be performed at the work site if practical. The welder or welding operator must apply his assigned symbol near each weld he makes as a permanent record.] Structural members must be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING. [Welding and nondestructive testing procedures for piping must be as specified in Section 40 05 13.96 WELDING, PRESSURE PIPING.]

3.5 PIPING

Unless otherwise specified, pipe and fittings installation must conform to the requirements of ASME B31.1. Pipe must be cut accurately to measurements established at the job site and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cuttings or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing must be cut square, must have burrs removed by reaming, and must be so installed as to permit free expansion and contraction without causing damage to building structure, pipe, joints, or hangers. Changes in direction must be made with factory made fittings, except that bending of pipe up to 4 inches will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center line radius of bends must not be less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Vent pipes must be installed through the roof as indicated and must be flashed as specified. Horizontal mains must pitch up or down in the direction of flow as indicated. The grade must be not less than 1 inch in 40 feet. Reducing fittings must be used for changes in pipe sizes. Open ends of pipelines and equipment must be capped or plugged during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified must be uncoated. Unions and other components for copper pipe or tubing must be brass or bronze. Connections between ferrous and copper piping must be electrically isolated using dielectric unions.

3.5.1 Joints

Except as otherwise specified, joints used on steel pipe must be threaded for fittings 1 inch and smaller; threaded or welded for 1-1/4 inches up through 2-1/2 inches; and flanged or welded for3 inches and larger. Joints between sections of copper tubing or copper pipe must be flared or sweated. Pipe and fittings 1-1/4 inches and larger installed in inaccessible conduits or trenches beneath concrete floor slabs must be welded. Unless otherwise specified, connections to equipment must be made with black malleable iron unions for pipe 2-1/2 inches or smaller in diameter, and with flanges for pipe 3 inches or larger in diameter.

3.5.2 Low Temperature Systems

Piping may have threaded, welded, flanged or flared, sweated, or grooved mechanical joints as applicable and as specified. Reducing fittings must be used for changes in pipe sizes. In horizontal lines, reducing fittings must be the eccentric type to maintain the top of the adjoining pipes at the same level.

3.5.3 Steam Systems

Piping may have threaded, welded, or flanged joints as applicable and as specified. Reducing fittings must be used for changes in pipe sizes. In horizontal steam lines, reducing fittings must be the eccentric type to maintain the bottom of the lines at the same level. Grooved mechanical joints must not be used.

3.5.4 High And Medium Temperature Systems

Temperature systems must have welded joints to the maximum extent practicable, except screwed joints and fittings may be used at connections to equipment and on piping 2-1/2 inches and smaller. Equipment connections 3 inches and larger must be flanged. Piping connections 3 inches and larger may be welded or flanged. In horizontal lines, reducing fittings must be the eccentric type to maintain the tops of adjoining pipes at the same level. Grooved mechanical joints must not be used.

3.5.5 Threaded Joints

Threaded joints must be made with tapered threads properly cut, and must be made tight with PTFE tape complying with ASTM D3308, or equivalent thread joint compound applied to the male threads only, and in no case to the fittings.

3.5.6 Welded Joints

Joints must be fusion-welded unless otherwise required. Changes in direction of piping must be made with welding fittings only. Branch connection may be made with either welding tees or branch outlet fittings. Branch outlet fittings must be forged, flared for improvement of flow where attached to the run, and reinforced against external strains.

3.5.7 Flanged Joints or Unions

Provide flanged joints or unions in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and similar items. Flanged joints must be faced true, provided with gaskets, and made square and tight. Full-faced gaskets must be used with cast iron flanges.

3.5.8 Flared and Sweated Pipe and Tubing

Pipe and tubing must be cut square and burrs must be removed. Both inside of fittings and outside of tubing must be cleaned with an abrasive before sweating. Care must be taken to prevent annealing of fittings and hard drawn tubing when making connection. Installation must be made in accordance with the manufacturer's recommendations. Changes in direction of piping must be made with flared or soldered fittings only. Solder and flux must be lead free. Joints for soldered fittings must be made with silver solder or 95:5 tin-antimony solder. Cored solder must not be used. Joints for flared fittings must be of the compression pattern. Provide swing joints or offsets on all branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing.

3.5.9 Mechanical Tee Joint

An extracted mechanical tee joint may be made in copper tube. Joint must be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, provide dimpled depth stops. The branch tube must be notched for proper penetration into fitting to assure a free flow joint. Joints must be brazed in accordance with NAPHCC NSPC. Soldered joints will not be permitted.

3.5.10 Grooved Joints for Copper Tube

Grooves must be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools must be products of the same manufacturer. Pipe and groove dimensions must comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field must be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe must be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints must not be used in concealed locations.

3.6 CONNECTIONS TO EQUIPMENT

Provide supply and return connections unless otherwise indicated. Valves and traps must be installed in accordance with the manufacturer's recommendations. Unless otherwise indicated, the size of the supply and return pipes to each piece of equipment must be not smaller than the connections on the equipment. Bushed connections are not permitted. Change in sizes must be made with reducers or increasers only.

3.6.1 Low Temperature Water and Steam and Return Connections

Connections, unless otherwise indicated, must be made with malleable iron unions for piping 2-1/2 inches or less in diameter and with flanges for pipe 3 inches or more in diameter.

3.6.2 High And Medium Temperature Water Connections

Connections must be made with 2000 pound black malleable iron unions for pipe 3/4 inch or less in diameter and with flanges for pipe 1 inch and larger in diameter.

3.7 BRANCH CONNECTIONS

Branches must pitch up or down as indicated, unless otherwise specified. Connection must be made to insure unrestricted circulation, eliminate air pockets, and permit drainage of the system.

3.7.1 Low Temperature Water Branches

Branches taken from mains must pitch with a grade of not less than 1 inch in 10 feet. [Special flow fittings must be installed on the mains to bypass portions of water through each radiator. Special flow fittings must be installed as recommended by the manufacturer.]

3.7.2 Steam Supply and Condensate Branches

Branches taken from mains must pitch with a grade of not less than 1 inch in 10 feet, unless otherwise indicated.

3.7.3 High And Medium Temperature Water Branches

Branches must take off at 45 degrees in the direction of the fluid flow from the supply and return lines and should be branched from the top or upper half of the main line unless otherwise indicated. Abrupt reduction in pipe sizes must be avoided.

3.8 RISERS

The location of risers is approximate. Exact locations of the risers must be as approved. [Steam supply downfeed risers must terminate in a dirt pocket and must be dripped through a trap to the return line.]

3.9 SUPPORTS

3.9.1 General

Hangers used to support piping 2 inches and larger must be fabricated to permit adequate adjustment after erection while supporting the load. Pipe guides and anchors must be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. All piping subjected to vertical movement when operating temperatures exceed ambient temperatures, must be supported by variable spring hangers and supports or by constant support hangers. Where threaded rods are used for support, they must not be formed or bent.

3.9.1.1 Seismic Requirements for Pipe Supports, Standard Bracing

All piping and attached valves must be supported and braced to resist seismic loads as specified under UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT [and 23 05 48.19 [SEISMIC] BRACING FOR HVAC] [as shown on the drawings]. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown must be provided under this section. Material used for supports must be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.9.1.2 Structural Attachments

Structural steel brackets required to support piping, headers, and equipment, but not shown, must be provided under this section. Material and installation must be as specified under Section 05 12 00 STRUCTURAL STEEL. [Pipe hanger loads suspended from steel joist panel points must not exceed 50 pounds. Loads exceeding 50 pounds must be suspended from panel points.]

3.9.1.3 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp must be used where each pipe crosses the base support member. Spacing of the base support members must not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run.

3.9.2 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts and supports must conform to MSS SP-58, except as specified as follows:

3.9.2.1 Types 5, 12, and 26

Use of these types is prohibited.

3.9.2.2 Type 3

Type 3 is prohibited on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe and if the clamp bottom does not extend through the insulation and the top clamp attachment does not contact the insulation during pipe movement.

3.9.2.3 Type 18 Inserts

Type 18 inserts must be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

3.9.2.4 Type 19 and 23 C-Clamps

Type 19 and 23 C-clamps must be torqued in accordance with MSS SP-58 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.9.2.5 Type 20 Attachments

Provide Type 20 attachments used on angles and channels with an added malleable iron heel plate or adapter.

3.9.2.6 Type 24

Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.9.2.7 Type 39 Saddle or Type 40 Shield

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle must be used on all pipe 4 inches and larger.

3.9.2.8 Horizontal Pipe Supports

Space horizontal pipe supports as specified in MSS SP-58 and install a support not over 1 foot from the pipe fitting joint at each change in direction of the piping. Do not space pipe supports over 5 feet apart at valves.

3.9.2.9 Vertical Pipe Supports

Support vertical pipe at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, except support pipe not more than 8 feet from end of risers, and at vent terminations.

3.9.2.10 Type 35 Guides

Provide Type 35 guides using steel, reinforced PTFE or graphite slides where required to allow longitudinal pipe movement. Provide lateral restraints as required. Slide materials must be suitable for the system operating temperatures, atmospheric conditions and bearing loads encountered. Where steel slides do not require provision for restraint or lateral movement, an alternate guide method may be used. On piping 4 inches and larger, a Type 39 saddle may be welded to the pipe and freely rest on a steel plate. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate. Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide must include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe must be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, which ever is greater.

3.9.2.11 Pipe Hanger Size

Except for Type 3, pipe hangers on horizontal insulated pipe must be the size of the outside diameter of the insulation.

3.9.3 Piping in Trenches

Support piping as indicated.

3.10 PIPE SLEEVES

3.10.1 Pipe Passing Through Concrete or Masonry

Provide pipe passing through concrete or masonry walls or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Sleeves must not be installed in structural members except where indicated or approved. Rectangular and square openings must be as detailed. Each sleeve must extend through its respective wall, floor, or roof, and must be cut flush with each surface. Unless otherwise indicated, sleeves must provide a minimum of 1/4 inch annular space between bare pipe or insulation surface and sleeves. Sleeves in bearing walls, waterproofing membrane floors, and wet areas must be steel pipe or cast iron pipe. Sleeves in nonbearing walls, floors, or ceilings may be steel pipe, cast iron pipe, or galvanized sheet metal with lock-type longitudinal seam and of the metal thickness indicated. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls and floors must be sealed as indicated and specified in Section 07 92 00 JOINT SEALANTS. Seal penetrations in fire walls and floors in accordance with Section 07 84 00 FIRESTOPPING.

3.10.2 Pipes Passing Through Waterproofing Membranes

Install pipes passing through waterproofing membranes through a 4 pound lead-flashing sleeve, a 16 ounce copper sleeve, or a 0.032 inch thick aluminum sleeve, each having an integral skirt or flange. Flashing sleeve must be suitably formed, and the skirt or flange must extend 8 inches or more from the pipe and must be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve must extend up the pipe a minimum of 2 inches above the highest flood level of the roof or a minimum of 10 inches above the roof, whichever is greater, or 10 inches above the floor. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation must be sealed as indicated. At the Contractor's option, pipes up to and including 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane must be clamped into place and sealant must be placed in the caulking recess.

3.10.3 Mechanical Seal Assembly

In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. The seals must consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. The links must be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolts must cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly must be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals must provide sleeves of the proper diameters.

3.10.4 Counterflashing Alternate

As an alternate to caulking and sealing the annular space between the pipe and flashing sleeve or metal-jacket-covered insulation and flashing sleeve, counterflashing may be by standard roof coupling for threaded pipe up to 6 inches in diameter; lead-flashing sleeve for dry vents and turning the sleeve down into the pipe to form a waterproof joint; or tack-welded or banded-metal rain shield round the pipe and sealing as indicated.

3.10.5 Waterproofing Clamping Flange

Pipe passing through wall waterproofing membrane must be sleeved as specified. In addition, a waterproofing clamping flange must be installed as indicated.

3.10.6 Fire Seal

Where pipes pass through fire walls, fire partitions, fire rated pipe chase walls or floors above grade, provide a fire seal as specified in Section 07 84 00 FIRESTOPPING.

3.10.7 Escutcheons

Provide escutcheons at all finished surfaces where exposed piping, bare or covered, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons must be fastened securely to pipe sleeves or to extensions of sleeves without any part of sleeves being visible. Where sleeves project slightly from floors, special deep-type escutcheons must be used. Escutcheons must be chromium-plated iron or chromium-plated brass, either one-piece or split pattern, held in place by internal spring tension or setscrew.

3.11 ANCHORS

Provide anchors where necessary or indicated to localize expansion or prevent undue strain on piping. Anchors must consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces must be installed using turnbuckles where required. Supports, anchors, or stays must not be attached in places where construction will be damaged by installation operations or by the weight or expansion of the pipeline.

3.12 PIPE EXPANSION

The expansion of supply and return pipes must be provided for by changes in the direction of the run of pipe, by expansion loops, or by expansion joints as indicated. Low temperature water and steam expansion joints may be one of the types specified. [High] [Medium] temperature water system expansion joints may be one of the joints specified, except slip-tube type.

3.12.1 Expansion Loops

Expansion loops must provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loops must be cold-sprung and installed where indicated. Provide pipe guides as indicated.

3.12.2 Slip-Tube Joints

Slip-tube type expansion joints must be used for steam and low temperature water systems only and must be installed where indicated. The joints must provide for either single or double slip of the connected pipes as indicated and for the traverse indicated. The joints must be designed for a working temperature and pressure suitable for the application and in no case less than [_____] psig. The joints must be in accordance with applicable requirements of EJMA Stds and ASME B31.1. End connections must be flanged. Provide anchor bases or support bases must be provided as indicated or required. Initial setting must be made in accordance with the manufacturer's recommendations to allow for ambient temperature at time of installation. Pipe alignment guides must be installed as recommended by the joint manufacturer, but in any case must be not more than 5 feet from expansion joint, except in lines 4 inches or smaller where guides must be installed not more that 2 feet from the joint.

3.12.3 Bellows-Type Joint

Bellows-type joint design and installation must comply with EJMA Stds standards. The joints must be designed for the working temperature and pressure suitable for the application and must be not less than 150 psig in any case.

3.12.4 Flexible Ball Joints

Flexible ball joints may be threaded (to 2 inches only), flanged, or welded end as required. The ball-type joint must be designed and constructed in accordance with the generally accepted engineering principle stated in ASME B31.1, and ASME BPVC SEC VIII D1, where applicable. Flanges must conform to the diameter and drilling of ASME B16.5. Molded gaskets furnished must be suitable for the service intended.

3.13 VALVES AND EQUIPMENT ACCESSORIES

3.13.1 Valves and Equipment

Install valves at the locations shown or specified, and where required for the proper functioning of the system as directed. Gate valves must be used unless otherwise indicated, specified, or directed. Valves must be installed with their stems horizontal to or above the main body of the valve. Valves used with ferrous piping must have threaded or flanged ends and sweat-type connections for copper tubing.

3.13.2 Gravity Flow-Control Valve

Install the valve to control the flow of water in the supply main near the heat exchanger. The valve must operate so that when the circulating pump starts, the increased pressure within the main will open the valve; when the pump stops, the valve will close. The valve must be constructed with a cast iron body and must be provided with a device whereby the valve can be opened manually to allow gravity circulation. The flow-control valve must be designed for the intended purpose, and must be installed as recommended by the manufacturer.

3.13.3 Thermometer Socket

Provide a thermometer well in each return line for each circuit in multicircuit systems.

3.13.4 Air Vents

Install vents where indicated, and on all high points and piping offsets where air can collect or pocket.

3.13.4.1 Water Air Vents

[High] [Medium] temperature water air vents must be as indicated. Vent discharge lines must be double-valved with globe valves and must discharge into a funnel drain.

3.13.4.2 Steam Air Vents

Steam air vents must be a quick-acting valve that continuously removes air. Valve must be constructed of corrosion-resisting metal, must be designed to withstand the maximum piping system pressure, and must automatically close tight to prevent escape of steam and condensate. Vent must be provided with a manual isolation valve. Provide a vent on the shell of each steam heat exchanger.

3.14 STEAM TRAPS

Install float Traps in the condensate line as indicated. Other steam traps must be installed where indicated.

3.15 UNIT HEATERS

Install unit heaters as indicated and in accordance with the manufacturer's instructions.

3.16 INSULATION

Thickness of insulation materials for piping and equipment and application must be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.17 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. The representative must supervise the installation, adjustment, and testing of the equipment.

3.18 TESTING AND CLEANING

Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of controls.

3.18.1 Pressure Testing

Notify the Contracting Officer [_____] days before the tests are to be conducted. Perform the tests in the presence of the Contracting Officer. Furnish all instruments and personnel required for the tests. Electricity, steam, and water will be furnished by the Government. All test results must be accepted before thermal insulation is installed. The entire low temperature heating system, including heat exchanger, radiators and fittings, must be hydrostatically tested and proved tight under a pressure of 45 psig for a period of four hours.

3.18.2 Test of Backflow Prevention Assemblies

Test backflow prevention assemblies in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.18.3 Cleaning

After the hydrostatic and backflow prevention tests have been made and prior to the operating tests, the heat exchanger and piping must be thoroughly cleaned by filling the system with a solution of 1 pound of caustic soda or 1 pound of trisodium phosphate per 50 gallons of water. Observe the proper safety precautions in the handling and use of these chemicals. Heat the water to approximately 150 degrees F, and circulate the solution in the system for a period of 48 hours, then drain and flush the system thoroughly with fresh water. Wipe clean all equipment , and remove all traces of oil, dust, dirt, or paint spots. The Contractor will be responsible for maintaining the system in a clean condition until final acceptance. Lubricate bearings with oil or grease as recommended by the manufacturer.

3.18.4 Water Treatment Testing

Identify in the water quality test report the chemical composition of the heating water. The report must include a comparison of the condition of the water with the chemical company's recommended conditions. Document any required corrective action within the report. Analyze the heating water [prior to the acceptance of the facility] [and] [a minimum of once a month for a period of one year] by the water treatment company. The analysis must include the following information recorded in accordance with ASTM D596.

Date of Sample	[_____]
Temperature	[_____] degrees F
Silica (SiO2)	[_____] ppm (mg/1)
Insoluble	[_____] ppm (mg/1)
Iron and Aluminum Oxides	[_____] ppm (mg/1)
Calcium (Ca)	[_____] ppm (mg/1)
Magnesium (Mg)	[_____] ppm (mg/1)
Sodium and Potassium (Na and K)	[_____] ppm (mg/1)
Carbonate (HCO3)	[_____] ppm (mg/1)
Sulfate (SO4)	[_____] ppm (mg/1)
Chloride (C1)	[_____] ppm (mg/1)
Nitrate (NO3)	[_____] ppm (mg/1)
Turbidity	[_____] unit
pH	[_____]
Residual Chlorine	[_____] ppm (mg/1)
Total Alkalinity	[_____] ppm (mg/1)

Noncarbonate Hardness	[_____] epm (mg/1)
Total Hardness	[_____] epm (mg/1)
Dissolved Solids	[_____] ppm (mg/1)
Fluorine	[_____] ppm (mg/1)
Conductivity	[_____] microsiemens/cm

3.19 FRAMED INSTRUCTIONS

Submit proposed diagrams, instructions, and other sheets, prior to posting. Show in the instructions wiring and control diagrams and complete layout of the entire system. The instructions must include, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system. Post framed instructions, containing wiring and control diagrams under glass or in laminated plastic, where directed. Condensed operating instructions, prepared in typed form, must be framed as specified above and posted beside the diagrams. Post the framed instructions before acceptance testing of the system.

3.20 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members. Provide training for a total period of [_____] hours of normal working time starting after the system is functionally complete but prior to final acceptance tests. Field training must cover all of the items contained in the approved Operation and Maintenance Manuals. Submit [6] [_____] copies of operation and [6] [_____] copies of maintenance manuals for the equipment furnished. One complete set, prior to performance testing and the remainder upon acceptance. Operating manuals must detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals must include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. Maintenance manuals must list routine maintenance procedures, water treatment procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals must include piping and equipment layout and simplified wiring and control diagrams of the system as installed. Provide manuals prior to the field training course.

3.21 TESTING, ADJUSTING AND BALANCING

Except as specified herein, testing, adjusting, and balancing must be in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

-- End of Section --

SECTION 23 64 00

PACKAGED WATER CHILLERS, ABSORPTION TYPE
11/16, CHG 2: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

ANSI/AHRI 560	(2000) Absorption Water Chilling and Water Heating Packages

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B395/B395M	(2018) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NEMA MG 11 (1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54 (2021) National Fuel Gas Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G[, [_____]]

SD-03 Product Data

Absorption Water Chiller; G[, [_____]]

Posted Instructions; G[, [_____]]

Verification of Dimensions; G[, [_____]]

System Performance Tests; G[, [_____]]

Demonstrations

[Absorption Water Chiller - Field Acceptance Test Plan

] SD-06 Test Reports

Field Acceptance Testing; G[, [_____]]

[Absorption Water Chiller - Field Acceptance Test Report; G[, [_____]]

] System Performance Tests; G[, [_____]]

SD-07 Certificates

Absorption Water Chiller; G[, [_____]]

SD-08 Manufacturer's Instructions

[Water Chiller - Installation Instructions; G[, [_____]]

] SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1. Fuel-fired equipment must be in accordance with NFPA 54.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items must be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged must be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.5 PROJECT REQUIREMENTS

1.5.1 Verification of Dimensions

The Contractor must become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor must carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and must arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. The Contractor must submit detailed drawings consisting of:

a. Equipment layouts which identify assembly and installation details.

b. Plans and elevations which identify clearances required for maintenance and operation.

c. Wiring diagrams which identify each component individually and all interconnected or interlocked relationships between components.

d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.

e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment must be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products must have been in satisfactory commercial or industrial use for two years prior to bid opening. The two year use must include applications of equipment and materials under similar circumstances and of similar size. The two years experience must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a two year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. System components must be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including chillers, water coolers, heat exchanges, and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates must be durable and legible throughout equipment life and made of [anodized aluminum][stainless steel][_____]. Plates must be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. [Motor bearings must be fitted with grease supply fittings and grease relief to outside of the enclosure.] Motor enclosure type may be either TEAO or TEFC.

e. [Where two-speed motors are indicated, variable-speed controllers may be provided to accomplish the same function.][Use adjustable frequency drives for all variable-speed motor applications.] Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 CHILLER COMPONENTS

[2.4.1 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, must be provided. Tools must be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

]2.5 ABSORPTION WATER CHILLER

2.5.1 General

Chiller must be tested and rated in accordance with ANSI/AHRI 560, ANSI/ASHRAE 15 & 34 and must bear the appropriate underwriter's laboratories (UL) label. [Integrated Part Load Value (IPLV)] [Application Part Load Value (APLV)] of [_____] COP in accordance with ANSI/AHRI 560. Chiller must have a minimum cooling COP of [_____] at part load conditions in accordance with ANSI/AHRI 560. Chiller must be the [single-stage] [two-stage] hermetic, water-cooled type design. Chiller must be [indirectly-fired with [steam] [hot water]] [directly-fired with a [single] [dual] fuel burner]. [For direct-fired units, ratings for cooling capacity, fuel consumption, and COP must be based on the higher heating value (HHV) or the specific type of fuel utilized.] Chiller exterior surfaces must be factory painted, finished, and insulated as applicable.

2.5.2 Assembly

Unless necessary for delivery purposes, chiller must be assembled, leak-tested, charged, and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged, and adjusted at the job site by a factory representative. Unit components delivered separately must be sealed and charged with a nitrogen holding charge. Unit assembly must be completed in strict accordance with manufacturer's recommendations.

2.5.3 Operation

Chiller must operate within capacity range and speed recommended by the manufacturer. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair must have lifting eyes or lugs. Chiller must be provided with insulation on surfaces subject to sweating including the water cooler and water boxes. Chiller must be provided from the factory with a single point wiring connection for incoming power supply. Magnetic across-the-line motor starters with overload protection must be provided for each factory supplied pump. Chiller must include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Unit shall be capable of operating automatically and continuously between 10 percent and 100 percent of full load.

2.5.4 Components

Chiller shall include the following as a minimum:

a. Absorber, evaporator, and condenser

b. [Generator][First and second stage generators]

c. Refrigerant, absorber, and inhibitor solutions

d. [Low][Low and high] temperature heat exchanger(s)

e. Self-contained, hermetically sealed, self lubricating, water cooled, refrigerant and solution pumps. Pumps shall be direct coupled with the motor and shall include isolation valves.

f. Anticrystallization or automatic decrystallization system

[g. Factory-installed combustion burner assembly and pre-piped fuel train

][h. Cooling/heating switch valve

][i. Exhaust gas economizer

] j. [Automatic][Manual] purge system

k. Chiller controls package

l. Interconnecting piping and wiring

m. [Grooved mechanical][Flanged][Welded] connections for water boxes

n. Refrigerant spray nozzles

o. Factory-mounted structural steel base (welded or bolted) or support legs

p. Thermometers and sight glasses to allow visual inspection of unit operation. Mercury shall not be used in thermometers.

2.5.4.1 Absorber, Evaporator, Condenser & Generator

The absorption unit shall be of the shell-and-tube type construction which shall be designed, constructed, tested, and certified in accordance with ASME BPVC SEC VIII D1. The absorber, evaporator, and condenser shall be suitable for not less than [150][250] psig working pressure. The generator shall have a heating medium of [steam] [hot water]. The absorption unit may be enclosed in one or two shells with removable water boxes or heads. Condenser tubes shall be seamless copper or copper-nickel. Generator tubes shall be seamless copper-nickel. Absorber and evaporator tubes shall be either seamless copper or seamless copper-nickel. Tube ends shall be rolled into or silver brazed to tube sheets. All copper or copper-nickel tubes shall be seamless and be in accordance with ASTM B395/B395M. [For double effect absorption chiller[/heaters], first stage concentrator tubes shall be titanium and the steam circuit shall comply with ASME BPVC SEC VIII D1. Double effect absorption chillers[/heaters] shall be equipped with capacity modulation to control solution flow entering and leaving the first stage concentrator.]

2.5.4.2 Tube Bundles

Provide sufficient clearance between tubes and an adequate number of support sheets, with tubes fitted in the sheets, to prevent chafing of tubes or crevice corrosion due to uneven tube expansion, vibration, or pulsation. Holes in the tube sheets shall not have sharp corners. Each tube shall be removable, in one piece, through holes individually provided for it in tube and support sheets. Water velocities through cooler, condenser and absorber tubes shall range from less than 3 to 12 fps. Condenser shall be [single][double]-tube bundle type.

2.5.4.3 Heads

Provide removable, welded-steel or cast-iron heads for external steam and water connections to permit access to tubes for inspection and cleaning. Design and test water spaces for a working pressure of not less than 150 psig. Water spaces that are not subject to the ASME Code, due to the size or other limitations, shall be tested at a pressure of not less than 1.5 times the working pressure.

2.5.4.4 Purge System

Provide chiller with an automatically controlled purge system consisting of a motor driven, jet type, or viscosity type, high vacuum pump with separators, pipe connections, and controls. Provide positive protection against return air to unit when evacuator is not in operation.

2.5.4.5 Crystallization

Provide for automatic decrystallization or anti-crystallization, in accordance with manufacturer's standard. If decrystallization is used, provide and arrange for supplemental heating elements if required for automatic operation.

2.5.4.6 Refrigerant and Absorber

Refrigerants shall be distilled or deionized water. Absorbent shall be lithium bromide.

Absorber unit shall be fully charged with water and a nontoxic absorber after installation. Refrigerant and inhibitors shall not generate films that would reduce machine efficiency by coating tubes. The corrosion inhibitor shall not cause the solution to be classified as hazardous waste under the Resource Conservation and Recovery Act.

2.5.5 Combustion Burner Assembly

Chiller shall be provided with a forced draft, flame retention type burner and fuel train assembly. Burner shall be the [single] [dual] fuel type capable of burning [natural gas] [propane] [and] [number 1 fuel oil] [number 2 fuel oil] [diesel]. Burner and fuel train shall be listed by the underwriters laboratories (UL). Burner assembly shall be provided with all pressure regulators, switches, controls, ignition system, blower fans, and other devices required for proper and safe operation of the burner. Burner assembly shall be equipped with an external primary-secondary air ratio adjustment that allows adjustment without dismantling the burner. Burner controls shall allow either manual or automatic burner operation. Fuel changeover shall be accomplished [by a manual fuel changeover switch] [automatically as indicated].

2.5.6 Controls Package

Chiller shall be provided with a complete factory mounted and prewired electric or microprocessor based control system. Controls package shall be [unit-mounted] [floor-mounted where indicated] which contains as a minimum a digital display or acceptable gauges, an on-auto-off switch, motor starters, power wiring, control wiring, and disconnect switches. Controls package shall provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and UMCS interfaces as defined below.

2.5.6.1 Operating Controls

Chiller shall be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.

2.5.6.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

b. Entering and leaving condenser water temperatures

c. Refrigerant and solution temperatures

d. Generator pressures and temperatures

e. Self diagnostic

f. Operation status

g. Operating hours

h. Number of starts

i. Number of purge cycles over the last 7 days

2.5.6.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. No parameters shall be capable of being changed without first entering a security access code. The programmable setpoints shall include the following as a minimum.

a. Leaving Chilled Water Temperature

b. Leaving Condenser Water Temperature

c. Time Clock/Calendar Date

2.5.6.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Refrigerant or solution pump thermal or current overload

b. Low refrigerant temperature

c. Loss of chilled water

d. Loss of condenser water

e. High or low condenser water temperatures

f. Power failure

g. Generator high temperature or pressure

h. Low solution level

[i. Burner or related combustion malfunction
]
[j. Burner controls and [gas][oil] train.

]2.5.6.5 Remote Alarm

During the initiation of a safety shutdown, the control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 4 inch diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.5.6.6 Utility Monitoring and Control System

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

a. Remote Unit Start/Stop

b. Remote Chilled Water Reset

c. Remote Condenser Water Reset

2.6 ACCESSORIES

2.6.1 Cleaning Brushes

Furnish chiller with two brushes, having jointed rods, suitable for cleaning evaporator and condenser tubes.

2.6.2 Gaskets

Gaskets shall conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 700 degrees F service.

2.6.3 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish.

2.7.2 Factory Applied Insulation

Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it shall be installed to provide easy removal and replacement of heads without damage to the insulation. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.8 SUPPLEMENTAL COMPONENTS/SERVICES

2.8.1 Charging and Testing

Unless fully assembled, tested, evacuated, and charged at factory, components shall be dried and sealed to prevent corrosion of internal surfaces prior to field assembly. Assemble, test, evacuate, and charge units under supervision of manufacturer's representative. Periodic tests shall be readily made on the concentration of the inhibitor and lithium bromide solution with a field test kit furnished by the manufacturer, or as recommended by the manufacturer.

2.8.2 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.8.3 Cooling Tower

Cooling towers shall be provided and installed in accordance with Section 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.

2.8.4 Temperature Controls

Chiller control packages shall be fully coordinated with and integrated [into the temperature control system indicated in Section 23 30 00 HVAC AIR DISTRIBUTION, [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC] [Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]][into the existing air-conditioning system].

PART 3 EXECUTION

3.1 INSTALLATION

Installation of absorption chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the manufacturer's written installation instructions, including the following:

[(1) Water chiller - installation instructions

]3.1.1 Installation Instructions

Provide manufacturer's standard catalog data, at least [5] [_____] weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials of construction, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions and procedures. Data must be adequate to demonstrate compliance with contract requirements

3.1.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.1.3 Posted Instructions

Provide posted instructions including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions must include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions must be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

3.1.4 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.1.5 System Performance Test Schedules

Provide a schedule, at least [2][_____] weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test.

3.1.6 Demonstrations

Provide a schedule, at least [2][_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

3.1.7 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above must be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

3.1.8 Operation and Maintenance Manuals

Provide [Six][_____] complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least [4][_____] weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. [Six][_____] complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.1.9 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting , and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.10 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.1.11 Field Applied Insulation

Field installed insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.12 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided for [_____] days. The representative shall advise on the following:

Absorption Units:

(1) Testing and evacuation.

(2) Charging the machine with lithium bromide solution and refrigerant water (distilled or deionized water).

(3) Starting the machine.

3.3 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing shall be as specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

3.4 FIELD ACCEPTANCE TESTING

3.4.1 Test Plans

a. Manufacturer's Test Plans: Within [120] [_____] calendar days after contract award, submit the following plans:

[Absorption water chiller - field acceptance test plan

] Field acceptance test plans shall be developed by the absorption chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the absorption chiller and subsequent test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under [Section 23 09 53.00 20, SPACE TEMPERATURE CONTROL SYSTEMS] [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

c. Prerequisite testing: Absorption chillers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

    Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

    Controller shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test.

    Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Chiller manufacturer shall furnish with each test procedure a description of acceptable results that have been verified.

    Chiller manufacturer shall identify the acceptable limits or tolerance within which each tested performance variable shall acceptably operate.

f. Job specific: Each test plan shall be job specific and shall address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as pressure valves.

3.4.2 Testing

a. Each absorption chiller system shall be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

[Absorption water chiller - field acceptance test report

] b. Manufacturer's recommended testing: Conduct the manufacturer's recommended field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.5 SYSTEM PERFORMANCE TESTS

[Six][_____] copies of the report must be provided in bound 8 1/2 by 11 inch booklets.

3.5.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than [48] [_____] hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5.2 Test Report

The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees F apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

(1) For absorption units, the cooling water pressures and temperatures entering and exiting the absorber and condenser. Also the refrigerant solution pressures, concentrations, and temperatures at each measurable point within the system.

(2) Running current, voltage and proper phase sequence for each phase of all motors.

(3) The actual on-site setting of all operating and safety controls.

(4) Chilled water pressure, flow and temperature in and out of the chiller.

(5) The position of the [capacity-reduction gear] [gas supply control valve] [fuel oil supply valve] at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.6 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

-- End of Section --

SECTION 23 64 10

WATER CHILLERS, VAPOR COMPRESSION TYPE

11/16, CHG 2: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 450	(2007) Water-Cooled Refrigerant Condensers, Remote Type
AHRI 480	(2007) Refrigerant-Cooled Liquid Coolers, Remote Type
AHRI 550/590 I-P	(2020) Performance Rating Of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle
AHRI 575	(2017) Method of Measuring Machinery Sound Within an Equipment Space
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-6 2021; Addenda AS-BF 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 37	(2021) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 54	(2021) National Fuel Gas Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J537	(2016) Storage Batteries

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82	Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2015; Reprint Feb 2021) UL Standard for Safety Battery Chargers for Charging

Engine-Starter Batteries

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Water Chiller; G[, [_____]]

Posted Instructions

Verification of Dimensions

Factory Tests

System Performance Tests

Demonstrations

Refrigerant

[Water Chiller - Field Acceptance Test Plan

] SD-06 Test Reports

Field Acceptance Testing

[Water Chiller - Field Acceptance Test Report

] Factory Tests

System Performance Tests

SD-07 Certificates

Refrigeration System; G[, [_____]]

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

[Water Chiller - Installation Instructions; G[, [_____]]

] SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.3 CERTIFICATIONS

1.3.1 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items must be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation will be the Contractor's responsibility. Any materials found to be damaged must be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.6 PROJECT REQUIREMENTS

1.6.1 Verification of Dimensions

The Contractor must become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment will be standard Commercial cataloged products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. These products must have a two year record of satisfactory field service prior to bid opening. The two year record of service must include applications of equipment and materials under similar circumstances and of similar size. Products having less than a two year record of satisfactory field service will be acceptable if a certified record of satisfactory field service for not less than 6000 hours can be shown. The 6000 hour service record must not include any manufacturer's prototype or factory testing. Satisfactory field service must have been completed by a product that has been, and presently is being sold or offered for sale on the commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

[Major equipment including chillers, compressors, compressor drivers, condensers, water coolers, receivers, refrigerant leak detectors, heat exchanges, fans, and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates must be durable and legible throughout equipment life. Plates must be fixed in prominent locations with nonferrous screws or bolts.

][Nameplates are required on major components if the manufacturer needs to provide specific engineering and manufacturing information pertaining to the particular component. Should replacement of this component be required, nameplate information will insure correct operation of the unit after replacement of this component.

]2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. [Motor bearings must be fitted with grease supply fittings and grease relief to outside of the enclosure.] Motor enclosure type may be either TEAO or TEFC.

e. [Where two-speed motors are indicated, variable-speed controllers may be provided to accomplish the same function.][Use adjustable frequency drives for all variable-speed motor applications.] Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 SELF-CONTAINED WATER CHILLERS, VAPOR COMPRESSION TYPE

Unless necessary for delivery purposes, units must be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately must be sealed and charged with a nitrogen holding charge. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, must have lifting eyes or lugs. Chiller must be provided with a single point wiring connection for incoming power supply. Chiller's condenser and water cooler must be provided with [standard] [marine] water boxes with [grooved mechanical] [flanged] [welded] connections.

2.4.1 Scroll, Reciprocating, or Rotary Screw Type

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Scroll, reciprocating, or rotary screw compressor

f. Compressor driver, [electric motor] [gas-engine]

g. Compressor driver connection

h. Water cooler (evaporator)

i. [Air][Water]-cooled condenser coil

[j. Heat recovery condenser

][k. Receiver
]
[l. Tools

]2.4.2 Centrifugal or Rotary Screw Type

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Centrifugal or rotary screw compressor

f. Compressor driver, [electric motor] [gas-engine] [steam turbine]

g. Compressor driver connection

h. Water cooler (evaporator)

i. [Air][Water]-cooled condenser coil

[j. Heat recovery condenser coil

][k. Receiver

] l. Purge system for chillers which operate below atmospheric pressure

[m. Tools

]2.5 SPLIT-SYSTEM WATER CHILLER, VAPOR COMPRESSION TYPE

Total chiller system must be certified for performance per AHRI 550/590 I-P. If chiller is not in scope of AHRI 550/590 I-P then chiller must be rated in accordance with AHRI 550/590 I-P. Individual chiller components must be constructed and rated in accordance with the applicable AHRI standards. Chiller system must conform to ANSI/ASHRAE 15 & 34. The chiller must be ASHRAE 90.1 - IP compliant and meet 10 CFR Part 433, 434 and 435 efficiency performance standards for federal construction. The manufacturer must provide certification of compliance. Chiller must be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site in strict accordance with manufacturer's recommendations. Unit components delivered separately must be sealed and charged with a nitrogen holding charge. Unit assembly must be completed in strict accordance with manufacturer's recommendations. Chiller must operate within capacity range and speed recommended by the manufacturer. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair, must have lifting eyes or lugs. Chiller must include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller's water cooler must be provided with [standard] [marine] water boxes with [grooved mechanical] [flanged] [welded] connections. Chillers must operate at partial load conditions without increased vibration over normal vibration at full load, and must be capable of continuous operation down to minimum capacity. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

[e. Receiver
]
[f. Tools

]2.5.1 Compressor-Chiller Unit

As a minimum, the compressor-chiller unit must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor

b. Compressor driver, electric motor

c. Compressor driver connection

d. Water cooler (evaporator)

2.5.2 Condensing Unit

As a minimum, the condensing unit must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor

b. Compressor driver, electric motor

c. Compressor driver connection

d. Air or water cooled condenser

2.5.3 Remote Water Cooler (Evaporator)

2.5.3.1 Shell and Tube Type

Cooler must be constructed and rated in accordance with AHRI 480. Cooler must be of the shell-and-coil or shell-and-tube type design. Cooler's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Cooler's water side must be designed and factory pressure tested for not less than [150] [250] [300] psi. Cooler shell must be constructed of seamless or welded steel. [Coil bundles must be totally removable and arranged to drain completely.] Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Cooler must be skid-mounted. Refrigerant circuit must be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. For the water side of water cooler, performance must be based on a fluid velocity not less than 3 fps and not more than 12 fps and a fouling factor per AHRI 550/590 I-P.[Evaporator must be provided with electric freeze protection type.]

2.5.3.2 Brazed Plate Type

Cooler must be rated in accordance with AHRI 480. Cooler must be of the brazed plate design. Cooler's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Cooler's water side must be designed and factory pressure tested for not less than [150] [250] [300] psi. Cooler shell must be constructed of stainless steel plates brazed together with copper. Refrigerant circuit must be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. For the water side of water cooler, performance must be based on a fluid velocity not less than 3 fps and not more than 12 fps and a fouling factor per AHRI 550/590 I-P. [Evaporator must be provided with electric freeze protection type.]

2.5.4 Remote Air-Cooled Condenser

Condenser must be a factory-fabricated and assembled unit, consisting of coils, fans, and condenser fan motors. Condenser must be rated in accordance with ANSI/AHRI 460. [Unless the condenser coil is completely protected through inherent design, louvered panel coil guards must be provided by the manufacturer to prevent physical damage to the coil.] Manufacturer must certify that the condenser and associated equipment are designed for the submitted condensing temperature. For design conditions, if matched combination catalog ratings matching remote condensers to compressors are not available, the Contractor must furnish a crossplotting of the gross heat rejection of the condenser against the gross heat rejection of the compressor, for the design conditions to show the compatibility of the equipment furnished.

2.5.4.1 Condenser Casing

Condenser casing must be aluminum not less than [0.040] [0.080] inch or hot-dip galvanized steel not lighter than 18 gauge 0.0516 inch. [Condensers having horizontal air discharge must be provided with discharge baffle to direct air upward, constructed of the same material and thickness as the casing].

2.5.4.2 Coil

[Condenser coil must be of the extended-surface fin-and-tube type and must be constructed of seamless [copper] [or] [aluminum] tubes with compatible [copper] [or] [aluminum] fins. Fins must be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils must be circuited and sized for a minimum of 5 degrees F subcooling and full pumpdown capacity. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.][The condenser coil must be of the microchannel heat exchanger technology (MCHX) type consisting of a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds in a two-pass arrangement. Provide coils constructed of aluminum alloys for fins, tubes, and manifolds. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.]

[Coil must be entirely coated in accordance with the requirements of paragraph COIL CORROSION PROTECTION.

]2.5.4.3 Fans

Provide centrifugal or propeller type fans as best suited for the application. Fans must be direct [or] [V-belt] driven. [Belt drives must be completely enclosed within the unit casing or equipped with a guard.] [When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment must be provided. Sheave sets must be matched and selected to provide the capacity indicated at the approximate midpoint of the adjustment.] Fans must be statically and dynamically balanced.

2.5.4.4 Condenser Sizing

Size condensers for full capacity at 30 degrees F temperature difference between entering outside air and condensing refrigerant. Subcooling must not be considered in determining compressor and condenser capacities. For design conditions, submit a cross-plot of net refrigeration effect of compressor to establish net refrigeration effect and compatibility of equipment furnished.

2.5.4.5 Low Ambient Control

Provide factory mounted head pressure control for operation during low ambient conditions. Head pressure must be controlled by [fan cycling,] [fan speed control,] [condenser refrigerant flooding]. Low ambient control must permit compressor operation below[40 degrees F][0 degrees F][[_____] degrees F].

2.5.4.6 High Ambient Unloading

Provide unloading capability to allow operation in high ambient conditions [[_____] degrees F] above design conditions.

2.5.5 Remote Water-Cooled Condenser

Condenser must be a factory-fabricated and assembled unit constructed and rated in accordance with AHRI 450. Condenser may be of either the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side must be designed and factory pressure tested for not less than [150] [250] [300] psi. Condensers must be complete with pressure relief valve or rupture disk, water drain connections, refrigerant charging valve, refrigerant valves, liquid-level indicating devices, and stand or saddle. Low pressure refrigerant condenser must be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell must be constructed of seamless or welded steel. [Coil bundles must be totally removable and arranged to drain completely.] Tubes may be either seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable, except for the coaxial tubes. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Condenser performance must be based on water velocities not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 20 percent in excess of the fully charged system for remote water cooled condensers. As a minimum, the condenser must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Liquid-level indicating devices.

b. Companion flanges, bolts, and gaskets for flanged water connections.

2.6 CHILLER COMPONENTS

2.6.1 Refrigerant and Oil

Refrigerants must be one of the fluorocarbon gases. Refrigerants must have number designations and safety classifications in accordance with ANSI/ASHRAE 15 & 34. CFC-based refrigerants are prohibited. Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0, with the exception of R-123. Provide SDS sheets for all refrigerants.

2.6.2 Structural Base

Chiller and individual chiller components must be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components must be isolated from the building structure by means of [molded neoprene isolation pads.] [vibration isolators with published load ratings. Vibration isolators must have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.]

2.6.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit must be completely piped and factory leak tested in accordance with ANSI/ASHRAE 15 & 34. [For multicompressor units, not less than 2 independent refrigerant circuits must be provided.]Circuit must include as a minimum a [combination filter and drier,] combination sight glass and moisture indicator, an electronic or thermostatic expansion valve with external equalizer or float valve, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.6.4 Controls Package

Provide chillers with a complete [factory-mounted] [remote-mounted where indicated], microprocessor based operating and safety control system. Controls package must contain as a minimum a digital display, an on-auto-off switch, [motor starters,] [variable frequency motor controller,] [disconnect switches,] power wiring, and control wiring. Controls package must provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and [BAS] [UMCS] interfaces as defined below.

2.6.4.1 Operating Controls

Chiller must be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. Adjustable timer or automated controls to prevent a compressor from short cycling

c. Automatic lead/lag controls (adjustable) for multi-compressor units

d. Load limiting

e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls must automatically re-cycle the chiller on power interruption.

f. Startup and head pressure controls to allow system operation at all ambient temperatures down to [_____] degrees F.

[g. Fan sequencing for air-cooled condenser

]2.6.4.2 Monitoring Capabilities

During normal operations, the control system must be capable of monitoring and displaying the following operating parameters. Access and operation of display must not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

b. [Entering and leaving chilled water pressure][Chilled water flow]

c. [Entering and leaving condenser water pressure][Condenser water flow]

d. Self diagnostic

e. Operation status

f. Operating hours

g. Number of starts

h. Compressor status (on or off)

i. Compressor load (percent)

j. Refrigerant discharge and suction pressures

k. Magnetic bearing levitation status (if applicable)

l. Magnetic bearing temperatures (if applicable)

m. Oil pressure

[n. Condenser water entering and leaving temperatures

][o. Number of purge cycles over the last 7 days

]2.6.4.3 Configurable Setpoints

The control system must be capable of being configured directly at the unit's interface panel. [No parameters may be capable of being changed without first entering a security access code.] The programmable setpoints must include the following as a minimum:

a. Leaving Chilled Water Temperature

[b. Leaving Condenser Water Temperature

][c. Time Clock/Calendar Date

]2.6.4.4 Safety Controls with Manual Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Low chilled water temperature protection

b. High condenser refrigerant discharge pressure protection

c. Low evaporator pressure protection

d. Chilled water flow detection

e. High motor winding temperature protection

f. Low oil flow protection if applicable

g. Magnetic bearing controller (MBC), Internal fault (if applicable)

h. MBC, High bearing temperature (if applicable)

i. MBC, Communication fault (if applicable)

j. MBC, Power supply fault (if applicable)

[k. Motor current overload and phase loss protection

]2.6.4.5 Safety Controls with Automatic Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

a. Over/under voltage protection

b. Chilled water flow interlock

c. MBC, Vibration (if applicable)

d. MBC, No levitation (if applicable)

[e. Phase reversal protection

]2.6.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system must be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor must provide an alarm circuit (including transformer if applicable) and a minimum 4 inch diameter alarm bell. Alarm circuit must activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell must not sound for a chiller that uses low-pressure cutout as an operating control.

2.6.4.7 Utility Monitoring and Control System Interface

Provide a Utility Monitoring and Control System (UMCS) interface meeting the requirements of Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and the requirements of [Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]. The interface must provide all system operating conditions, capacity controls, and safety shutdown conditions as network points. In addition, the following points must be overridable via the network interface:

a. Unit Start/Stop

[b. Leaving Chilled Water Temperature Setpoint

][c. Leaving Condenser Water Temperature Setpoint

]2.6.5 Compressor(s)

2.6.5.1 Scroll Compressor(s)

Compressors must be of the hermetically sealed design. Compressors must be mounted on vibration isolators to minimize vibration and noise. Rotating parts must be statically and dynamically balanced at the factory to minimize vibration. Lubrication system must be centrifugal pump type equipped with a means for determining oil level and an oil charging valve. Crankcase oil heater must be provided.[Provide continuous compressor unloading to [10 percent][15 percent] of full-load capacity by way of variable speed compressor motor controller or variable unloading of the scroll.]

2.6.5.2 Rotary Screw Compressor(s)

Compressors must operate stably for indefinite time periods to at least 25 percent capacity reduction without gas bypass external to the compressor. Provision must be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors must include:

a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Allow access to internal compressor components for repairs, inspection, and replacement of parts.

b. Rotors must be solid steel, possessing sufficient rigidity for proper operation.

c. A maximum rotor operating speed no greater than 3600 RPM. Provide cast iron rotor housing.

d. Casings of cast iron, precision machined for minimal clearance about periphery of rotors with minimal clearance at rotor tops and rotor ends.

e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

f. Bearing housing must be conservatively loaded and rated for an L(10) life of not less than 200,000 hours. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11.

g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.

h. [A temperature- or pressure-initiated, hydraulically actuated, single-slide-valve, capacity-control system to provide minimum automatic capacity modulation from 100 percent to 15 percent.] [Use a Variable Frequency Drive (VFD) to modulate capacity modulation from 100 percent to 15 percent.]

i. An oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.

j. Crankcase oil heaters must be provided.

2.6.5.3 Centrifugal Compressor(s)

Centrifugal compressors may be either single or multistage, having dynamically balanced impellers, either direct or gear driven by the compressor driver. Impellers must be over-speed tested at 1.2 times the impeller-shaft speed. Impeller shaft must be steel with sufficient rigidity for proper operation at any required operating speed. Compressors must be capable of variable speed operation and may have either oil-free bearing drives or oil-lubricated bearing drives. Centrifugal compressors must include:

a. Shaft main bearings that are either oil lubricated, oil free ceramic or magnetic levitated. The oil lubricated bearings must be the rolling element type in accordance with ABMA 9 or ABMA 11, journal type with bronze or babbitt liners, or of the aluminum-alloy one-piece insert type. Oil lubricated or oil free ceramic bearings must be rated for an L(10) life of not less than 200,000 hours. Magnetic levitated main shaft bearings must be in accordance with ISO 14839-1, ISO 14839-2, ISO 14839-3, ISO 14839-4, and provided with radial and axial magnetic levitated bearings (combination permanent and electro magnets) to levitate the shaft thereby eliminating metal to metal contact and thus eliminating the need for oil. The active magnetic bearings must be equipped with an automatic vibration reduction and balancing system. Each bearing position must be sensed by position sensors and provide real time positioning of the rotor shaft, controlled by on-board digital electronics. In the event of a power failure, the magnetic bearings will remain in operation throughout the compressor coast-down using a reserve power supply. Provide mechanical bearings designed for emergency touchdowns, as a backup to the magnetic bearings.

b. Casing of cast iron, aluminum, or steel plate with split sections gasketed and bolted or clamped together.

c. Lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

d. Provisions to ensure proper lubrication of bearings and shaft seals prior to starting and upon stopping with or without electric power supply (if applicable). On units providing forced-feed lubrication prior to starting, a differential oil pressure cutout interlocked with the compressor starting equipment must allow the compressor to operate only when the required oil pressure is provided to the bearings (if applicable).

e. Oil sump heaters controlled as recommended by the manufacturer.

f. Temperature-or pressure-actuated prerotation vane, variable geometry diffuser or suction damper to provide automatic capacity modulation from 100 percent capacity to 25 percent capacity. If operation to 25 percent capacity cannot be achieved without providing gas bypass external to the compressor, then the Contractor must indicate in the equipment submittal the load percent at which external hot gas bypass is required to prevent surge and to provide the specified capacity reduction and its impact on performance.

2.6.6 Compressor Driver, Electric Motor

Components such as motors, [starters], [variable speed drives] and wiring must be in accordance with paragraph ELECTRICAL WORK. [Motor starter][Variable frequency drive] must be [unit mounted] [remote mounted] as indicated with [starter][variable frequency drive] type, wiring, and accessories coordinated with the chiller manufacturer.

2.6.7 Compressor Driver, Gas-Engine

Gas-engine compressor driver must operate on natural gas and be in accordance with NFPA 37 and NFPA 54. Engine must be designed for stationary applications and include all ancillaries necessary for operation. Engine must be a manufacturer's standard production model and be specifically designed for chiller operation. Engine must include as a minimum a [heavy duty industrial] [standard automotive] grade block, starting system, lubrication system, coolant system, engine heat exchanger, [engine cooling radiator,] fuel supply system, electronic ignition, and controls package. Engine must be either [naturally aspirated,] [supercharged,] or [turbocharged] and include appropriate air filters. Engine must be 2- or 4-stroke-cycle and compression-ignition type. Engine must be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. Engine must have a minimum of 2 cylinders. Opposed-piston type engines must have not less than 4 cylinders. Engine block must have a coolant drain port.

2.6.7.1 Starting System

Engine starting system must be either the [electric] [pneumatic] type and be of sufficient capacity, at the maximum temperature specified, to crank the engine without damage or overheating. [Electric starting system must operate on a [24] [_____]-volt DC system utilizing a negative circuit ground. A starting battery system must be provided and must include the battery, corrosion resistant battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Battery must be in accordance with SAE J537. Battery charger must conform to UL 1236 and be the current-limiting type with overcurrent protection.] [Pneumatic starting system must be as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE, for a working pressure of 150 psi.]

2.6.7.2 Lubrication System

Engine must be provided with a pressurized oil lubrication system. System must include a lubrication oil pump that is engine driven. One full-flow filter must be provided for each pump. Filters must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. System pressure must be regulated as recommended by the engine manufacturer. A pressure relief valve must be provided on the crankcase. Crankcase breathers must be piped to the outside. System must be readily accessible for servicing such as draining, refilling, and overhauling.

2.6.7.3 Coolant System

Engine must include an automatic engine jacket water cooling system. Water must be circulated through the system with an engine-driven circulating pump. [System coolant must use a combination water and ethylene-glycol sufficient for freeze protection at the minimum temperature specified.]

[2.6.7.4 Engine Heat Exchanger

Engine heat exchanger must be of the shell-and-tube type construction and be in accordance with ASME BPVC SEC VIII D1. Shell material must be carbon steel. Tubes must be seamless copper or copper-nickel. Tubes must be individually replaceable. Unit's waterside working pressure must be rated for not less than 150 psig and factory tested at 150 percent of design working pressure. Water connections larger than 3 inches must be ASME

Class 1500 flanged. Unit must be provided with gasketed removable covers, drains, and vents.

][2.6.7.5 Engine Cooling Radiator

Heat exchanger may be factory coated with corrosive resistant film, provided that correction measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Internal surfaces must be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers must be the pressure type incorporating a pressure valve, vacuum valve and a cap. Caps must be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system must be capable of withstanding a minimum pressure of 7 psi and must be protected with a strong grille or screen guard. Each heat exchanger must have at least 2 tapped holes; one must be equipped with a drain cock, the rest must be plugged.

]2.6.7.6 Fuel Supply System

Engine fuel supply system must be factory mounted. System must include as a minimum a solenoid shut-off valve, a gas pressure regulator, and carburetors (including a throttle body assembly) or fuel injectors.

2.6.7.7 Controls Package

The controls for the gas-engine must be incorporated into the overall controls package for the water chiller. The engine controls must be capable of monitoring, displaying, and controlling, as applicable, the following conditions. The control system must be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data must include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system must also be capable of receiving at a minimum the following operating conditions:

a. Coolant-fluid inlet and outlet temperatures

b. Lubricating-oil inlet and outlet temperatures and pressures

c. Engine run-time hours

d. Engine current status mode (on/off)

e. Engine speed

f. Percent engine load

g. Engine jacket temperature

2.6.7.8 Exhaust Piping

Exhaust piping must be ASTM A53/A53M Schedule 40 seamless black iron, exhaust piping installation must be per the engine manufacturer's recommendations, except as modified herein. Horizontal sections of exhaust piping must be sloped downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction must be long radius. Exhaust piping and mufflers must be insulated in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL

SYSTEMS. Vertical exhaust piping must be provided with a hinged, gravity-operated, self-closing, rain cover.

2.6.7.9 Exhaust Muffler

Engine must be provided with a chamber type exhaust muffler. The muffler must be of welded steel and designed for [outside] [inside] [vertical] [horizontal] mounting. Eyebolts, lugs, flanges, or other items must be provided as necessary for support in the location and position indicated. Pressure drop through the muffler must not exceed the recommendations of the engine manufacturer. Outside mufflers must be zinc coated or painted with high temperature [_____ degrees F] resisting paint. The muffler and exhaust piping together must reduce the noise level to less than [_____] dBa at a distance of 75 feet from the end of the exhaust piping with the chiller operating at 100 percent of rated output capacity. The muffler must have a drain valve, nipple, and cap at the low-point of the muffler.

2.6.7.10 Exhaust System Connections

Flexible connectors must be provided at the exhaust piping connection to the engine. An expansion joint must be provided in the exhaust piping at the muffler connection. Flexible connectors and expansion joints must have flanged connections. Flexible sections must be made of convoluted seamless tube without joints or packing. Expansion joints must be the bellows type. Expansion and flexible elements must be stainless steel suitable for engine exhaust gas at 1200 degrees F. Flexible connectors and expansion joints must be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.6.8 Compressor Driver, Steam Turbine

Steam turbine must be suitable for direct connection to the compressor. Turbine must have a capacity 10 percent greater than the compressor brake horsepower requirement at full-load condition. Steam strainer must be either internally mounted or installed in connecting piping. Turbine must include sentinel warning valve, forced-feed lubrication, oil cooler, oil reservoir, oil relief valve, oil piping, oil-pressure gauge, tachometer, and gland-seal piping if a condensing turbine is used. If a non-condensing turbine is used, provision must be made for drain piping. The turbine must be suitable for automatic control. An overspeed trip governor must be provided to shut off the steam supply at 115 percent of design speed. Provision must be made to stop the turbine upon operation of the compressor safety devices and upon power failure by the use of a solenoid trip on the emergency overspeed governor. Turbine must be governed by a pneumatically controlled hydraulic governor during automatic operation and with a manual control effective during failure of the air supply. Pneumatic valve must be actuated by a temperature controller with its sensing element in contact with the chilled water. Turbine must be designed to operate at the steam pressure and exhaust conditions indicated. If the turbine is a condensing type, a surface-type steam condenser complete with single-stage air ejector, inter- and after-condenser, electric-driven dual condensate pumps, atmospheric relief valve, and expansion joint must be furnished.

2.6.9 Compressor Driver Connections

[Each compressor must be driven by a V-belt drive or direct connected through a flexible coupling, except that flexible coupling is not required on hermetic units. V-belt drives must be designed for not less than 150 percent of the driving motor capacity. Flexible couplings must be of the type that does not require lubrication.] [Each machine driven through speed-increasing gears must be so designed as to assure self-alignment, interchangeable parts, proper lubrication system, and minimum unbalanced forces. Bearings must be of the sleeve or roller type. Gear cases must be oil tight. Shaft extensions must be provided with seals to retain oil and exclude all dust.

]2.6.10 Water Cooler (Evaporator)

Cooler must be of the shell-and-coil or shell-and-tube type design. Cooler shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on a water velocity not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P.

Brazed plate heat exchanger must be constructed of 304 or 316 stainless steel, designed to a refrigerant-side working pressure of 430 psig and a waterside working pressure of 150 psig. Evaporator must be factory tested at 1.1 times maximum allowable refrigerant side working pressure and 1.5 times maximum allowable water side working pressure. [Provide cooler heaters to protect the evaporator to an ambient of minus 20 degrees F.]Provide cooler with factory-installed flow switches. All water connections must use either flanged or grooved-pipe connections. Factory insulate all cold surfaces.

2.6.11 Air-Cooled Condenser Coil

[Condenser coil must be of the extended-surface fin-and-tube type and must be constructed of seamless [copper] [or] [aluminum] tubes with compatible [copper] [or] [aluminum] fins. Fins must be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils must be circuited and sized for a minimum of 5 degrees F subcooling and full pumpdown capacity. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.][The condenser coil must be of the microchannel heat exchanger technology (MCHX) type consisting of a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds in a two-pass arrangement. Provide coils constructed of aluminum alloys for fins, tubes, and manifolds. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.]

[Coil must be entirely coated in accordance with the requirements of paragraph COIL CORROSION PROTECTION.

]2.6.12 Water-Cooled Condenser Coil

Condenser must be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side must be designed and factory pressure tested for not less than [150] [250] [300] psi. Condensers must be complete with refrigerant relief valve/rupture disc assembly, water drain connections, and refrigerant charging valve. Low pressure refrigerant condenser must be provided with a purging device to purge non-condensibles trapped in the condenser while keeping refrigerant emissions below requirements of ASHRAE Std 147. Purge units must be certified per AHRI 580. Condenser shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable, except for the coaxial tubes. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on water velocities not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 5 percent in excess of the fully charged system for single packaged systems.

2.6.13 Heat Recovery Condenser Coil

Condenser must be of the shell-and-coil or shell-and-tube type design and must not be a part of the standard condenser. Condenser must be provided and installed by the chiller manufacturer. Condenser's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side must be designed and factory pressure tested for not less than [150] [250] [300] psi. Condenser must have performance characteristics as indicated on the drawings. Condenser shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable, except for the coaxial tubes. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on water velocities not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P.

2.6.14 Receivers

Receiver must bear a stamp certifying compliance with ASME BPVC SEC VIII D1 and must meet the requirements of ANSI/ASHRAE 15 & 34. Inner surfaces must be thoroughly cleaned by sandblasting or other approved means. Each receiver must have a storage capacity not less than 20 percent in excess of that required for the fully-charged system. Each receiver must be equipped with inlet, outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ANSI/ASHRAE 15 & 34, and two bull's eye liquid-level sight glasses. Sight glasses must be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 3 inches horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves may be provided.

2.6.15 Chiller Purge System

Chillers which operate at pressures below atmospheric pressure must be provided with a purge system. Purge system must automatically remove air, water vapor, and non-condensible gases from the chiller's refrigerant while keeping refrigerant emissions below requirements of ASHRAE Std 147. Purge units must be certified per AHRI 580. Purge system must condense, separate, and return all refrigerant back to the chiller. An oil separator must be provided with the purge system if required by the manufacturer. Purge system must not discharge to occupied areas, or create a potential hazard to personnel. Purge system must include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system must include lights or an alarm which indicate excessive purge or an abnormal air leakage into chiller.

[2.6.16 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, must be provided. Tools must be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

]2.7 ACCESSORIES

2.7.1 Refrigerant Leak Detector

Detector must be the continuously-operating, halogen-specific type. Detector must be appropriate for the refrigerant in use. Detector must be specifically designed for area monitoring and must include [a single sampling point] [[_____] sampling points] installed where indicated. Detector design and construction must be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector must have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector must be supplied factory-calibrated for the appropriate refrigerant(s). Detector must be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant(s) in use. The detector's relay must be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector must be provided with a failure relay output that energizes when the monitor detects a fault in its operation. [Detector must be compatible with the facility's Building Control Network (BCN). The BCN must be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.]

2.7.2 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly must be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly must be in accordance with ASME BPVC SEC VIII D1 and ANSI/ASHRAE 15 & 34. The assembly must be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc must be the non-fragmenting type.

2.7.3 Refrigerant Signs

Refrigerant signs must be a medium-weight aluminum type with a baked enamel finish. Signs must be suitable for indoor or outdoor service. Signs must have a white background with red letters not less than 0.5 inches in height.

2.7.3.1 Installation Identification

Each new refrigerating system must be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.7.3.2 Controls and Piping Identification

Refrigerant systems containing more than 110 lb of refrigerant must be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow [, the ventilation system,] and the refrigerant compressor(s).

b. Pressure limiting device(s).

[2.7.4 Automatic Tube Brush Cleaning System

2.7.4.1 Brush and Basket Sets

One brush and basket set (one brush and two baskets) must be furnished for each condenser tube. Brushes must be made of nylon bristles, with titanium wire. Baskets must be polypropylene.

2.7.4.2 Flow-Diverter Valve

Each system must be equipped with one flow-diverter valve specifically designed for the automatic tube brush cleaning system and have parallel flow connections. The flow-diverter valve must be designed for a working pressure of [150][250][300] psig. End connections must be flanged. Each valve must be provided with an electrically operated air solenoid valve and position indicator.

2.7.4.3 Control Panel

The control panel must provide signals to the diverter valve at a preset time interval to reverse water flow to drive the tube brushes down the tubes and then signal the valve to reverse the water flow to drive the brushes back down the tubes to their original position. The controller must have the following features as a minimum:

a. Timer to initiate the on-load cleaning cycle.

b. Manual override of preset cleaning cycle.

c. Power-on indicator.

d. Diverter-position indicator.

e. Cleaning-cycle-time adjustment

f. Flow-switch bypass.

]2.7.5 Gaskets

Gaskets must conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 700 degrees F service.

2.7.6 Bolts and Nuts

Bolts and nuts, except as required for piping applications, must be in accordance with ASTM A307. The bolt head must be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.8 FABRICATION

2.8.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand [125] [500] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.8.2 Factory Applied Insulation

Chiller must be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it must be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation must be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors must have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by ASTM E84. Insulation must be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

[2.8.3 Coil Corrosion Protection

[Provide coil with a uniformly applied [epoxy electrodeposition] [phenolic] [vinyl] type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating must be applied at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation. Coating must be capable of withstanding a minimum [1,000][3,000] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

]]2.9 FACTORY TESTS

2.9.1 Chiller Performance Test

The Contractor and proposed chiller manufacturer shall be responsible for performing the chiller factory test to validate the specified full load capacity, full load EER, and [IPLV] [NPLV] in accordance with AHRI 550/590 I-P except as indicated. The Contractor and chiller manufacturer must provide to the Government a certified chiller factory test report in accordance with AHRI 550/590 I-P to confirm that the chiller performs as specified. Tests must be conducted in an AHRI certified test facility in conformance with AHRI 550/590 I-P procedures and tolerances, except as indicated. At a minimum, chiller capacity must be validated to meet the scheduled requirements indicated on the drawings. Tolerance or deviation must be in strict accordance with AHRI 550/590 I-P. Stable operation at minimum load of [10] [_____] percent of total capacity must be demonstrated during the factory test.

2.9.1.1 Temperature Adjustments

Temperature adjustments must adhere to AHRI 550/590 I-P to adjust from the design fouling factor to the clean tube condition. Test temperature adjustments must be verified prior to testing by the manufacturer. There must be no exceptions to conducting the test with clean tubes with the temperature adjustments per AHRI 550/590 I-P. The manufacturer must clean the tubes prior to testing to obtain a test fouling factor of 0.0000.

2.9.1.2 Test Instrumentation

The factory test instrumentation must be per AHRI 550/590 I-P and the calibration must be traceable to the National Institute of Standards and Technology.

2.9.1.3 Equipment Adjustments

If the equipment fails to perform within allowable tolerances, the manufacturer must be allowed to make necessary revisions to his equipment and retest as required. [The manufacturer shall assume all expenses incurred by the Government to witness the retest.]

[2.9.2 Chiller Sound Test

Chillers must be sound tested at the factory prior to shipment to confirm the sound pressure level specified herein. Tests and data must be conducted and measured in strict accordance with AHRI 575 at the full load system operating conditions. The chiller sound pressure level, in decibels (dB), with a reference pressure of 20 micropascals, must not exceed [85] [90] [_____] dB, A weighted. Ratings must be in accordance with AHRI 575. No reduction of entering condenser water temperature or raising of leaving chilled water temperature will be allowed. A minimum of 75 percent of the sound data points must be taken along the length of the machine, and established as the minimum percentage of total possible points used to determine sound levels. In the event that the chiller does not meet the dBA sound pressure level, the manufacturer shall, at his expense, provide sufficient attenuation to the machine to meet the specified value. This attenuation must be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller. The attenuation material, adhesives, coatings, and other accessories must have surface burning characteristics as determined by ASTM E84.

]2.10 SUPPLEMENTAL COMPONENTS/SERVICES

2.10.1 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories must be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.10.2 Refrigerant Piping

Refrigerant piping for split-system water chillers must be provided and installed in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.10.3 Cooling Tower

Cooling towers must be provided and installed in accordance with Section 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.

2.10.4 Temperature Controls

Chiller control packages must be fully coordinated with and integrated [into the temperature control system indicated in Section 23 30 00 HVAC AIR DISTRIBUTION and [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC] and [Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]] [into the existing air-conditioning system].

PART 3 EXECUTION

3.1 INSTALLATION

Installation of water chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with the manufacturer's written installation instructions, including the following:

[(1) Water chiller - installation instructions

]3.1.1 Installation Instructions

Provide manufacturer's standard catalog data, at least [5] [_____] weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions and procedures. Data must be adequate to demonstrate compliance with contract requirements.

3.1.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.1.3 Posted Instructions

Provide posted instructions, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions must include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions must be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

3.1.4 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.1.5 System Performance Test Schedules

Provide a schedule, at least [2] [_____] weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test.

3.1.6 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above must be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

3.1.7 Operation and Maintenance Manuals

Provide [Six] [_____] complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least [4] [_____] weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. [Six] [_____] complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.1.8 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.9 Refrigeration System

3.1.9.1 Equipment

Refrigeration equipment and the installation thereof must conform to

ANSI/ASHRAE 15 & 34. Necessary supports must be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, water coolers, and similar items. Compressors must be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations must be provided. Each foundation must include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment must be set on not less than a 6 inch concrete pad doweled in place. Concrete foundations for floor mounted pumps must have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block must be of mass not less than three times the combined pump, motor, and base weights. Isolators must be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators must limit vibration to [_____] percent at lowest equipment rpm. Lines connected to pumps mounted on pedestal blocks must be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts must be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Equipment must be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.9.2 Field Refrigerant Charging

a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system must be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor must provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system must be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points must be installed and tightened.

b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must immediately be isolated from the remainder of the system and the refrigerant must be pumped into the system receiver or other suitable container. The refrigerant must not be discharged into the atmosphere.

c. Contractor's Responsibility: The Contractor must, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps must include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time must more than 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year must be repaired in accordance with the specified requirements including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.1.9.3 Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase must be furnished. One charge must be used during the performance testing period, and upon the satisfactory completion of the tests, the oil must be drained and replaced with the second charge.

3.1.10 Mechanical Room Ventilation

Mechanical ventilation systems must be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.1.11 Field Applied Insulation

Field installed insulation must be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.12 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 FACTORY TEST SCHEDULING AND REPORTS

Provide schedules which identify the date, time, and location for each test. Schedules must be submitted for the Chiller Performance Tests [and the Chiller Sound Test].[The Chiller Performance Test schedule must also allow the witnessing of the test by a Government Representative.]

[Six] [_____] copies of the certified test report must be forwarded to the Government for approval prior to project acceptance. Calibration curves and information sheets for all instrumentation must be included. Provide copies in bound 8 1/2 by 11 inch booklets. Reports must certify the compliance with performance requirements and follow the format of the required testing standard for the Chiller Performance Tests [and the Chiller Sound Tests]. Test report must include certified calibration report of all test instrumentation. Calibration report must include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report must be submitted [1] [_____] week after completion of the factory test.

3.3 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative must be provided for [_____] days. The representative shall advise on the following:

a. Hermetic machines:

(1) Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 micrometers.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

b. Open Machines:

(1) Erection, alignment, testing, and dehydrating.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

3.4 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. At least one week before the official equipment warranty start date, all condenser coils on air-cooled water chillers and split-system water chillers must be cleaned in accordance with the chiller manufacturer's instructions. This work covers two coil cleanings. The condenser coils must be cleaned with an approved coil cleaner by a service technician, factory trained by the chiller manufacturer. The condenser coil cleaner must not have any detrimental affect on the materials or protective coatings on the condenser coils. Testing, adjusting, and balancing must be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5 FIELD ACCEPTANCE TESTING

3.5.1 Test Plans

a. Manufacturer's Test Plans: Within [120][_____] calendar days after contract award, submit the following plans:

[(1) Water chiller - Field Acceptance Test Plan

] Field acceptance test plans must be developed by the chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the chiller and subsequent test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under [Section 23 09 53.00 20, SPACE TEMPERATURE CONTROL SYSTEMS] [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL

SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

c. Prerequisite testing: Chillers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controller must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Chiller manufacturer must furnish with each test procedure a description of acceptable results that have been verified.

Chiller manufacturer must identify the acceptable limits or tolerance within which each tested performance variable must acceptably operate.

f. Job specific: Each test plan must be job specific and must address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.5.2 Testing

a. Each water chiller system must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

[(1) Water chiller - Field Acceptance Test Report

] b. Manufacturer's recommended testing: Conduct the manufacturer's recommended field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.6 SYSTEM PERFORMANCE TESTS

[Six] [_____] copies of the report must be provided in bound 8 1/2 by 11 inch booklets.

3.6.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment must be conducted by the manufacturer's approved start-up representative experienced in system start-up and testing, at such times as directed. Tests must cover a period of not less than [48] [_____] hours for each system and must demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments must be made as necessary and tests must be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points must be installed and tightened. Any refrigerant lost during the system startup must be replaced. If tests do not demonstrate satisfactory system performance, deficiencies must be corrected and the system must be retested. Tests must be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test must be provided by the Contractor. Field tests must be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.6.2 Test Report

The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report must also include the following information and must be taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees F apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

(1) The refrigerant used in the system.
(2) Condensing temperature and pressure.
(3) Suction temperature and pressure.
(4) Running current, voltage and proper phase sequence for each phase of all motors.
(5) The actual on-site setting of all operating and safety controls.
(6) Chilled water pressure, flow and temperature in and out of the chiller.
(7) The position of the [capacity-reduction gear] [gas supply control valve] [fuel oil supply valve] at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.7 DEMONSTRATIONS

Contractor must conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

Provide a schedule, at least [2] [_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

-- End of Section --

SECTION 23 64 26

CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS
08/09, CHG 5: 11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22/CSA 4.4 — (2015; R 2020) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 — (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.1 — (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.3 — (2021) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.5 — (2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.9 — (2018) Factory-Made Wrought Buttwelding Fittings

ASME B16.11 — (2016) Forged Fittings, Socket-Welding and Threaded

ASME B16.18 — (2021) Cast Copper Alloy Solder Joint Pressure Fittings

ASME B16.21 — (2021) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.22 — (2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.26 — (2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes

ASME B16.39 — (2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

ASME B18.2.2 — (2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASME B31.9	(2020) Building Services Piping
ASME B36.10M	(2022) Welded and Seamless Wrought Steel Pipe
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(2020) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1017	(2009) Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2015) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014; R 2020) Standard Specification for

	Carbon Steel Forgings, for General-Purpose Piping
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A197/A197M	(2000; R 2019) Standard Specification for Cupola Malleable Iron
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B813	(2016) Standard Specification for Liquid

	and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D1384	(2005; R 2019) Corrosion Test for Engine Coolants in Glassware
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials
ASTM F1007	(2018) Standard Specification for Pipeline Expansion Joints of the Packed Slip Type for Marine Application
ASTM F1120	(1987; R 2019) Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
ASTM F1199	(2021) Standard Specification for Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)
ASTM F2389	(2021) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2015) (10th Ed) EJMA Standards

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	(2014) Rotodynamic (Centrifugal) Pump for Nomenclature and Definitions

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MSS SP-67	(2017; Errata 1 2017) Butterfly Valves
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2021) Plastics Piping System Components and Related Materials

1.2 SYSTEM DESCRIPTION

Provide the water systems having the minimum service (design) temperature-pressure rating indicated. Provision of the piping systems, including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the required and advisory provisions of ASME B31.9 except as modified or supplemented by this specification section or design drawings. This specification section covers the water systems piping which is located within, on, and adjacent to building(s) within the building(s) 5 foot line.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Grooved Mechanical Connections For Steel; G[, [_____]]

Grooved Mechanical Connections For Copper; G[, [_____]]

Calibrated Balancing Valves; G[, [_____]]

Automatic Flow Control Valves; G[, [_____]]

Pump Discharge Valve

Water Temperature Mixing Valve; G[, [_____]]

Water Temperature Regulating Valves; G[, [_____]]

Water Pressure Reducing Valve

Pressure Relief Valve

Combination Pressure and Temperature Relief Valves

Expansion Joints; G[, [_____]]

Pumps; G[, [_____]]

Combination Strainer and Pump Suction Diffuser

Expansion Tanks

Air Separator Tanks

Water Treatment Systems; G[, [_____]]

Proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions including the items listed in paragraph WATER ANALYSIS", a list of chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals.

SD-06 Test Reports

Piping Welds NDE Report

Pressure Tests Reports; G[, [_____]]

Report shall be provided in bound 8-1/2 by 11 inch booklets. In the reports, document all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results.

Condenser Water Quality Test Reports; G[, [_____]]

Test reports, each month for a period of one year after project completion, in bound 8-1/2 by 11 inch booklets. In the reports, identify the chemical composition of the condenser water. Also include the comparison of the manufacturer's recommended operating conditions for the cooling tower and condenser in relation to the condition of the condenser water. Document in the report any required corrective action taken.

One-Year Inspection Report For Cooling Water; G[, [_____]]

At the completion of one year of service, in bound 8-1/2 by 11 inch booklets. In the report, identify the condition of each cooling tower and condenser. Include a comparison of the condition of the cooling tower and condenser with the manufacturer's recommended operating conditions. Identify all actions taken by the Contractor and manufacturer to correct deficiencies during the first year of service.

SD-07 Certificates

Employer's Record Documents (For Welding)

Welding Procedures and Qualifications

Certificates shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Piping for Steam and Condensate

Piping for High-Pressure Compressed-Air Systems

Fittings

Unions

Flanges

Gaskets

Bolting

SD-08 Manufacturer's Instructions

Lesson plan for the Instruction Course; G[, [_____]]

SD-10 Operation and Maintenance Data

Requirements for data packages are specified Section 01 78 23 OPERATION AND MAINTENANCE DATA, except as supplemented and modified by this specification section.

Submit spare parts data for each different item of equipment specified, with operation and maintenance data packages. Include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Submit a list of qualified permanent service organizations with operation and maintenance data packages. Include service organization addresses and service area or expertise. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

Water Treatment Systems; G[, [_____]]

An operation manual in bound 8-1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown. Include testing procedures used in determining water quality.

A maintenance manual in bound 8-1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide.

Calibrated Balancing Valves, Data Package 3; G[, [_____]]

Automatic Flow Control Valves, Data Package 3; G[, [_____]]

Pump Discharge Valve, Data Package 2; G[, [_____]]

Water Temperature Mixing Valve, Data Package 3; G[, [_____]]

Water Temperature Regulating Valves, Data Package 3; G[, [_____]]

Water Pressure Reducing Valve, Data Package 3; G[, [_____]]

Pressure Relief Valve, Data Package 2; G[, [_____]]

Combination Pressure and Temperature Relief Valves, Data Package 2; G[, [_____]]

Expansion Joints, Data Package 2; G[, [_____]]

Pumps, Data Package 3; G[, [_____]]

Combination Strainer and Pump Suction Diffuser, Data Package 2; G[, [_____]]

Expansion Tanks, Data Package 2; G[, [_____]]

Air Separator Tanks, Data Package 2; G[, [_____]]

1.4 MODIFICATIONS TO REFERENCES

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in

these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.5 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter. Any porous materials found to be contaminated with mold or mildew will be replaced at the Contractor's expense. Non-porous materials found to be contaminated with mold or mildew will be disinfected and cleaned prior to installation.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.7.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.7.3 Accessibility

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

The two year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures.

Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. System components shall be environmentally suitable for the indicated locations.

The equipment items shall be supported by service organizations. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.2 STEEL PIPING

Water piping shall be steel pipe or copper tubing. Provide steel piping with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

2.2.1 Pipe

Steel pipe, conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B. Do not use Type F pipe.

2.2.2 Fittings and End Connections (Joints)

Piping and fittings 1 inch and smaller shall have threaded connections. Piping and fittings larger than 1 inch and smaller than 3 inches shall have either threaded, [grooved,] or welded connections. Piping and fittings 3 inches and larger shall have [grooved,] welded, or flanged connections. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

2.2.2.1 Threaded Connections

Use threaded valves and pipe connections conforming to ASME B1.20.1. Used threaded fitting conforming to ASME B16.3. Use threaded unions conforming to ASME B16.39. Use threaded pipe nipples conforming to ASTM A733.

2.2.2.2 Flanged Connections

Flanges shall conform to ASME B16.1, Class 125. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type. These gaskets shall contain aramid fibers bonded with styrene butadeine rubber (SBR) or nitrile butadeine rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.1.

2.2.2.3 Welded Connections

Welded valves and pipe connections (both butt-welds and socket-welds types) shall conform to ASME B31.9. Butt-welded fittings shall conform to ASME B16.9. Socket-welded fittings shall conform to ASME B16.11. Welded fittings shall be identified with the appropriate grade and marking symbol.

2.2.2.4 Grooved Mechanical Connections For Steel

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Use fitting and coupling houses of malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12; or steel conforming ASTM A106/A106M, Grade B or ASTM A53/A53M. Use gaskets of molded synthetic rubber with central cavity, pressure responsive configuration and conforming to ASTM D2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 230 degrees F or Grade No. M3BA610A15B44Z for circulating medium up to 200 degrees F. Grooved mechanical connections shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183. Pipe connections and fittings shall be the product of the same manufacturer. Provide joint installation be in compliance with joint manufacturer's written instructions.

2.2.2.5 Dielectric Waterways and Flanges

Provide dielectric waterways with a water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600-volt breakdown test. Provide dielectric waterways constructed of galvanized steel and have threaded end connections to match connecting piping. Dielectric waterways shall be suitable for the required operating pressures and temperatures. Provide dielectric flanges with the same pressure ratings as standard flanges and provide complete electrical isolation between connecting pipe and/or equipment as described herein for dielectric waterways.

2.3 POLYPROPYLENE PIPING (CHILLED WATER APPLICATIONS ONLY)

2.3.1 Pipe

Polypropylene pipe shall be Schedule 40, copolymer, and shall meet ASTM F2389 and NSF/ANSI 14.

2.3.2 Fittings

Fittings shall meet ASTM F2389 and NSF/ANSI 14 and shall be NSF listed for the service intended. Plastic pipe, fittings, and solvent cement shall bear the NSF seal "NSF-PW."

Polypropylene fittings shall conform to dimensional requirements of Schedule 40. Polypropylene piping that will be exposed to UV light shall be provided with a Factory applied UV resistant coating.

2.4 PIPING FOR STEAM AND CONDENSATE

Steam and condensate piping for 150-, 350-, 2,000-, and 6,000-pound per square inch (psi) service shall be black carbon steel (BCS). Steam and condensate piping includes fittings, unions, flanges, gaskets, and bolting.

2.4.1 Type BCS-150 (150-psi Service)

Pipe or tube (1/8 inch through 10 inches): Schedule 40 for steam, Schedule 80 for condensate, seamless black carbon steel, conforming to ASTM A106/A106M, Grade B and ASME B36.10M

Fittings (1/8 inch through 2 inches): 300-psi working steam pressure (wsp) banded malleable iron, screwed end, conforming to ASTM A197/A197M and ASME B16.3

Fittings (1/8 inch through 2 inches): 2,000-or 3,000-psi water, oil, or gas (wog) forged carbon steel, socket weld or screwed end, conforming to ASTM A105/A105M and ASME B16.11

Fittings (2-1/2 through 10 inches): Wall thickness to match pipe, long radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9

Unions (1/8 inch through 2 inches): 250-psi wsp, malleable iron, screwed end, ground joint, with brass or bronze seat insert, conforming to ASME B16.39

Unions (1/8 inch through 2 inches): 2,000 or 3,000-psi wog, forged carbon steel; socket weld through 2-inch, screwed end through 1-inch, conforming to ASTM A105/A105M and ASME B16.11, with ground joint and stainless-steel seat insert

Flanges (2-1/2 through 10 inches): 150-pound, forged carbon steel, welding neck, with raised face or flat face and concentric finish, conforming to ASTM A105/A105M and ASME B16.5

Flange Gaskets: Compressed non-asbestos sheet conforming to ASTM F104, Type 1, P1161A, coated on both sides with graphite or similar lubricant, containing not less than 75-percent non-asbestos fiber materials

Bolting: Bolting and flange bolting shall be hexhead and shall conform to ASTM A325. Heavy hex-nuts shall conform to ASME B18.2.2. Square-head bolts and nuts are not acceptable.

2.4.2 Type BCS-350 (350-psiService)

Pipe or tube (1/8 inch through 10 inches): Schedule 40 for steam, Schedule 80 for condensate; seamless black carbon steel, conforming to ASTM A106/A106M, Grade B and ASME B36.10M

Fittings (1/8 inch through 2 inches): 2,000-or 3,000-psi wog to match pipe wall, forged carbon steel, socket weld or screwed end, conforming to ASTM A105/A105M and ASME B16.11

Fittings (1/8 inch through 10 inches): Schedule 40, long-radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9

Unions (1/8 inch through 2 inches): 2,000-or 3,000-psi wog to match pipe wall, forged carbon steel, socket weld through 2-inch, screwed end through 1-inch, conforming to ASTM A105/A105M and ASME B16.11, with ground joint and stainless-steel seat insert

Flanges (2-1/2 through 10 inches): 300-pound, forged carbon steel, weld neck, with raised face and concentric serrated finish, conforming to ASTM A181/A181M, Class 70, and ASME B16.5

Gaskets: Spiral-wound, non-asbestos-fiber-filled, carbon steel, with centering provisions, conforming to ASME B16.5, Group 1

Bolting: Heavy hex-head, carbon-steel bolts or bolt studs and semifinished heavy hexnuts, conforming to ASTM A325.

Square-head bolts are not acceptable.

2.5 PIPING FOR HIGH-PRESSURE COMPRESSED-AIR SYSTEMS

High-pressure compressed-air condensate piping includes fittings, unions, flanges, gaskets, and bolting.

2.5.1 Type BCS-2,000 (2,000-psi Service)

Pipe or tube (1/8 inch through 3 inches): Schedule 40, seamless black carbon steel, conforming to ASTM A106/A106M, Grade B, or ASTM A53/A53M, Grade B, Type S, and ASME B36.10M

Fittings (1/8 inch through 1-1/2 inches): 2,000-psi wog, forged carbon steel, socket weld, conforming to ASTM A105/A105M and ASME B16.11

Fittings (2 through 3 inches): Schedule 40, long radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9

Flanges (1 inch through 3 inches): 900-pound, forged carbon steel, welding neck, with raised face and concentric serrated finish, conforming to ASTM A105/A105M or ASTM A181/A181M, Class 60, and ASME B16.5

Gaskets: Spiral wound, non-asbestos-fiber-filled, carbon steel, with centering provisions, conforming to ASME B16.5, Group 1

Bolting: Alloy-steel bolt studs conforming to ASTM A193/A193M, Grade B7, and semifinished heavy hex-nuts, conforming to ASTM A194/A194M, Grade 2H

2.5.2 Type BCS-6,000 (6,000-psi Service)

Pipe or tube (1/2 inch through 3 inches): XXS, seamless, black carbon steel, conforming to ASTM A106/A106M, Grade B, or ASTM A53/A53M, Grade B, Type S and ASME B36.10M

Fittings (1/2 inch through 1-1/2 inches): 6,000-psi wog, forged carbon steel, socket weld, conforming to ASTM A105/A105M and ASME B16.11

Fittings (2 through 3 inches): XXS, long-radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, ASME B16.9, and ASME B36.10M

Flanges (2 through 3 inches): 2,500-pound, forged carbon steel, welding neck with raised face and concentric serrated finish, conforming to ASTM A105/A105M and ASME B16.5

Gaskets: Spiral-wound, non-asbestos-filled, carbon steel, with centering provisions, conforming to ASME B16.5, Group 1

Bolting: Alloy steel bolt studs conforming to ASTM A193/A193M, Grade B7, and semifinished heavy hex-nuts, conforming to ASTM A194/A194M, Grade 2H

2.6 COPPER TUBING

Provide copper tubing and fittings with a ANSI/ASME Class 125 service rating, which for 150 degrees F., the pressure rating is 175 psig.

2.6.1 Tube

Use copper tube conforming to ASTM B88, Type L or M for aboveground tubing, and Type K for buried tubing.

2.6.2 Fittings and End Connections (Solder and Flared Joints)

Wrought copper and bronze solder joint pressure fittings, including unions ands flanges, shall conform to ASME B16.22 and ASTM B75/B75M. Provide adapters as required. Cast copper alloy solder-joint pressure fittings , including unions and flanges, shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62. ASTM B42 copper pipe nipples with threaded end connections shall conform to ASTM B42.

Copper tubing of sizes larger than 4 inches shall have brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

Extracted brazed tee joints may be used if produced with an acceptable tool and installed in accordance with tool manufacturer's written procedures.

2.6.3 Grooved Mechanical Connections For Copper

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A536. Provide gaskets for use in grooved joints shall constructed of molded synthetic polymer of pressure responsive design and shall conform to ASTM D2000 for circulating medium up to 230 degrees F. Provide grooved joints in conformance with AWWA C606.

2.6.4 Solder

Provide solder in conformance with ASTM B32, grade Sb5, tin-antimony alloy. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B813.

2.6.5 Brazing Filler Metal

Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.7 VALVES

Provide valves with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

Valves in sizes larger than 1 inch and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be furnished by the same manufacturer as the grooved pipe joint and fitting system.

2.7.1 Gate Valve

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 Class 125 and shall be bronze with wedge disc, rising stem and threaded, soldered, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70, Class 125, cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.7.2 Globe and Angle Valve

Globe and angle valves 2-1/2 inches and smaller shall conform to MSS SP-80, Class 125. Globe and angle valves 3 inches and larger shall conform to MSS SP-85, Class 125.

2.7.3 Check Valve

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80. Check valves 3 inches and larger shall conform to MSS SP-71, Class 125.

2.7.4 Butterfly Valve

Butterfly valves shall conform to MSS SP-67, Type 1 and shall be either the wafer or lug type. Valves smaller than 8 inches shall have throttling handles with a minimum of [two][seven] locking positions. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators.

2.7.5 Plug Valve

Plug valves 2 inches and larger shall conform to MSS SP-78, have flanged or threaded ends, and have cast iron bodies with bronze trim. Valves 2 inches and smaller shall be bronze with NPT connections for black steel pipe and brazed connections for copper tubing. Valve shall be lubricated, non-lubricated, or tetrafluoroethylene resin-coated type. Valve shall be resilient, double seated, trunnion mounted with tapered lift plug capable of 2-way shutoff. Valve shall operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. [Valve shall a weatherproof operators with mechanical position indicators.] Valves 8 inches or larger shall be provided with manual gear operators with position indicators.

2.7.6 Ball Valve

Full port design. Ball valves 1/2 inch and larger shall conform to MSS SP-72 or MSS SP-110 and shall be cast iron or bronze with threaded, soldered, or flanged ends. Valves 8 inches or larger shall be provided with manual gear operators with position indicators. Ball valves may be provided in lieu of gate valves.

2.7.7 Square Head Cocks

Provide copper alloy or cast-iron body with copper alloy plugs, suitable for 125 psig water working pressure.

2.7.8 Calibrated Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts. Provide valve calibrated so that flow can be determined when the temperature and pressure differential across valve is known. Valve shall have an integral pointer which registers the degree of valve opening. Valve shall function as a service valve when in fully closed position. Valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation.

Provide valve bodies with tapped openings and pipe extensions with positive shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable differential pressure meter connections to verify the pressure differential. Provide metal tag on each valve showing the gallons per minute flow for each differential pressure reading. [In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.]

2.7.9 Automatic Flow Control Valves

Valve shall automatically maintain the constant flow indicated on the design drawings. Valve shall modulate by sensing the pressure differential across the valve body. Valve shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Provide valve that controls the flow within 5 percent of the tag rating. Valve materials shall be the same as specified for the ball or plug valves.

Provide valve that are [electric][or][pneumatic] type as indicated. Valve shall be capable of positive shutoff against the system pump head, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings and differential meter, suitable for the operating pressure specified. Provide the meter complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer.

2.7.10 Pump Discharge Valve

Valve shall shall perform the functions of a nonslam check valve, a manual balancing valve, and a shutoff. Valve shall be of cast iron or ductile iron construction with bronze and/or stainless steel accessories. Provide an integral pointer on the valve which registers the degree of valve opening. Flow through the valve shall be manually adjustable from bubble tight shutoff to full flow. Valves smaller than 2 inches shall have NPT connections. Valves 2 inches and larger shall have flanged or grooved end connections. Valve design shall allow the back seat for the stem to be replaced in the field under full line pressure.

2.7.11 Water Temperature Mixing Valve

Valve, ASSE 1017 for water service.

2.7.12 Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

2.7.13 Water Pressure Reducing Valve

Valve, ASSE 1003 for water service, copper alloy body.

2.7.14 Pressure Relief Valve

Valve shall prevent excessive pressure in the piping system when the piping system reaches its maximum heat buildup. Valve, ANSI Z21.22/CSA 4.4 and shall have cast iron bodies with corrosion resistant internal working parts. The discharge pipe from the relief valve shall be the size of the valve outlet unless otherwise indicated.

2.7.15 Combination Pressure and Temperature Relief Valves

ANSI Z21.22/CSA 4.4, copper alloy body, automatic re-seating, test lever, and discharge capacity based on AGA temperature steam rating.

2.7.16 Float Valve

[Angle pattern][and][or] [Globe pattern]. Valve bodies 3 inches nominal pipe size and smaller shall be bronze. Valve bodies larger than 3 inches shall be cast iron or bronze. Steel parts shall be corrosion resistant. Where float rods are extended for tank applications, extension shall be properly supported and guided to avoid bending of float rod or stressing of valve pilot linkage.

2.7.17 Drain Valves

Valves, MSS SP-80 gate valves. Valve shall be manually-operated, 3/4 inch pipe size and above with a threaded end connection. Provide valve with a water hose nipple adapter. [Freeze-proof type valves shall be provided in installations exposed to freezing temperatures.]

2.7.18 Air Venting Valves

[Manually-operated general service type air venting valves, brass or bronze valves that are furnished with threaded plugs or caps.] [Automatic type air venting shall be the ball-float type with brass/bronze or brass bodies, 300 series corrosion-resistant steel float, linkage and removable seat.] Air venting valves on water coils shall have not less than 1/8 inch threaded end connections. Air venting valves on water mains shall have not less than 3/4 inch threaded end connections. Air venting valves on all other applications shall have not less than 1/2 inch threaded end connections.

2.7.19 Vacuum Relief Valves

ANSI Z21.22/CSA 4.4

2.8 PIPING ACCESSORIES

2.8.1 Strainer

Strainer, ASTM F1199, except as modified and supplemented in this specification. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. Strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. The bodies shall have arrows clearly cast on the sides indicating the direction of flow.

Provide strainer with removable cover and sediment screen. The screen shall be made of minimum 22 gauge [brass sheet,] [monel,] [corrosion-resistant steel,] with small perforations numbering not less than 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.8.2 Cyclonic Separator

Metal- bodied, with removal capability of removing solids 45 microns/325 mesh in size and heavier than 1.20 specific gravity, maximum pressure drop of 5 psid, with cleanout connection.

2.8.3 Combination Strainer and Pump Suction Diffuser

Angle type body with removable strainer basket and internal straightening vanes, a suction pipe support, and a blowdown outlet and plug. Strainer shall be in accordance with ASTM F1199, except as modified and supplemented by this specification. Unit body shall have arrows clearly cast on the sides indicating the direction of flow.

Strainer screen shall be made of minimum 22 gauge [brass sheet,] [monel,] [corrosion-resistant steel,] with small perforations numbering not less than 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. Flow shall be into the screen and out through the perforations. Provide an auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal.

Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Provide unit casing with blowdown port and plug. Provide a magnetic insert to remove debris from system.

2.8.4 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid. Equip flanged assemblies with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Provide covers to protect the bellows where indicated.

2.8.5 Pressure and Vacuum Gauges

Gauges, ASME B40.100 with throttling type needle valve or a pulsation dampener and shut-off valve. Provide gauges with 4.5 inch dial, brass or aluminum case, bronze tube, and siphon. Gauge shall have a range from 0 psig to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.8.6 Temperature Gauges

Temperature gauges, shall be the industrial duty type and be provided for the required temperature range. Provide gauges with fixed thread connection, dial face gasketed within the case; and an accuracy within 2 percent of scale range. Gauges shall have Fahrenheit scale in 2 degree graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 5 feet of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 5 to 7 feet above the finished floor or in locations indicated. Remote element type temperature gauges shall be provided in thermal wells located 7 feet above the finished floor or in locations indicated.

2.8.6.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 9 inches long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.8.6.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 3-1/2 inches, stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment.

2.8.6.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 3-1/2 inches, stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.8.6.4 Thermal Well

Thermal well shall be identical size, 1/2 or 3/4 inch NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 1/2 inch NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 1 inch.

2.8.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports: to MSS SP-58 and MSS SP-69.[If ferrous materials are utilized provide hot-dipped galvanized hangers, inserts and supports.]

2.8.8 Escutcheons

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Secure plates in place by internal spring tension or set screws. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.8.9 Expansion Joints

2.8.9.1 Slip-Tube Type

Slip-tube expansion joints, ASTM F1007, Class I or II. Joints shall be provided with internally-externally alignment guides, injected semi-plastic packing, and service outlets. End connections shall be flanged or beveled for welding as indicated. Initial settings shall be made in accordance with the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer.

2.8.9.2 Flexible Ball Type

Flexible ball expansion joints shall be capable of 360 degrees rotation plus 15 degrees angular flex movement. Joints shall be constructed of carbon steel with the exterior spherical surface of carbon steel balls plated with a minimum 5 mils of hard chrome in accordance with EJMA Stds. Joint end connections shall be threaded for piping 2 inches or smaller. Joint end connections larger than 2 inches shall be grooved, flanged, or beveled for welding. Provide joint with pressure-molded composition gaskets suitable for continuous operation at twice design temperature.

2.8.9.3 Bellows Type

Bellows expansion type joints, ASTM F1120 with Type 304 stainless steel corrugated bellows, reinforced with equalizing rings, internal sleeves, and external protective covers. Joint end connections shall be grooved, flanged, or beveled for welding. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint.

2.9 PUMPS

Pumps shall be the electrically driven, non-overloading, centrifugal type which conform to HI 1.1-1.2. Pumps shall be selected at or within 5 percent of peak efficiency. Pump curve shall rise continuously from maximum capacity to shutoff. Pump motor shall conform to NEMA MG 1, be [open] [splash-proof] [totally enclosed], and have sufficient horsepower for the service required. Pump motor shall have the required capacity to prevent overloading with pump operating at any point on its characteristic curve. Pump speed shall not exceed 3,600 rpm, except where the pump head is less than 60 feet of water, the pump speed shall not exceed 1,750 rpm. Pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in the cover.

2.9.1 Construction

Each pump casing shall be designed to withstand the discharge head specified plus the static head on system plus 50 percent of the total, but not less than 125 psig. Pump casing and bearing housing shall be close grained cast iron. High points in the casing shall be provided with manual air vents; low points shall be provided with drain plugs. Provide threaded suction and discharge pressure gage tapping with square-head plugs.

Impeller shall be statically and dynamically balanced. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Shaft shall be carbon or alloy steel, turned and ground. Bearings shall be ball-bearings, roller-bearings, or oil-lubricated bronze-sleeve type bearings, and be efficiently sealed or isolated to prevent loss of oil or entrance of dirt or water.

[Pump and motor shall be mounted on a common cast iron base having lipped edges and tapped drainage openings or structural steel base with lipped edges or drain pan and tapped drainage openings. Pump shall be provided with steel shaft coupling guard. Base-mounted pump, coupling guard, and motor shall each be bolted to a fabricated steel base which shall have bolt holes for securing base to supporting surface.] [Close-coupled pump shall be provided with integrally cast or fabricated steel feet with bolt holes for securing feet to supporting surface. Close- coupled pumps shall be provided with drip pockets and tapped openings.] Pump shall be accessible for servicing without disturbing piping connections. Shaft seals shall be mechanical-seals or stuffing-box type.

2.9.2 Mechanical Shaft Seals

Seals shall be single, inside mounted, end-face-elastomer bellows type with stainless steel spring, brass or stainless steel seal head, carbon rotating face, and tungsten carbide or ceramic sealing face. Glands shall be bronze and of the water-flush design to provide lubrication flush across the face of the seal. Bypass line from pump discharge to flush connection in gland shall be provided, with filter or cyclone particle separator in line.

2.9.3 Stuffing-Box Type Seals

Stuffing box shall include minimum 4 rows of square, impregnated TFE (Teflon) or graphite cord packing and a bronze split-lantern ring. Packing gland shall be bronze interlocking split type.

2.10 EXPANSION TANKS

Tank shall be welded steel, constructed for, and tested to pressure-temperature rating of 125 psi at 150 degrees F. Provide tanks precharged to the minimum operating pressure. Tank shall have a replaceable polypropylene or butyl lined diaphragm which keeps the air charge separated from the water; shall be the captive air type.

Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with a drain, fill, an air charging valve, and system connections. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.11 AIR SEPARATOR TANKS

[External air separation tank shall have an internal design constructed of stainless steel and suitable for creating the required vortex and subsequent air separation. Tank shall be steel, constructed for, and tested to pressure-temperature rating of 125 psi at 150 degrees F. Tank shall have tangential inlets and outlets connections, threaded for 2 inches and smaller and flanged for sizes 2-1/2 inches and larger. Air released from a tank shall be [to the atmosphere] [vented as indicated]. Tank shall be provided with a blow-down connection.

][Design to separate air from water and to direct released air to automatic air vent. Unit shall be of one piece cast-iron construction with internal baffles and two air chambers at top of unit; one air chamber shall have outlet to expansion tank and other air chamber shall be provided with automatic air release device. Tank shall be steel, constructed for, and tested to a ANSI Class 125 pressure-temperature rating.

]2.12 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing equivalent chromium (CPR) is prohibited.

2.12.1 Water Analysis

Conditions of make-up water to be supplied to the condenser and chilled water systems were reported in accordance with ASTM D596 and are as follows:

Date of Sample	[_____]
Temperature	[_____] degrees F
Silica (Sino 2)	[_____] pp (mg/1)
Insoluble	[_____] pp (mg/1)
Iron and Aluminum Oxides	[_____] pp (mg/1)
Calcium (Ca)	[_____] pp (mg/1)

Magnesium (Mg)	[_____] pp (mg/1)
Sodium and Potassium (Nan and AK)	[_____] pp (mg/1)
Carbonate (HO 3)	[_____] pp (mg/1)
Sulfate (SO 4)	[_____] pp (mg/1)
Chloride (JCL)	[_____] pp (mg/1)
Nitrate (NO 3	[_____] pp (mg/1)
Turbidity	[_____] unit
pH	[_____]
Residual Chlorine	[_____] pp (mg/1)
Total Alkalinity	[_____] PM (me/1
Non-Carbonate Hardness	[_____] PM (me/1
Total Hardness	[_____] PM (me/1
Dissolved Solids	[_____] pp (mg/1)
Fluorine	[_____] pp (mg/1)
Conductivity	[_____] McMahon/cm

2.12.2 Chilled and Condenser Water

Water to be used in the chilled and condenser water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.12.3 Glycol Solution

A [_____] percent concentration by volume of industrial grade [ethylene] [propylene] glycol shall be provided in the chilled water. The glycol shall be tested in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicate based inhibitors shall not be used. The solution shall be compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.12.4 Water Treatment Services

The services of a company regularly engaged in the treatment of [condenser] [condenser and chilled] water systems shall be used to determine the correct chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company shall maintain the chemical treatment and provide all chemicals required for the [condenser] [condenser and chilled] water systems for a period of 1 year from the date of occupancy. The chemical treatment and services provided over the 1 year period shall meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Acid treatment and proprietary chemicals shall not be used.

2.12.5 Chilled Water System

A shot feeder shall be provided on the chilled water piping as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.12.6 Condenser Water

The water treatment system shall be capable of [automatically] [continuously] feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. [Automatic chemical feed systems shall automatically feed chemicals into the condenser water based on varying system conditions.] [Continuous chemical feed systems shall continuously feed chemicals into the condenser water at a constant rate. The system shall be initially set manually based on the water analysis of the make-up water.]

2.12.6.1 Chemical Feed Pump

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.12.6.2 Tanks

Two chemical tanks shall be provided. The tanks shall be constructed of [high density polyethylene] [stainless steel] with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.12.6.3 Injection Assembly

An injection assembly shall be provided at each chemical injection point along the condenser water piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the condenser water piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the condenser water line.

2.12.6.4 Water Meter

Water meters shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the make-up water line, as indicated.

2.12.6.5 Timers

Timers shall be of the automatic reset, adjustable type, and electrically operated. The timers shall be suitable for a 120 volt current. The timers shall be located within the water treatment control panel.

2.12.6.6 Water Treatment Control Panel

The control panel shall be a NEMA 12 enclosure suitable for surface mounting. The panel shall be constructed of [stainless steel] [steel] with a hinged door and lock. The panel shall contain a laminated plastic nameplate identifying each of the following functions:

(1) Main power switch and indicating light
(2) MAN-OFF-AUTO selector switch
(3) Indicating lamp for bleed-off valve
(4) Indicating lamp for each chemical feed pump
(5) Set point reading for each timer

2.12.6.7 Chemical Piping

The piping and fittings shall be constructed of [schedule 80 PVC] [stainless steel] suitable for the water treatment chemicals.

2.12.6.8 Sequence of Operation

[The chemicals shall be added based upon sensing the make-up water flow rate and activating appropriate timers. A separate timer shall be provided for each chemical. The blow down shall be controlled based upon the make-up water flow rate and a separate timer.] [The system shall contain an adjustable valve for continuous blow down. The flow rate from the appropriate chemical tanks shall be manually set at the metering pump for continuous chemical feed.] The injection of the chemical required for biological control shall be controlled by a timer which can be manually set for proper chemical feed. Timer set points, blow down rates, and chemical pump flow rates shall be determined and set by the water treatment company.

2.12.6.9 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.12.6.10 Bleed Line

A bleed line with a flow valve of the needle-valve type sized for the flow requirement or fixed orifice shall be provided in the pump return to the tower. The bleed line shall be extended to the nearest drain for continuous discharge.

2.13 ELECTRICAL WORK

Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

Provide polyphase, squirrel-cage medium induction motors, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

[Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors.] [Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.]

2.14 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

2.14.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided. The factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test.

Salt-spray fog test shall be in accordance with ASTM B117, and for that test, the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of 0.125 inch on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen.

If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

2.14.2 Shop Painting Systems for Metal Surfaces

Clean, retreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where hot-dip galvanized steel has been cut, resulting surfaces with no galvanizing shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

b. Temperatures Between 120 and 400 degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

c. Temperatures Greater Than 400 degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

2.15 FACTORY APPLIED INSULATION

Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 25 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84.

Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.16 NAMEPLATES

Major equipment including pumps, pump motors, expansion tanks, and air separator tanks shall have the manufacturer's name, type or style, model or serial number on a plate secured to the item of equipment. The nameplate of the distributing agent will not be acceptable. Plates shall be durable and legible throughout equipment life and made of [anodized aluminum][stainless steel][_____]. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.17 RELATED COMPONENTS/SERVICES

2.17.1 Drain and Make-Up Water Piping

Requirements for drain and make-up water piping and backflow preventer is specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.17.2 Cathodic Protection

Requirements for cathodic protection systems is specified in [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM][and][Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM].

2.17.3 Field Applied Insulation

Requirements for field applied insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.17.4 Field Applied Insulation

Requirements for field installed insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as supplemented and modified by this specification section.

2.17.5 Field Painting

Requirements for painting of surfaces not otherwise specified, and finish painting of items only primed at the factory, are specified in Section 09 90 00PAINTS AND COATINGS.

[2.17.5.1 Color Coding

Requirements for color coding for piping identification are specified in Section 09 90 00 PAINTS AND COATINGS.

][2.17.5.2 Color Coding For Hidden Piping

A color coding scheme for locating hidden piping shall be in accordance with [Section 22 00 00 PLUMBING, GENERAL PURPOSE] [Section 22 00 70 PLUMBING, HEALTHCARE FACILITIES].

]PART 3 EXECUTION

3.1 INSTALLATION

Cut pipe accurately to measurements established at the jobsite, and work into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation is not permitted without written approval. Cut pipe or tubing square, remove burrs by reaming, and fashion to permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.1 Welding

Provide welding work specified this section for piping systems in conformance with ASME B31.9, as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, welders, welding operators, brazers, brazing operators, and nondestructive examination personnel; maintenance of welding records, and examination methods for welds.

3.1.1.1 Employer's Record Documents (For Welding)

Submit for review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with ASME B31.9.

a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.

b. List of qualified welders, brazers, welding operators, and brazing operators that are proposed to be used to provide the work specified in this specification section.

c. List of qualified weld examination personnel that are proposed to be used to provide the work specified in this specification section.

3.1.1.2 Welding Procedures and Qualifications

a. Specifications and Test Results: Submit copies of the welding procedures specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.

b. Certification: Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

3.1.1.3 Examination of Piping Welds

Conduct non-destructive examinations (NDE) on piping welds and brazing and verify the work meets the acceptance criteria specified in ASME B31.9. NDE on piping welds covered by ASME B31.9 is visual inspection only. Submit a piping welds NDE report meeting the requirements specified in ASME B31.9.

3.1.1.4 Welding Safety

Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

3.1.2 Directional Changes

Make changes in direction with fittings, except that bending of pipe 4 inches and smaller is permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees is not permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations is not acceptable.

3.1.3 Functional Requirements

Pitch horizontal supply mains down in the direction of flow as indicated. The grade shall not be less than 1 inch in 40 feet. Reducing fittings shall be used for changes in pipe sizes. Cap or plug open ends of pipelines and equipment during installation to keep dirt or other foreign materials out of the system.

Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 2-1/2 inches or less in diameter, and with flanges for pipe 3 inches and above in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric waterways or flanges.

Piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Electric isolation fittings shall be provided between dissimilar metals.

3.1.4 Fittings and End Connections

3.1.4.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.4.2 Brazed Connections

Brazing, AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.4.3 Welded Connections

Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding, the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.9. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.4.4 Grooved Mechanical Connections

Prepare grooves in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.1.4.5 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.4.6 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for the intended application.

3.1.5 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.6 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.7 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.8 Flexible Pipe Connectors

Connectors shall be attached to components in strict accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.9 Temperature Gauges

Temperature gauges shall be located on coolant supply and return piping at each heat exchanger, on condenser water piping entering and leaving a condenser, at each automatic temperature control device without an integral thermometer, and where indicated or required for proper operation of equipment. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 1 inch.

3.1.10 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as supplemented and modified in this specification section. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.10.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.10.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.1.10.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.10.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.10.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Type 40 shields shall be used on all piping less than 4 inches and all piping 4 inches and larger carrying medium less than 60 degrees F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 2 inches and larger.

3.1.10.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves. [Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 50 pounds shall have the excess hanger loads suspended from panel points.]

3.1.10.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.

3.1.10.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.10.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger, a Type 39 saddle shall be used. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.10.10 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.10.11 Seismic Requirements

Piping and attached valves shall be supported and braced to resist seismic loads as specified under Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC [as shown on the drawings]. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.1.10.12 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.1.11 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 5 feet on each side of each expansion joint, and in lines 4 inches or smaller not more than 2 feet on each side of the joint.

3.1.12 Pipe Anchors

Anchors shall be provided where indicated. Unless indicated otherwise, anchors shall comply with the requirements specified. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required.

Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal.

3.1.13 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Except as indicated otherwise piping sleeves shall comply with requirements specified. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, [Schedule 30][Schedule 20][Standard weight]. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 1/2 inch depth. Sleeves shall not be installed in structural members.

3.1.13.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar.

In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors.

Integral cast-in collar type sleeve shall be flashed [as indicated.] [with not less than 4 inches of cold side vapor barrier overlap of sleeve surface.] Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than [4][_____] inches of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer.

Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.1.13.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 1/4 inch all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 00 JOINT SEALANTS.

3.1.13.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a .17 ounce copper sleeve, or a 0.032 inch thick aluminum sleeve, each within an integral skirt or flange.

Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 8 inches from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 2 inches above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut.

   After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.13.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

3.1.13.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.14 Access Panels

Access panels shall be provided where indicated for all concealed valves, vents, controls, and additionally for items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in[Section 08 31 00 ACCESS DOORS AND PANELS][Section 05 51 33 METAL LADDERS][Section 05 52 00 METAL RAILINGS][Section 05 51 00 METAL STAIRS].

3.2 INSTALLATION FOR POLYPROPYLENE PIPING (CHILLED WATER APPLICATIONS ONLY)

3.2.1 Locations

Plastic pipe to include polypropylene shall not be installed in air plenums. Plastic pipe to include polypropylene shall not be installed in a pressure piping system in buildings greater than three stories including any basement levels.

3.2.2 Pipe Joints

Joints for polypropylene pipe and fittings shall be made by heat fusion welding socket-type or butt-fusion type fittings and shall comply with ASTM F2389. Joint surfaces shall be clean and free from moisture, and shall be undisturbed until cool.

3.2.3 Overheating Precautions

Adequate provisions shall be taken to ensure that the pipe does not exceed operating temperatures recommended by the manufacturer. This includes a safeguard provision from preventing a pump from running with zero flow, if such operation could overheat the pipe beyond pipe manufacturer's recommendations. If heat tracing is permitted elsewhere in the specifications, ensure that the heat tracing is installed per piping manufacturer's recommendations to prevent overheating of the pipe.

3.2.4 Testing and Flushing

Pressure test shall be conducted for 15 minutes at 1.5 times the operating pressure or 150 psi, whichever is greater, with no observable loss in pressure. Water, rather than air, must be used for pressure testing plastic pipe. After satisfactory pressure test is obtained, flush piping system using a minimum velocity of 4 fps through all portions of the piping system. Flushing shall be continued until discharge water shows no discoloration and strainers are no longer collecting dirt and other foreign materials. Upon completion of flushing, drain all water from system at low points, and remove/clean/replace strainers.

3.3 ELECTRICAL INSTALLATION

Install electrical equipment in accordance with NFPA 70 and manufacturers instructions.

3.4 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for all water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from all water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.5 FIELD TESTS

Field tests shall be conducted in the presence of the QC Manager or his designated representative to verify systems compliance with specifications. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor.

3.5.1 Equipment and Component Isolation

Prior to testing, equipment and components that cannot withstand the tests shall be properly isolated.

3.5.2 Pressure Tests

Each piping system , except for polypropylene piping, shall be hydrostatically tested at a pressure not less than 188 psig for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Test pressure shall be monitored by a currently calibrated test pressure gauge. Leaks shall be repaired and piping retested until test requirements are met. No leakage or reduction in gage pressure shall be allowed.

Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before concealing.

Submit for approval pressure tests reports covering the above specified piping pressure tests; describe the systems tested, test results, defects found and repaired, and signature of the pressure tests' director. Obtain approval from the QC Manager before concealing piping or applying insulation to tested and accepted piping.

3.5.3 Condenser Water Quality Test Reports

The condenser water system shall be analyzed by the water treatment company a minimum of once a month for a period of one year after system acceptance. Submit for approval the specified condenser water quality test reports. The analysis and resulting reports shall include the following information recorded in accordance with ASTM D596.

Date of Sample	[_____]
Temperature	[_____] degrees F

Silica (Sino 2)	[_____] pp (mg/1)
Insoluble	[_____] pp (mg/1)
Iron and Aluminum Oxides	[_____] pp (mg/1)
Calcium (Ca)	[_____] pp (mg/1)
Magnesium (Mg)	[_____] pp (mg/1)
Sodium and Potassium (Nan and AK)	[_____] pp (mg/1)
Carbonate (HO 3)	[_____] pp (mg/1)
Sulfate (SO 4)	[_____] pp (mg/1)
Chloride (JCL)	[_____] pp (mg/1)
Nitrate (NO 3	[_____] pp (mg/1)
Turbidity	[_____] unit
pH	[_____]
Residual Chlorine	[_____] ppm (mg/1)
Total Alkalinity	[_____] epm (meq/1)
Non-Carbonate Hardness	[_____] epm (meq/1)
Total Hardness	[_____] epm (meq/1)
Dissolved Solids	[_____] ppm (mg/1)
Fluorine	[_____] ppm (mg/1)
Conductivity	[_____] microhm/cm

3.5.4 Related Field Inspections and Testing

3.5.4.1 Piping Welds

Examination of Piping Welds is specified in the paragraph EXAMINATION OF PIPING WELDS (above).

3.5.4.2 HVAC TAB

Requirements for testing, adjusting, and balancing (TAB) of HVAC water piping, and associated equipment is specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Coordinate with the TAB team, and provide support personnel and equipment as specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC to assist TAB team to meet the TAB work requirements.

3.6 INSTRUCTION TO GOVERNMENT PERSONNEL

Furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the [chilled water,] [chilled-hot water,][and][condenser water piping system[s]]. Instructors shall be thoroughly familiar with all parts of the installation and shall be instructed in operating theory as well as practical operation and maintenance work. Submit a lesson plan for the instruction course for approval. The lesson plan and instruction course shall be based on the approved operation and maintenance data and maintenance manuals.

Conduct a training course for the operating staff and maintenance staff selected by the Contracting Officer. Give the instruction during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be [one man-day.][[_____][_____] continuous man-days]. Use approximately half of the time for classroom instruction and the other time for instruction at the location of equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

[3.7 ONE-YEAR INSPECTION REPORT FOR COOLING WATER

At the conclusion of the one year period, each connecting [cooling tower] [and] [liquid chiller condenser] inspect for problems due to corrosion, scale, and biological growth. If the equipment is found not to conform to the manufacturers recommended conditions, and the water treatment company recommendations have been followed; the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

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SECTION 23 65 00

COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS
11/16, CHG 2: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.13	(2005; R 2010) Methods for the Measurement of Sound Pressure Levels in Air (ASA 118)

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

ANSI/AHRI 495	(2005) Performance Rating of Refrigerant Liquid Receivers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 64	(2020) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C67/C67M	(2021) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

COOLING TECHNOLOGY INSTITUTE (CTI)

CTI ATC-105	(2000) Acceptance Test Code
CTI ESG-114	(2007) Design of Cooling Towers with Douglas Fir Lumber
CTI STD-111	(2018) Gear Speed Reducers for Application on Industrial Water Cooling Towers
CTI STD-134	(2007) Plywood for Use in Cooling Towers
CTI Std-103	(2007) Redwood Lumber Specifications
CTI Std-112	(2019) Pressure Preservative Treatment of Dimensional Lumber
CTI Std-137	(2017) Fiberglass Pultruded Structural Products for Use in Cooling Towers
CTI Std-201	(2011) Standard for the Certification of Water Cooling Tower Thermal Performance

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA

20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

NFPA 214	(2021) Standard on Water-Cooling Towers

REDWOOD INSPECTION SERVICE (RIS) OF THE CALIFORNIA REDWOOD ASSOCIATION (CRA)

RIS Grade Use	(1998) Redwood Lumber Grades and Uses

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J534	(2021) Lubrication Fittings

UNDERWRITERS LABORATORIES (UL)

UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA G-5	(2017) Western Lumber Grading Rules

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Cooling Towers; G[, [_____]]

Posted Instructions; G[, [_____]]

Demonstrations; G[, [_____]]

Verification of Dimensions; G[, [_____]]

Remote Evaporatively-Cooled Condensers

SD-06 Test Reports

[Packaged Cooling Tower - Installation Instructions; G[, [_____]]

][Field-Erected Cooling Tower - Installation Instructions; G[, [_____]]

][Packaged Cooling Tower - Field Acceptance Test Plan; G[, [_____]]

][Field-Erected Cooling Tower - Field Acceptance Test Plan; G[, [_____]]

][Packaged Cooling Tower - Field Acceptance Test Report; G[, [_____]]

][Field-Erected Cooling Tower - Field Acceptance Test Report; G[, [_____]]

] SD-07 Certificates

Service Organization

Cooling Tower

Remote Evaporatively-Cooled Condensers

SD-08 Manufacturer's Instructions

[Packaged Cooling Tower - Installation Instructions

][Field-Erected Cooling Tower - Installation Instructions

] Remote Evaporatively-Cooled Condensers

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Remote Evaporatively-Cooled Condensers

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.[[Catwalk,] [ladder,] [and guardrail] must be provided where indicated and in accordance with[Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS][Section 05 51 33 METAL LADDERS][Section 05 52 00 METAL RAILINGS][Section 05 51 00 METAL STAIRS].]

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items must be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor must carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and must arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment must be standard commercial catalogued products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products must have been in satisfactory commercial or industrial use in field service for two years prior to bid opening. The two year use must include applications of equipment and materials under similar circumstances and of similar size. Products having less than a two year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. This 6000 hour record must not include any manufacturer's prototype or factory testing. Records of satisfactory field use must be completed by a product that had been, and presently is, sold, or offered for sale on a commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures. Products must be supported by a service organization. System components must be environmentally suitable for the indicated locations.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Major equipment including cooling towers, cooling tower gear drive assemblies, fans, and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates must be durable and legible throughout equipment life. Plates must be fixed in prominent locations.

2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. [Motor bearings must be fitted with grease supply fittings and grease relief to outside of the enclosure.] Motor enclosure type may be either TEAO or TEFC.

e. [Where two-speed motors are indicated, variable-speed controllers may be provided to accomplish the same function.][Use adjustable frequency drives for all variable-speed motor applications.] Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 COOLING TOWER MATERIALS

2.4.1 Lumber

2.4.1.1 Douglas Fir

CTI ESG-114, WWPA G-5, Grade B and better, Industrial Clear. Douglas fir must have a preservative treatment in accordance with CTI Std-112.

2.4.1.2 Plywood

CTI STD-134, Exterior Grade, type and thickness as specified for the application.

2.4.1.3 Pressure Treated Lumber

Pressure treated lumber must be in accordance with CTI Std-112. Wood exposed as the result of notching, cutting, or drilling must be saturated with the preservative.

2.4.1.4 Redwood

CTI Std-103, RIS Grade Use California Redwood, clear of all hearts.

2.4.2 Fiberglass Reinforced Plastic (FRP)

FRP components must be inert, corrosion resistant, and fire-retardant with a thickness of 12 ounces per square foot. FRP components must contain an ultraviolet (UV) ray inhibitor as per CTI Std-137, Grade 1 or 3. Components manufactured of polystyrene will not be permitted.

2.4.3 Zinc-Coated Steel

Components fabricated of zinc-coated steel must be not lighter than 16 gauge 0.0635 inch steel, protected against corrosion by a zinc coating. The zinc coating must conform to ASTM A653/A653M, as applicable and have an extra heavy coating of not less than 2.35 ounces per square foot of surface. Galvanized surfaces damaged due to welding must be coated with zinc rich coating conforming to ASTM D520, Type 1.

2.4.4 Polyvinyl Chloride (PVC) Formed Sheets

ASTM D1784, Type I, Grade 1 with a flame spread rating in accordance with ASTM E84, Class A.

2.4.5 High Density Polyethylene (HDPE)

Components manufactured from HDPE must be seamless with a minimum thickness of 0.375 inch. The material must have the appropriate inhibitors to protect the component from any UV degradation. Tanks and cooling tower shells must be seamlessly molded to minimize water loss/consumption.

2.4.6 Stainless Steel Sheets

Type [304][316].

2.4.7 Concrete

Concrete must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE. Exposed concrete must be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete will not be permitted.

2.4.8 Hardware

Bolts must be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt must be provided with neoprene and cadmium-plated steel washers under the heads. Nails must be silicon bronze, commercial bronze, or stainless steel. Hardware must meet the salt-spray fog test as defined by ASTM B117. Angle brackets and similar parts must be zinc-coated steel. Zinc coatings must conform to ASTM A153/A153M and [ASTM A123/A123M], as applicable, and must have an extra heavy coating of not less than 2.35 ounces per square foot of surface. Nails must be silicon bronze, commercial bronze, or stainless steel. Subject hardware to a salt-spray fog test in accordance with ASTM B117. No signs of corrosion must be evident after 1,000 hours continuous exposure to a 5 percent salt spray.

2.5 COOLING TOWERS

2.5.1 Factory Assembled Towers

2.5.1.1 Description

The cooling tower must be of the [induced mechanical draft][or forced mechanical draft] type. The cooling tower must include frames and casings, louvers, drift eliminators, partitions, windbreak baffles, drift-check walls, cold water basin equipment, fans and fan walls, blowers, drives, electric motors, access doors, [working platforms,] inspection plates, and panels.

2.5.1.2 Construction

Tower must be constructed to withstand a wind pressure of not less than 30 psf on any external surface. Fan deck must be constructed to withstand a live load of not less than 60 psf in addition to the concentrated or distributed loads of equipment mounted on the fan deck. [A 15 percent increased loading must be included for ice or snow load.]

The hot water distribution system must be of the open basin gravity feed type or the pressurized spray header type design.

2.5.1.3 Tower Frame and Louvers

Provide frame constructed from [galvanized steel][_____]. Intermediate structural members must be provided for rigidity and support of casings, louvers, fill, distribution systems, fan decks, and other equipment. Inlet air louvers must permit free air passage but no splashout, and must be designed to prevent debris and sunlight from entering the cold water basin.

[2.5.1.4 Air Inlet And Discharge Connections

On forced draft centrifugal type units, the air inlet and discharge connections must have flanged or lipped projections for connecting to ductwork.

]2.5.1.5 Fill

The fill must support expected loads without sag or failure and arranged to effectively break up the water. The fill must be manufactured and performance tested by the cooling tower manufacturer. The fill must be of the materials as specified. Polyvinyl chloride (PVC) fill is suitable for inlet temperatures to 125 degrees F on cross flow type units and temperatures to 130 degrees F on counterflow type units. Chlorinated polyvinyl chloride(CPVC) fill must be used for applications where inlet temperatures are greater than 130 degrees F. Fill must be in accordance with ASTM E84, Class A.

2.5.1.6 Drift Eliminators

Provide drift eliminator sections designed and arranged to effectively trap water droplets entrained in the discharge airstream. Sections must be assembled in easily removable sections for [forced mechanical drift tower][and][counterflow induced mechanical draft tower]. Drift eliminators must be constructed of Polyvinyl chloride (PVC) in accordance with ASTM E84, Class A.

2.5.1.7 Cold Water Basin Equipment.

Include [galvanized steel] [Type 304 stainless steel] sump with stainless steel removable screen and vortex breaker, float valves, and necessary pipe connections and fittings within the tower. [Provide float valves with adjustable arms. Valve sizes larger than 1/2 inch pipe size must be the balanced piston type. Valve seats and disks must be replaceable.] [Electronic water level control must be provided.]

Provide cold water basins and casings suitably sealed and flashed at joints and connections to ensure watertight construction.

2.5.1.7.1 Electric Basin Heater

Heater must be the electric immersion type with water-tight junction boxes mounted in the basin with sufficient capacity to maintain the basin water temperature above 55 degrees F at an ambient temperature of 40 degrees F. Heater must be complete with control thermostat, transformer, contactor, and low water level heater protection.

2.5.1.8 Fans, Blowers, and Drives.

The towers must have axial propeller-type fans having not less than four aluminum alloy or glass-reinforced polypropylene blades or squirrel-cage, centrifugal-type blowers, as applicable. Fans and blowers must be designed and constructed to withstand 50 percent overspeed above normal maximum operating speeds.

If belt drives are utilized, multi-grooved solid back single belt design must be used to avoid uneven belt stretch. Adjustment must be provided for belt tension and drive centers. Belt drives must be designed and constructed for 150 percent overload. Sheaves located in the airstream must be corrosion-resistant material. Shafting for gear drives must have flexible-type couplings requiring no lubrication. The gear assemblies must be enclosed in an oil filled housing provided with fill and drain plugs.

2.5.1.9 Tower Piping

Piping must be schedule 40 PVC and conform to ASTM D2996. Fittings for other piping materials must be of the same material or equal and of the same class and grade as the pipe.

2.5.1.10 Electric Motors

Requirements are specified in paragraph ELECTRICAL WORK.

[2.5.1.11 Vibration Cutout Switch.

Provide [mechanical vibration cutout switch] [electronic vibration cutout switch with auxiliary contacts] in a protected position and most effective location, interlocked with the fan wiring to electrically open the motor circuit under excessive fan vibration.

]2.5.1.12 Performance

The factory assembled tower must have Cooling Tower Institute certification that, in accordance with CTI Std-201, the cooling tower will perform thermally at the rating published by the tower manufacturer in his copyrighted literature.

2.5.1.13 Sound Power Level

Sound power levels, in decibels (dB)with a reference pressure of 0.0002 microbars, of the cooling tower must be not greater than the maximum permitted dB levels for the designated octave band as set forth in Table I or Table II. The sound power level data for the cooling tower must have been verified in tests conducted in accordance with ASA S1.13.

Table I. Sound Power Level For Induced Mechanical Draft Type

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level (dB)	112	112	110	108	102	98	93	90

Table II. Sound Power Level For Forced Mechanical Draft Type								
Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level (dB)	112	112	110	108	102	98	93	90

2.5.1.14 Drift Loss

Drift loss must be not greater than 0.005 percent of the water circulated.

2.5.2 Lubrication

The lubricating points must be extended to the outside of the unit for easy accessibility. Hydraulic lubrication fittings must be in accordance with SAE J534. Where use of high pressure lubricating equipment, 1000 psi or higher, will damage grease seals or other parts, a suitable warning must be affixed to the equipment in a conspicuous location.

2.5.3 Factory Finish System

[Factory painting system] [Galvanized metal] must have been proven to withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Equipment located in a sea coast environment must withstand 3,000 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117. For salt-spray fog test, the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system must be designed for the temperature service and must have been proven to pass the specified salt-spray test.

[2.5.4 Field-Assembled Cooling Towers

Factory fabricated, factory-assembled towers which are shipped to the job site in separate cells or modules must be provided with all appropriate manufacturer's hardware for assembly in the field. Factory fabricated, field-assembled towers must be assembled and adjusted at the job site by a factory representative.

2.5.4.1 Framework, Casing, and Supports

Towers must be designed and constructed to withstand a wind pressure of not less than [30] [_____] pound-force per square foot (psf) on external surfaces. [A 15 percent increased loading must be included for ice or snow load.] [Air inlet and discharge terminations must have flanged or lipped projections for connecting ductwork.] Framework, structural supports, and equipment supports must be [zinc-coated steel,] [Type 304 stainless steel,] [air-entrained concrete] [FRP,] [or] [lumber]. Casing (exterior enclosing walls) must be constructed of [zinc-coated steel] [Type 304 stainless steel] [air-entrained concrete] [FRP] [or] [lumber]. Framework design for wood towers must conform to requirements of CTI Std-103 for redwood construction and CTI ESG-114 for Douglas fir construction. Notching structural wood members may be permissible only if the members are increased proportionately in size to provide equivalent strength. Materials provided for framework, casings and equipment supports must be compatible. Structural supports must be provided in accordance with the recommendations of the manufacturer of the tower unless otherwise indicated. [Cold-pour concrete joints in vertical walls must have a continuous water-stop stripping of molded polyvinyl plastic (6 inch dumbbell).]

2.5.4.2 Foundations

Cooling tower foundations must meet the requirements of the cooling tower manufacturer and wind and seismic loads, wind and seismic loads and be as indicated. Foundation design must be based on the load conditions and soil bearing value indicated. Foundation calculations must be submitted with the equipment drawings.

2.5.4.3 Stairways and Ladders

Provide stairs, 60-degree ship ladders or straight-rung ladders of standard design, starting at [ground] [roof] level and extending as high as required to gain access to fan decks and water distribution systems. Stairways and ladders must be hot-dip, zinc-coated steel. Ladders higher than 12 feet must have a safety cage.

2.5.4.4 Hand Railings

Steel hand railings must be not less than 42 inches high around the exterior of each working surface that is 12 feet or more above the ground, roof, or other supporting construction. Railings must be not smaller than 1-1/4 inch zinc-coated steel pipe with standard zinc-coated steel railing.

2.5.4.5 Access Doors

Each tower must be provided with access doors at grade level to provide entry to the interior for service maintenance without removal of the fill. Doors must be provided on each endwall of each cooling tower cell. Frame and brace access doors to prevent damage when opening and closing. Doors must be located adjacent to float controls.

2.5.4.6 Louvers

Air inlets for each cooling tower must be provided with individually removable louvers arranged to prevent the escape of water. Louvers must be constructed of [PVC] [fiberglass reinforced polyester] [zinc-coated steel] [Type 304 stainless steel] [FRP] [lumber]. Materials provided for casings and louvers must be compatible; one material must not produce stains upon the other. Louvers constructed of lumber must be of a thickness to withstand alternate wetting and drying without cracking or splitting. Air intakes must be provided with 1 inch zinc-coated steel mesh.

2.5.4.7 Fan Deck and Cylinder

Each fan must be mounted in a fan cylinder (or stack) to elevate the fan discharge air. Total extension height must not exceed the fan diameter.

Each fan cylinder must be provided with a zinc-coated steel, 12 gauge 0.108 inch wire mesh securely mounted to the top of the cylinder in accordance with manufacturer's recommendations. Fan decks must be designed to withstand a live load of not less than [40] [60] psf in addition to the concentrated or distributed loads of equipment mounted on the fan decks. [Fan deck and cylinders must be constructed of zinc-coated steel, lumber, Type 304 stainless steel, or FRP and be compatible with the entire tower construction.] [Fan deck must be constructed of precast, reinforced lightweight concrete, in multiple sections, forming a complete, vibration-free base for mounting fan, speed reducer, drive shaft, motor, and fan stacks. Fan cylinders (or stacks) must be constructed of precast, reinforced lightweight concrete in multiple sections, constrained with bands of zinc-coated steel conforming to ASTM A123/A123M, not less than 1/8 by 3 inches, and bolted to form a compressive load on stack perimeter. Fan cylinder must be secured in place on the fan deck with Class A mortar.]

2.5.4.8 Fans

Fans must be the [centrifugal] [or] [adjustable-pitch propeller] type, constructed of zinc-coated steel, Type 304 stainless steel, aluminum or an aluminum alloy, or FRP. Propeller type fans must have a maximum tip speed of 10,800 fpm. Fan blade assembly must be both statically and dynamically balanced after assembly of the cooling tower. Fan hub must be constructed of [zinc-coated steel] [stainless steel] [cast aluminum] with adequate surface protection against corrosion. Complete fan assembly (fan and mounting) must be designed to give maximum fan efficiency and long life when handling saturated air at high velocities. Each cooling tower fan must be provided with a ball and pedestal type vibration limit switch which must stop the corresponding fan motor in the event of sensing excessive fan vibration.

2.5.4.9 Speed Reducers Gears and Drive Shaft

Speed reducer gears must be rated in accordance with CTI STD-111. Gear reducers must be of the [spiral bevel, single reduction] [spiral or helical, double reduction] type. Reducer must be mounted in accordance with manufacturer's recommendations. Each reducer must be provided with an oil level cutoff switch interlocked to the fan motor. Each reducer must be provided with an oil level sight glass, fill, drain, and vent lines located in a readily accessible position. Drive shafts must be the full floating type with flexible couplings at both ends and have a service factor of 1.0 or greater. Drive shafts must be of stainless steel, fitted each end with flexible couplings (stainless steel plate type). Each drive shaft must be provided with a galvanized steel guard, to prevent damage to surrounding equipment in case of shaft failure. Provision must be made for lubrication of all bearings. Bearings must be accessible to the extent that each bearing can be lubricated without dismantling fan.

2.5.4.10 Electric Motors

Each motor must be a [single speed] [two speed] [variable speed], totally enclosed, insulation Class B, NEMA Design B, continuous-rated type which conforms to NEMA MG 1. Motors must have [open] [dripproof] [totally enclosed] [explosion proof] enclosures and be located outside the discharge airstream. Motors must be mounted according to manufacturer's recommendations. [Two-speed motors must have a single winding with variable torque characteristics.][Motors for variable speed application must be inverter-duty type.]Motors must be provided specifically for either pump or fan application and must comply with the requirements of paragraph ELECTRICAL WORK.

2.5.4.11 Cold Water Basin

Basin must be completely watertight and constructed of [zinc-coated steel] [Type 304 stainless steel] [FRP]. Basin must be constructed and installed to ensure that air will not be entrained in outlets when operating and no water will overflow on shutdown. Each individual sump must be provided with an individual outlet. Each outlet must be provided with a 1/2 inch stainless steel wire mesh, securely mounted to prevent trash from entering the outlet. Each basin must be provided with overflow and drain valve connections. Each basin must be provided with a float-controlled, makeup water valve as indicated. The makeup water must discharge not less than 2 inches or two pipe diameters, whichever is greater, above the top of the basin.

2.5.4.12 Electric Basin Heater

Heater must be the electric immersion type with water-tight junction boxes mounted in the basin with sufficient capacity to maintain the basin water temperature above 40 degrees F at an ambient temperature of [_____] degrees F. Heater must be complete with control thermostat, transformer, contactor, and low water level heater protection.

2.5.4.13 Hot Water Distribution System

Water distribution must be the [gravity-flow] [pressurized-flow] type system which distributes waters evenly over the entire fill surface. Each tower cell must be designed so that a water flow of 140 percent capacity will not cause overflowing or splashing. The distribution system for each cell must include adjustable flow control valves. The entire distribution system must be self-draining and nonclogging. Piping must be either cast iron, ductile iron, threaded-glass-fiber reinforced epoxy pipe, polypropylene, PVC or Schedule 80 black steel.

a. Gravity-Flow System: System must be provided with open basins which include a splash box or baffles to minimize splashing of incoming hot water and holes that evenly distribute the water over the entire decking area. Holes used in a water basin must be provided with ceramic or plastic orifice inserts.

b. Pressurized-Flow System: System must include piping, fittings, branches, and spray nozzles. Spray nozzles must be schedule 40 PVC. Nozzles must be cleanable, nonclogging, removable, and spaced for even distribution.

c. Basin Cover: Hot water distribution basins must be provided with the tower manufacturer's standard removable, [zinc-coated galvanized steel] [304 stainless steel] [FRP] covers. Covers must prevent airborne debris from entering the basin.

]2.5.5 Drift Eliminators

Eliminators must be provided in the tower outlet to limit drift loss to not over [0.005] percent of the circulating water rate. Eliminators must be constructed of polyvinyl chloride (PVC).[Eliminators sections must be supported on PVC or FRP tee sections. Tee sections must be suspended with 1/4 inch brass rods connected to stainless steel clips embedded in the bottom side of the roof deck at the time of casting. Stainless steel clips must be supplied by cooling tower manufacturer for installation by Contractor at time of roof deck pour. Eliminators may be supported by brass or stainless steel suspension rods from the fan deck or supported directly on concrete beams.]

2.5.6 Cold Water Basin Equipment.

Include sump with removable screen and vortex breaker, float valves, and necessary pipe connections and fittings within the tower. Provide float valves with adjustable arms. Valve sizes larger than 1/2 inch pipe size must be the balanced piston type. Valve seats and disks must be replaceable. [Electric water level control must be provided.]

Provide cold water basins and casings suitably sealed and flashed at joints and connections to ensure watertight construction.

2.5.7 Fill (Heat Transfer Surface)

Tower fill must be the [splash] [or] [film] type. Fill material must be free to expand or contract without warping or cracking. No plasticized wood cellulose must be provided for fill material. Fill must be removable or otherwise made accessible for cleaning. Space supports must be corrosion resistant and must prevent warping, sagging, misalignment, or vibration of the fill material. Fill material and supports must be designed to provide for an even mixing of air and water. Fill material must be constructed of [aluminum] [stainless steel] [tile of multi-cell design, set without mortar] [PVC formed sheets, zinc-coated steel, or lumber] in a pattern, and of sufficient height to meet the performance specifications. [Tile fill must be vitreous, with a low water absorption that will pass a freeze-thaw test conducted in accordance with ASTM C67/C67M. Tile fill must have a minimum crushing strength of 2,000 psi over the gross area of the tile when the load is applied parallel to the cells as tested in accordance with ASTM C67/C67M. Cast iron tee section lintels supporting the tile fill must conform to ASTM A48/A48M, Class 25, 1/8 inch additional thickness for corrosion. Lintels must be designed with a safety factor of 2 minimum.]

2.5.8 Fire Safety

Towers must conform to NFPA 214. Fire hazard rating for plastic impregnated materials must not exceed 25. Plastics must not drip or run during combustion. Fire hazard ratings must be in accordance with ASTM E84, Class A and UL 723.

[2.5.9 Meters and Controls

Tower must be provided with makeup and blowdown meters, conductivity controller, and overflow alarm.

]2.6 REMOTE EVAPORATIVELY-COOLED CONDENSERS

Condenser must be rated and tested in accordance with the requirements of ASHRAE 64. Condenser must include fans, water pump with suction strainer, electric motor and drive equipment, water eliminators if required, condensing coil, liquid receiver if required, water pan or sump, spray nozzles or water-distribution pan, water strainer, water make-up assembly, bleeder with flow valve of the needle valve type sized for the flow required or a fixed orifice, enclosure with suitable access doors, and air-inlet and outlet openings. No water may carry over into the unit discharge outlet.

2.6.1 Condenser Casing

Enclosure must be constructed of not lighter than 18 gauge 0.516 inch[hot-dip galvanized steel][304 stainless steel], reinforced and braced. Access doors or panels suitably sized and located must be provided for access to water nozzles or distribution pan, coils, and valves for cleaning, repair, or removal of the item. Access doors or panels must be gasketed with synthetic rubber, or equivalent gasket material, and locked in place with thumb screws or catches. One-half inch mesh hot-dip galvanized steel or copper air-inlet screens must be provided on each air inlet.

2.6.2 Refrigerant Section

Condenser coil must be constructed of unfinned copper or steel tubes hot-dip galvanized after fabrication. The receiver must be welded steel and must be fitted and tested in accordance with ANSI/AHRI 495. A refrigerant charging valve must be installed in the liquid line between the receiver cut-off valve and the expansion device. Refrigerant section must be tested in accordance with ANSI/ASHRAE 15 & 34 for the refrigerant employed in the system. CFC-based refrigerants are prohibited.

2.6.3 Fans

Fans must be centrifugal or propeller type as best suited for the application. Fans must be direct or V-belt driven. Belt drives must be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment must be provided. Sheave set must be matched and selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans must be statically and dynamically balanced. Fan motor must be totally enclosed type or open drip-proof and located within an enclosure to be fully protected from the weather.

2.6.4 Water Section

Water eliminators must be constructed of nonferrous metal, of an approved nonmetallic material, or of not lighter than 24 gauge 0.0276 inch steel, hot-dip galvanized after fabrication. Spray nozzles must be brass non-clogging type designed to permit easy disassembly, and must be arranged for easy access. Water pump must be bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pump suction must be fully submerged and provided with screened inlet. Water pan or sump must be constructed of not lighter than 14 gauge 0.0785 inch steel, hot-dip galvanized after fabrication, or molded acid-resistant glass-fiber-reinforced polyester. Water distribution pan must be constructed of not lighter than 16 gauge 0.0635 inch steel, hot-dip galvanized after fabrication. Joints must be watertight. Water pan or sump must be provided with drain, overflow, and make-up water connection with stop valve and float valve. A bleed line with a flow valve of the needle type sized for the flow required or fixed orifice must be provided in the pump discharge line and must be extended to the nearest drain for continuous discharge.

2.7 FABRICATION

Equipment and component items, must have been proven to withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Equipment located in a sea coast environment must withstand 3,000 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.8 SUPPLEMENTAL COMPONENTS/SERVICES

2.8.1 Condenser Water Piping and Accessories

Condenser water piping and accessories must be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.8.2 Cooling Tower Water Treatment Systems

Cooling tower water treatment systems must be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT AND CONDENSER WATER PIPING SYSTEMS.

2.8.3 Temperature Controls

Cooling towers must be fully coordinated with and integrated [into the temperature control system specified in [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]] [into the existing air-conditioning system].

PART 3 EXECUTION

3.1 DEMONSTRATIONS

Contractor must conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

Provide a schedule, at least [2] [_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

3.2 INSTALLATION

Installation of cooling tower systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with NFPA 70, and in compliance with the manufacturer's written installation instructions, including the following:

[(1) Packaged cooling tower - installation instructions

][(2) Field-erected cooling tower - installation instructions

]3.2.1 Installation Instructions

Provide manufacturer's standard catalog data, at least [5] [_____] weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials of construction, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions and procedures. Data must be adequate to demonstrate compliance with contract requirements.

3.2.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.2.3 Posted Instructions

Provide posted instructions, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions must include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions must be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

3.2.4 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.2.5 Demonstrations

Provide a schedule, at least [2] [_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

3.2.6 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above must be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

3.2.7 Operation and Maintenance Manuals

Provide [Six] [_____] complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least [4] [_____] weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. [Six] [_____] complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.2.8 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

[3.3 RELATED FIELD TESTING

3.3.1 Test Plans

a. Manufacturer's Test Plans: Within [120] [_____] calendar days after contract award, submit the following plans:

[(1) Packaged cooling tower - field acceptance test plan

][(2) Field-erected cooling tower - field acceptance test plan

] Field acceptance test plans must developed by the cooling tower manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance test plans must be the plan and procedures followed for the field acceptance tests of the cooling towers and subsequent test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under [Section 23 09 53.00 20, SPACE TEMPERATURE CONTROL SYSTEMS] [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

c. Prerequisite testing: Cooling towers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Tower manufacturer must furnish with each test procedure a description of acceptable results that have been verified.

Tower manufacturer must identify the acceptable limits or tolerances within which each tested performance variable must acceptably operate.

f. Job specific: Each test plan must be job specific and must address the particular cooling towers and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

]3.4 TESTING

a. Each cooling tower system must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

[(1) Packaged cooling tower - field acceptance test report

][(2) Field-erected cooling tower - field acceptance test report

] b. Manufacturer's recommended testing: Conduct the manufacturer's recommend field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed must result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

g. Towers with thermal performance not CTI certified to CTI Std-201 must have their thermal performance verified by field testing that meets the requirements of CTI ATC-105

-- End of Section --

SECTION 23 72 00.00 10

ENERGY RECOVERY SYSTEMS
01/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC I	(2017) BPVC Section I-Rules for Construction of Power Boilers
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 19.3 TW	(2016) Thermowells Performance Test Codes

ASTM INTERNATIONAL (ASTM)

ASTM D1066	(2018; E 2018) Standard Practice for Sampling Steam
ASTM D2186	(2005; R 2009) Deposit-Forming Impurities in Steam

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation

SD-03 Product Data

Calculations

Welding Procedures and Qualifications

Spare Parts

Posted Instructions

Performance Tests; G[, [_____]]

SD-06 Test Reports

Tests

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

1.3 WELDING PROCEDURES AND QUALIFICATIONS

[Submit a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators. Furnish qualified procedures and welders in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. Notify Contracting Officer 24 hours in advance of tests and perform tests at the work site if practicable. The welder or welding operator must apply his assigned symbol near each weld he makes as a permanent record. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] [Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING.]

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt and dust, or other contaminants.

1.5 EXTRA MATERIALS

Furnish all special tools necessary for the operation and maintenance of boilers, pumps, fans, and other equipment. Furnish small hand tools with a suitable cabinet, mounted where directed.

1.5.1 Tube Cleaner

Provide water-driven type with three rotary cutters and rotary wire brush, complete with the necessary length of armored water hose, valves, and other appurtenances necessary for operation. Provide tube cleaner and rotary brush for each size of water tube in the boiler, with one extra set of cutters for each size cleaner. Provide necessary valves and fittings to permit quick connection of the raw water supply hose to one boiler feed pump for operation of the cleaner.

1.5.2 Tube Brush

Provide tube brush, with steel bristles and jointed handle of sufficient length to clean full length of fire tubes.

1.5.3 Smoke Pipe Cleaner

Provide smoke pipe cleaner to clean the breeching and smoke connections. Provide cleaner with a jointed handle long enough to clean breeching and smoke connections without dismantling the system.

1.5.4 Special Wrenches

Provide special wrenches as required for opening boiler manholes, handholes, and cleanouts.

1.5.5 Spare Parts

Submit spare parts data for each different item of equipment specified, after approval of the detail drawings and not later than [_____] months before the date of beneficial occupancy. Include in the data a complete list of spare parts and supplies with current unit prices and source of supply.

1.6 OPERATION AND MAINTENANCE MANUALS

The manuals will be approved by [the Contracting Officer] [_____] before acceptance of the installed system. Submit [6] [_____] complete copies of operation manual for energy recovery system outlining the step-by-step procedures required for system startup, operation, and shutdown. Include in the manuals the manufacturer's name, model number, service manual, parts list, and a brief description of all equipment items and their basic operating features. Submit [6] [_____] copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and provide troubleshooting guide. Include in the manuals piping layout, equipment layout, and simplified wiring and control diagrams of the system as installed.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Provide equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

For each major item of equipment, secure a plate to the item of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.1.3 Prevention of Rust

Unless otherwise specified, factory prime-paint surfaces of ferrous metal subject to corrosion with a rust-inhibiting coating and subsequently factory finish-painted in accordance with the manufacturer's standard practice. Prime heat recovery equipment exposed to high temperature when in service and finish paint with the manufacturer's standard heat resistant paint to a minimum thickness of 1 mil.

2.1.4 Equipment Guards and Access

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts located where personnel contact is possible. Guard or cover high temperature equipment and piping located within personnel contact or where a potential fire hazard exists with insulation of a type specified. Provide items such as catwalks, operating platforms, ladders, and guardrails where shown and construct them in accordance with Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS].

2.2 HEAT RECOVERY EQUIPMENT

Provide a heat recovery system that is an integrated design package compatible with the prime mover [cooling] [and] [exhaust] system in accordance with the drawings and data sheets. Provide a [diesel engine exhaust waste heat boiler only to generate [saturated steam at [_____] psig pressure] [hot water at [_____] degrees F and [_____] psig pressure].] [diesel engine [jacket water cooling and heat reclaim system] [and] [lube oil cooling and heat reclaim facilities].] [diesel engine ebullient cooling system combining jacket water heat reclaim and exhaust waste heat boiler to generate up to 15 psig steam.] [gas turbine exhaust heat reclaim unit to generate [steam at [_____] psig] [hot water at [_____] degrees F and [_____] psig pressure].]

2.2.1 Diesel Engine Cooling

2.2.1.1 Antifreeze

[For ebullient cooling, provide a cooling system suitable for a combination of water and an azeotropic antifreeze compatible with the equipment (methoxy propanol) as a cooling medium, hereafter called the coolant.] [For cooling systems where steam is not required, utilize an ethylene glycol permanent type antifreeze. Base size of cooling system upon the use of an antifreeze solution which will protect the system down to minus 50 degrees F.] Provide a permanent type antifreeze for cooling the lube oil and auxiliaries suitable for use with water, or use the antifreeze solution specified above and connect to a separate section of the waste heat condenser from the engine coolant. Provide valve trim and materials that are compatible for use with the antifreeze solution. Operation of the cooling system must be fully automatic while the prime mover is running.

2.2.1.2 Water Jacket Temperature

For diesel engine ebullient cooling, provide jacket water temperature no lower than 230 degrees F, nor higher than 250 degrees F in the steam separator at all loads with a maximum differential of [_____] degrees F for coolant in and out of the engine.

2.2.1.3 Construction

Where cooling system design is part of prime mover installation, components other than the wasteheat condenser and condensate receiver or pump units may be mounted on the engine skid extension. For any antifreeze cooling system, provide a PVC makeup tank with an electric motor-driven pump unit as indicated. Manifold pump to allow using it as a mixing unit by shunting the flow back to the tank. System fill must be [manual] [automatic] with feed into the piping system steel expansion tank connection line as indicated.

2.2.2 Electrical Equipment

Provide electric motor-driven equipment specified complete with motors and necessary motor control devices. Provide motors and motor control devices conforming to the applicable requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM including requirements for hazardous area locations. Provide premium efficiency integral size motors in accordance with NEMA MG 1.

2.2.2.1 Motor Ratings

Furnish motors that are suitable for the voltage and frequency provided. Motors 1/2 horsepower and larger must be three-phase, unless otherwise indicated. Ratings must be adequate for the duty imposed, but not less than indicated.

2.2.2.2 Motor Controls

Where a motor controller is not shown in a motor control center on the electrical drawings, provide a motor controller. Where required, provide motor controllers complete with properly sized thermal overload protection and other equipment at the specified capacity including an allowable service factor, and other appurtenances necessary for the motor control specified. Provide manual or automatic control and protective or signal devices required for operation specified and any wiring required to such devices not shown on the electrical drawings. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function.

2.2.3 Heat Recovery Silencer for Diesel Engine

For each combination boiler silencer or supplementary silencer, reduce the generated sound spectrum to standard commercial level permitted for [industrial] [semi-residential] [residential, critical] area. Provide exhaust gas boiler that is a combination boiler silencer or a boiler with a supplementary silencer to meet the noise limits, and construct heat recovery unit in accordance with ASME BPVC SEC VIII D1 for [_____] psig steam working pressure. Design the boiler for maximum efficient heat recovery under any load condition up to 110 percent of full load with an exit exhaust gas temperature not less than 330 degrees F. Design each boiler for continuous wet operation or for periods of dry operation without interruption of the diesel engine operation when located and connected as indicated. Make provisions for expansion and contraction to prevent overstressed conditions in the pressure vessel during continuous wet or dry operation. Gas side pressure drop through the boiler exceeding the recommendations of the engine manufacturer is not permitted. Provide each boiler with standard boiler trim including, but not limited to, pressure gauge, water gauge with try cocks, water level control, ASME-rated safety relief valve, surface blowoff valve, bottom blowdown valves, and bottom dump valves. Insulate the shell as required by the paragraph "INSULATION" and cover the insulation by lagging.

2.2.4 Heat Recovery Section for Gas Turbine

Furnish unit consisting of a [fire tube] [water tube or water wall] exhaust boiler equipped with an exhaust gas bypass. Design unit for the specified installation and provide a complete package with thermal insulation, controls, accessories, and base. The insulation must be in accordance with the paragraph "INSULATION." If heat recovery section does not meet the turbine exhaust sound levels specified, supply a supplementary exhaust silencer to meet specification requirements for both on-stream and bypass conditions.

2.2.5 Steam Separator Unit

Provide unit consisting of a combination flash tank and steam separator unit of sufficient size for the engine cooling and waste heat recovery system when engine is operated at 110 percent load in an ambient temperature of [105] [_____] degrees F at [_____] feet altitude. The unit must be complete with low-water alarm switch, low-level cutout switch (set at a level lower than the low-water alarm switch), pressure gauge, safety valve, gauge glass and cocks, vent valve, water-level control, high-water-level alarm, condensate-motor control, and blowdown connection. Position controls so that coolant level is visible in gauge glass at all times. Construct and certify the vessel in accordance with the ASME requirements and hydrostatically test conforming to ASME requirements. Use steam at 15 psig from this separator for [space heating] [and] [absorption cooling] [_____]. Insulate the unit as required by paragraph "INSULATION."

2.2.6 Condensate Pumps and Receiver

Furnish condensate unit with duplex pumps and receiver and skid-mount. Provide pump that is capable of full capacity at 120 percent full steam rate when all of the heat is wasted under 110 percent engine load in an ambient temperature of [105] [_____] degrees F. Provide an alternator for automatically switching the pumps under response from the liquid level control of the steam generator units each time an ON-OFF cycle is completed. Provide electric motor-driven pumps with stainless steel shafts and bronze impellers for operation with condensate at 200 degrees F. Control pump operation to maintain condensate level between high and low visible levels indicated on the glass gauge of the receiver. Provide receiver sized to hold at least enough condensate for 15 minutes of operation without raw water makeup and complete with skid mounting, gauge glass, float-type makeup water valve with emergency manual valve, air vent, high-and low-level controlled pump switch, low-level alarm, and drain connection. Provide air vent suitable for use with coolant selected.

2.2.7 Load Control Condenser

Furnish condenser unit with a capacity to dissipate the heat rejected by the engine and its components at 110 percent full-rated load under temperature of [_____] degrees F and at [_____] feet elevation from above sea level. The maximum coolant temperatures leaving the engine must not be in excess of that recommended by the engine manufacturer; however, temperature differential must not be greater than [_____] degrees F for coolant in and out of the engine.

2.2.7.1 Air-Cooled Condenser

Provide main core unit suitable for condensing the vapor generated during engine operation from zero to 110 percent of full load when there is no utilization of the steam for useful purposes. Use a secondary core for cooling the auxiliary system coolant. The condenser must be the [vertical] [horizontal] air discharge type with round tubes. Construct fins and tubes of nonferrous materials; provide carbon steel headers of the plug type. Firmly bond fins to tubes; construct tanks and supporting framework of steel; and construct adjustable-pitch fan of aluminum. Make inlet and outlet coolant connections on one side. Install a drain cock at the low point of each core. Provide a welded structural frame for entire unit, drilld and arrange for mounting on a concrete base, and design to withstand winds up to [50] [_____] mph. [Provide hail screens in areas where hails storms are prevalent.] Provide reliefs to protect against excessive pressures and temperatures developed in the system.

a. Furnish condenser complete with motor-driven fan or fans and with face dampers controlled by the condensate temperature. [Provide two fans per bay.] Avoid excessive subcooling of the condensate by overexposure to the air stream. Provide freeze protection for all modes of operation. Do not exceed fan tip speed of 12,000 feet/minute.

b. Direct-connect or belt connect rhe fan motor to the fan and seal bearings. Provide motor that is three-phase, squirrel cage induction type, [208] [460] volts at 60 Hz, synchronous speed not to exceed [1,200] [1,800] rpm. Provide motor size such that seasonal adjustments of the fan blade pitch are not necessary to prevent motor overloads when ambient air temperature drops to lowest value or rises to highest value specified for the prime mover operating conditions. Provide a 60 Hz, across-the-line, enclosed type, magnetic motor starter having thermal overload protection in each ungrounded phase. If the condenser fan motor is large enough to cause a transient voltage dip of 20 percent or more during starting inrush, use a reduced-voltage type magnetic motor starter. Make connections such that the fan motor will start automatically as its respective engines are started.

c. The distance between condenser and engine must be [[_____] feet] [as shown]. Furnish complete unit with a matched float and thermostatic trap installation. Provide air flow from the fan motor [upward] [downward] [inward] [outward] through the condenser. Furnish twelve-inch lengths of flexible hose or pipe for all inlet and outlet pipe connections. Provide a valved vent for release of noncondensible gases. Provide condenser sized by the engine manufacturer for this application. Auxiliary system coolant temperature must not exceed 180 degrees F, with a maximum differential of 15 degrees F. Maintain temperature for the system by regulating the steam pressure.

2.2.7.2 Water-Cooled Condenser

Provide a shell-and-tube type unit rated for 85 degrees F entering water and 105 degrees F leaving water. Furnish a complete unit with a matched float and thermostatic trap installation as well as a subcooler unit to reduce flashing of condensate. Provide a valved vent for release of noncondensible gases.

2.2.8 Pressure-Operated Control Valve

Provide butterfly control valve with maximum 60 percent full open operating position for good control characteristics. Nominal rating must be 1 psig with pressure drop at 60 percent of full open position. For use as a back pressure valve when there is no auxiliary fired boiler, provide metal-to-metal seats which do not provide 100 percent shutoff to condenser. For use with an auxiliary fired boiler, provide high temperature butyl or silicone rubber or EPDM seats for bubble-tight shutoff to the condenser. Provide valve operator that is [electric proportional operator with pressure control mounted internally] [pneumatic with controller with proportional band, reset and filter regulator mounted on operator]. Valve must open on loss of air supply pressure.

2.2.9 Auxiliary Boiler for Supplemental Firing

Provide boiler and related equipment as specified in Section 23 52 30.00 10 HEAT RECOVERY BOILERS .

2.2.10 Forced Circulation Pump

Where an engine-driven pump is not provided for jacket water circulation, provide a separate electric motor-driven pump interlocked with engine operation as required by the engine manufacturer.

2.2.11 Heat Exchangers

Provide heat exchangers as shown. Provide heat exchangers that are the shell-and-tube design, either U-tube type or helical coil type. Other types of construction are not acceptable unless prior written approval is received. Design, fabricate, test, and stamp heat exchangers in accordance with ASME BPVC SEC VIII D1.

a. Furnish construction materials suitable for the intended service except do not use cast material. The manufacturer's drawing submittal must indicate the grade of material that has been used, giving the full ASME specification number designation for each component. Furnish U-tube materials as light drawn temper; furnish fully annealed helical coils. Provide carbon construction materials on the shell side [casing]. Provide tube side materials that are 90-10 Copper-Nickel for the tubes, tubesheets, and channel bonnets for U-tube designs. Provide tubing and headers for the helical coil designsthat are 90-10 Copper-Nickel.

b. Provide either rolled or welded tube-to-tube sheet connections and tube-to-header connections for helical coils for the condensate cooler and lube oil cooler, and welded for lube oil preheater.

2.2.11.1 Lube Oil Cooling

Furnish lube oil cooling and heat reclamation exchangers as part of the engine. The designs must provide for the oil to be on the outside of the tubes and the cooling water on the inside. Provide a thermal sensing unit in the oil outlet piping where it can sense the mixed average temperature of the oil leaving the cooler and actuate the control valve on the cooling water flow to prevent overcooling the lube oil.

2.2.11.2 Fuel Oil Preheating

If fuel oil preheating is required, provide this heat exchanger as part of the boiler package. The designs must provide for the oil to be on the outside of the tubes and the steam or high temperature water on the inside. Provide a thermal sensing unit in the oil outlet piping where it can sense the mixed average temperature of the oil leaving the preheater and actuate the control valve on the high temperature hot water/steam to ensure that oil temperature is in the proper range for the prime mover.

2.2.11.3 Condensate Heat Exchanger

High pressure condensate heat exchanger must provide heating of domestic or boiler feedwater while reducing the condensate temperature to minimize flashing in the condensate surge tank. The designs must provide for the condensate to be on the outside of the tubes and the cooling water (domestic or boiler feedwater) to be on the inside.

2.2.12 High Temperature Water Heat Recovery Systems

Where high temperature water is utilized as a heat recovery system medium, provide system with proper expansion tank, dump tank, pressurization system, circulation pumps, makeup water facilities, controls, unit heaters, and piping as specified in Section 23 50 52.00 10 CENTRAL HIGH TEMPERATURE WATER (HTW) GENERATING PLANT AND AUXILIARIES.

2.2.13 Pressure Gauges

Provide heavy-duty industrial type gauges conforming to ASME B40.100, style as required, suitable for pressure or vacuum specified, with minimum 6 inch diameter dial, except as otherwise specified. Install pressure gauges on each boiler, on the low-pressure side of each pressure reducing valve, on the discharge side of each pump, and where shown or where required for proper operation. Provide gauges that are readily accessible and easily read from the operating floor. Equip gauges with integral or separate siphons and connect by brass pipe and fittings with shutoff cocks. Where pressure-reducing valves are used, place gauges close to the pressure-reducing assembly, both downstream and upstream, but connect approximately 10 feet therefrom. Provide operating ranges of the gauges be as follows:

Gauges	Operating Pressure, psig	Pressure Range, psig
Boiler	100-125	0-200
Medium-Pressure Steam	50	0-100
Low-Pressure Steam	2-5	0-30
Boiler Feed Pump	2-5	0-200
Other Pumps	20-50	0-100

2.2.14 Thermometers

Furnish thermometers conforming to ASME PTC 19.3 TW, Type I, Class 3, with wells. Do not use Mercury in thermometers. Temperature ranges must be suitable for the intended use. Install thermometers in the feedwater pipeline between the feedwater heater and boiler feed pump in the main condensate return line before entering the surge tank, and elsewhere as indicated or specified. Thermometers must have straight or angle stems as required and must be easily read from the operating floor.

2.3 WATER TREATMENT EQUIPMENT

Water treatment equipment is required and must be as specified in Section 23 25 00 CHEMICAL TREATMENT OF WATER FOR MECHANICAL SYSTEMS.

2.4 INSULATION

Apply insulation in sufficient thickness to limit the surface temperature of the lagging to not more than [120] [150] degrees F when in still air at site maximum dry bulb temperature. Submit Heat transfer calculations to the Contracting Officer to substantiate insulation material and thickness selection. Provide insulation with waterproof lagging when installed outdoors. Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install equipment in accordance with manufacturer's instructions and recommendation. Bolt all pieces of equipment in place on foundations unless they are skid-mounted on the prime mover base skid. Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, drawings, and installation instructions. Include in the drawings complete piping and wiring drawings, schematic diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Also show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances required for maintenance and operation. Use flexible connectors to connect any piping to the prime mover. Provide piping for interconnecting various components of the heat recovery equipment conforming to the requirements of ASME B31.1. Submit calculations, manufacturer's design data and structural computations for walls, roof, foundations, and other features for specialty type of construction, with design data for lateral forces that may be encountered due to wind loads and seismic zone forces.

3.3 CLEANING OF BOILERS AND PIPING

3.3.1 Boiler Cleaning

After the hydrostatic tests have been made and before starting the operating tests, thoroughly and effectively clean the boiler of foreign materials, including mill scale, grease, and oil deposits. The Contractor may use the following described procedure or may submit his own standard procedure for review and approval by the Contracting Officer. Wherever possible, wire-brush surfaces in contact with water to remove loose material before filling the boiler with a solution containing:

caustic soda	24 pounds

sodium nitrate	8 pounds
disodium phosphate, anhydrous	24 pounds
approved wetting agent, 1000 gallons water	1/2 pound

Dissolve chemicals thoroughly in the water before placing in the boilers. Operate the boiler at 30 to 50 psig and minimum rating for 24 to 48 hours, exhausting the steam to atmosphere. After the boiling period, allow the boiler to cool before being drained and thoroughly flushed out. Clean piping by operating the boilers for a period of approximately 48 hours, wasting the condensate.

3.3.2 Boiler Water Conditioning

Provide chemical treatment and blowdown of boiler water during periods of boiler operation to prevent scale and corrosion in boilers and in steam and return distribution systems from initial startup of the system, through the testing period, and to final acceptance by the Government. Chemicals used and method of treatment must be approved by the Contracting Officer.

3.4 POSTED INSTRUCTIONS

Submit framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, to be posted where directed. Submit proposed diagrams, instructions, and other sheets, prior to posting, as specified. Prepare condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system in typed form, frame as specified above for the wiring and control diagrams, and post beside the diagrams. Post the framed instructions before acceptance testing of the systems.

3.5 FIELD TRAINING

Provide a field training course for designated operating staff members. Training must be provided for a total of [_____] hours of normal working time and must start after the system is functionally complete, but prior to final acceptance tests. Cover all of the items contained in the approved operation and maintenance instructions.

3.6 TESTS

Following installation, test each boiler hydrostatically and prove that the system is tight under a gauge pressure of 1.5 times the working pressure specified and in accordance with applicable ASME requirements. Following the installation of piping and heat recovery equipment, but before the application of any insulation, perform hydrostatic tests and prove that the system is tight under gauge pressures of 1.5 times the working pressure specified, but no less than the following:

Low-pressure lines	40 psi

Medium-pressure lines	60 psi
High-pressure-steam lines	150 psi
Boiler feed lines	225 psi

The boilers and the piping must be inspected by a boiler inspector qualified as required by ASME BPVC SEC VIII D1, ASME BPVC SEC I, or ASME BPVC SEC IV, as applicable. Supply a certificate of approval for each boiler. Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of controls.

3.7 EFFICIENCY AND OPERATING TESTS

Upon completion, and before acceptance of the work, subject the heat recovery plant to such operating tests as may be required to demonstrate satisfactory functional operation. Conduct each operating test at such times as directed by the Contracting Officer. Use water meter in the test that is suitable for hot water. Provide instruments, test equipment, and test personnel required to properly conduct all tests; the necessary fuel, water, and electricity will be furnished by the [Government] [_____]. Conduct boiler operating tests, as a minimum, continuously at the following capacities for the following time:

Test Percentage of Operating Capacity		
Testing Time	Water Wall or Water Tube Boilers	Firebox Boilers
First 2 hours	50	50
Next 2 hours	75	75
Next 6 hours	100	100*
Next 2 hours	110	--

a. Do not operate firebox boiler above 100 percent of capacity.

b. Conduct general performance tests on the heating plant by an experienced test engineer and tests will be observed by the Contracting Officer. Submit a proposed performance test procedure, 30 days prior to the proposed test date. Include in the procedure a complete description of the proposed test with calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in the tests. Do not start the test until the procedure has been approved. Deliver test report including logs, heat balance calculations, tabulated results, and conclusions to the Contracting Officer as stated in the paragraph "PERFORMANCE TEST REPORTS." [Submit an analysis of the fuel being burned on the test to the Contracting Officer.]

c. Test of capacity of water treatment equipment and quality of the effluent must meet the requirements specified. Perform tests for ion-exchange units covering at least two complete regenerations and capacity runs. Conduct tests for hot process or other precipitation type softeners continuously for a period of at least 48 hours, with samples taken at 2-hour intervals.

d. Conduct tests for steam quality in accordance with ASTM D1066 under the operating conditions specified.

e. Test quality of steam used for air conditioning equipment in accordance with the conductivity method in ASTM D2186 with the conductivity of the steam corrected for carbon dioxide and ammonia content not to exceed 4.0 micromhos at 65 degrees F.

3.8 RETESTING

If any deficiencies are revealed during test, correct such deficiencies and reconduct the tests at no additional costs to the Government.

3.9 FIELD PAINTING

Clean, prepare, and paint ferrous metal surfaces not specified to be coated at the factory as specified in Section 09 90 00 PAINTS AND COATINGS. Paint exposed pipe covering as specified in Section 09 90 00 PAINTS AND COATINGS. Do not paint aluminum lagging over insulation.

-- End of Section --

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SECTION 23 76 00

EVAPORATIVE COOLING SYSTEMS
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 210 (2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410 (2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9 (2015) Load Ratings and Fatigue Life for Ball Bearings

ABMA 11 (2014) Load Ratings and Fatigue Life for Roller Bearings

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A240/A240M (2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

ASTM A924/A924M (2022) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

ASTM A1011/A1011M (2018a) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B696	(2000; R 2015) Standard Specification for Coatings of Cadmium Mechanically Deposited
ASTM E2016	(2022) Standard Specification for Industrial Woven Wire Cloth

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PS 10.01	(1982; E 2004) Hot-Applied Coal Tar Enamel Painting System
SSPC Paint 16	(2006; R 2015; E 2015) Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 200-1-13	(2016) Environmental Quality -- Minimizing the Risk of Legionellosis Associated with Building Water Systems on Army Installation

UNDERWRITERS LABORATORIES (UL)

UL 94	(2013; Reprint Apr 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 507	(2017; Reprint Aug 2018) UL Standard for Safety Electric Fans
UL 746C	(2018; Reprint Sep 2021) UL Standard for Safety Polymeric Materials - Use in Electrical Equipment Evaluations
UL 900	(2015) Standard for Air Filter Units

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will

review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Letter Of Qualification

Manufacturer's Authorized Service Representative; G[, [_____]]

SD-02 Shop Drawings

Installation Drawings; G[, [_____]]

SD-03 Product Data

Evaporative Coolers; G[, [_____]]

Air Washers; G[, [_____]]

Water Tanks; G[, [_____]]

[Thermostats; G[, [_____]]

] Corrosion Coating; G

SD-06 Test Reports

Performance Tests; G[, [_____]]

SD-07 Certificates

Test Procedures; G[, [_____]]

Energy Efficient Products for Evaporative Cooler; S[, [_____]]

System Diagrams; G[, [_____]]

SD-08 Manufacturer's Instructions

Installation; G[, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

Operational Training; G[, [_____]]

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Coordination of Trades

Furnish tank supports, piping offsets, fittings, and any other accessories as required to provide a complete and functional system in accordance with the manufacturer's published criteria for the type of system installed and to eliminate interference with other construction.

1.4 QUALITY CONTROL

1.4.1 Standard Products

Provide evaporative air-cooling equipment designed and assembled by a manufacturer regularly engaged in the manufacturing of systems that are of a similar design, workmanship, capacity, and operation. Systems of similar design and capacity must have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2 years must be satisfactorily completed by a system which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Systems having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The system must be supported by a Manufacturer's Authorized Service Representative.

1.4.2 Manufacturer's Representative

Perform the work specified in this section under the supervision of a manufacturer's authorized representative. Provide manufacturer-approved installation drawings, test procedures, and test results.

a. The Manufacturer's Representative must have no less than 3 continuous years of experience directly involved in the design and installation of evaporative air-cooling equipment, and have served in a similar capacity on no fewer than five projects of similar size and scope during that period. Submit a letter of qualification, at least 2 weeks prior to the start of work, listing the actual experience and training of the Manufacturer's Representative.

b. Submit installation drawings consisting of layout of equipment including assembly and installation details and electrical connection diagrams. Include on the drawings any information required to demonstrate that the system has been coordinated and will properly function as a unit and showing equipment relationship to other parts of the work, including clearances required for operation and maintenance. Concurrent with installation drawings, submit manufacturer's certification of installation drawings.

c. Submit proposed test procedures for performance tests of systems, at least 2 weeks prior to the start of related testing.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Store equipment in shipping crates and original packaging containers until ready to install. When required to be removed for inspection; repackage to protect equipment. In the event original packaging material is no longer suitable for storing the equipment or its components, provide storage containers agreed to by the government.

PART 2 PRODUCTS

2.1 SYSTEM DESRIPTION

Provide water treatment and positive water bleed-off for the evaporative air-cooling equipment. The color of finished coat, lubrication, and treatment for fungus resistance must be the manufacturer's standard. Provide solenoid valves in water supply lines. Furnish starting switch separated from coolers, [as a stand-alone switch][integral with the thermostat control][as part of the DDC controls].[Provide manual reset control for motors rated greater than one HP.][Provide air filters for air inlets for rotary-type evaporative coolers.][Minimize the risk of Legionellosis by following the guidance in EM 200-1-13.]

2.2 PRODUCT SUSTAINABILITY CRITERIA

For products in this section, where applicable and to extent allowed by performance criteria, provide and document the following:

2.2.1 Energy Efficient Products for Evaporative Coolers

Provide equipment meeting the efficiency requirements as stated within this section and provide documentation in conformance with Section 01 33 29 SUSTAINABILITY REPORTING paragraph ENERGY EFFICIENT PRODUCTS.

2.3 MATERIALS AND EQUIPMENT

2.3.1 Standard Products

Provide evaporative air-cooling equipment designed and assembled by a manufacturer regularly engaged in the manufacturing of systems that are of a similar design, workmanship, capacity, and operation. Systems of similar design and capacity must have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2 years must be satisfactorily completed by a system which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Systems having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The system must be supported by a Manufacturer's Authorized Service Representative.

2.3.2 Asbestos Prohibition

Asbestos and asbestos-containing products will not be accepted.

2.3.3 Nameplates

All equipment must have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.3.4 Equipment Guards and Access

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard must be properly guarded or covered with insulation of a type specified.[Provide catwalks, operating platforms, ladders, and guardrails where shown and construct according to Section [05 50 13 MISCELLANEOUS METAL FABRICATIONS][05 51 33 METAL LADDERS]].

2.4 PIPING COMPONENTS

Piping components must be as specified in Section 23 30 00 HVAC AIR DISTRIBUTION.

2.5 SYSTEM COMPONENTS

2.5.1 Air Supply, Distribution, Ventilation and Exhaust

Provide ductwork and related accessories, including air filters and terminal units, as specified in Section 23 30 00 HVAC AIR DISTRIBUTION.

2.5.2 Electrical Components

Electrical motor-driven equipment specified must be provided complete with motor, motor starter, controls and appropriate enclosures. Unless otherwise specified, electric equipment, including wiring, must be according to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motor controllers, contactors and overloads must comply with NEMA ICS 2. Enclosures must comply with NEMA ICS 6. Electrical characteristics and enclosure type must be as shown. Integral size motors must be the premium efficiency type in accordance with NEMA MG 1. Each motor must be according to NEMA MG 1 and must be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, must be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers must be utilized for fractional hp through 10 hp ratings. Provide adjustable frequency drives for motors larger than 10 hp.

a. Provide pump motors with moisture-proof windings and a factory installed three conductor rubber sheathed flexible cord with the third wire being the grounding conductor.

b. Provide [dripproof] [totally enclosed] type pump motors, suitable for the available electric service. Provide [manual] [magnetic] across-the-line type motor starter with [general purpose] [weather resistant] [watertight] enclosure. Provide thermal overload protection in the starter or integral with the motor.

2.6 MISCELLANEOUS MATERIALS

Materials must conform to the following:

2.6.1 Aluminum Sheets

ASTM B209, Alloy 3003, temper H14.

2.6.2 Steel Sheets, Galvanized

ASTM A924/A924M, commercial quality.

2.6.3 Steel Sheets, Uncoated

ASTM A1011/A1011M, hot-rolled, commercial quality.

2.6.4 Structural Steel

ASTM A36/A36M.

2.6.5 Stainless Steel

ASTM A240/A240M.

2.6.6 Structural Polymeric Components

Components made of structural polymeric materials must meet the applicable requirements of UL 746C.

2.6.7 Nonstructural Polymeric Components

Components not made of structural polymeric materials must meet or exceed the requirements of UL 94 for Classifying Materials 94HB.

2.7 EVAPORATIVE COOLERS

Units must be a self-contained [direct] [indirect] [indirect/direct] [multi-stage], weather resistant [drip,] [rotary,] [slinger] type, [blow through] [draw through] and must conform to UL 507 and UL 746C. Unit must be the [side] [or] [vertical downblast] discharge type as indicated. A guillotine type manual winterizing damper complete with holding rack must be provided on the discharge side of each unit. Holding rack must retain damper during operating season.

2.7.1 Fan Unit

The unit must be the centrifugal or axial type, complete with motor, drive equipment, and vibration-isolation supports between motor and fan housing. Water distributor or rotary wheel motor must be [synchronized to start and stop with the fan unit] [separately controlled] [provided with a time delay in the fan circuit to allow media to be thoroughly wetted before air flow starts] [provided with a time delay in the fan circuit to allow media to be thoroughly dried before air flow terminates].[Remote manual switch with pilot indicating light must be provided where indicated.] Fan scroll and wheel must be constructed of galvanized steel, aluminum, stainless steel, or polymeric material with stainless steel, hot-dip zinc coated steel or cadmium coated steel shaft. Fan scroll may be made of a different material than the wheel. Bearings must be sleeve type, self-aligning and self-oiling with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Grease fittings must be connected to tubing and serviceable from a single accessible point. Bearing life must be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11.

2.7.1.1 Fan Rating

Evaporative cooler fans must have air delivery ratings based on AMCA 210 tests by an AMCA approved laboratory.

2.7.1.2 Retarding Agent

An ultraviolet retarding agent such as additives, gel coatings or other manufacturer approved equivalents must be part of or applied on exterior nonmetallic components susceptible to ultraviolet degradation from sun rays and must conform to UL 746C.

2.7.2 Evaporative Media

2.7.2.1 Evaporative and Eliminator Media for [_____] Type Units

Media must be fabricated of [wood aspen fibers,] [refined cellulose matrix,] [bonded synthetic fiber,] [glass fiber,] [nonferrous metal].

Media must conform to UL 900 Class II. Media must be of the type specifically manufactured for use with evaporative coolers. Nonferrous metal media must be constructed of corrosion and fungus resistant material not susceptible to decomposition by fungal or bacterial action. [Eliminator media must be provided for slinger-type systems.] Media-pad face velocities must not exceed [250 fpm for wood aspen fiber]. Media must be securely mounted in a galvanized steel, stainless steel, or polymeric material frame. Louvers must be positioned in such manner that the water will not run on the outside surface. Nonrigid filter media must be held in frame by a rigid retainer grid, a 1/4 inch wire mesh or fabric netting.

2.7.2.2 Evaporative Media for Rotary-Type Units

The evaporative filter unit must be either drum or disk type. Media must be fabricated of copper, bronze, or polymer material. No moisture entrainment must occur. Where necessary to prevent such entrainment, eliminator media constructed of copper, copper alloy, or polymer material must be provided. Face velocities must be limited to those recommended by media manufacturer.

2.7.3 Water Handling Equipment

2.7.3.1 Water Handling Equipment for Drip Coolers

Water handling equipment must thoroughly wet and continuously flush evaporative surfaces of the media material. The water distribution system must be designed, to provide equal flow of water directly to the pads or to each trough. Troughs, if used, must be adjustable hot-dip galvanized steel, stainless steel, or polymeric and suitably designed in a manner that will effectively regulate the flow of water to the media pad to obtain even and complete saturation. Troughs must be adjustable for leveling or sectionalized and each section supplied with water by means of an individual tube. The water pump must be a centrifugal type with capacity and head characteristics for the specified operation of the unit and must be provided with a low water safety shut-off. The motor shaft must be constructed of stainless steel, hot-dip galvanized steel or cadmium coated steel. The impeller must be constructed of stainless steel or polymeric material conforming to UL 746C. Pump housing must be constructed of [painted] [hot-dip zinc coated] steel, brass, or polymeric material conforming to UL 746C. Pump housing bottom must be removable for impeller cleaning and must not permit galvanic action with cooler bottom. Water pump must be provided with a filter screen constructed of plastic or bronze which must project 1 inch above the high water level of the water tank.

2.7.3.2 Water Handling Equipment for Slinger Coolers

Water distribution to the evaporative pad must be accomplished by a motor driven water slinger to uniformly distribute water to the pad.

2.7.3.3 Water Blowdown Equipment

Water must be periodically dumped (approximately every six to twelve hours). This must be done by either the use of a mechanical timer or by measuring the conductivity and dumping the water when the conductivity reaches 1500-2000 micro mhos.

2.7.4 Indirect Cooler Section

The indirect cooler must consist of a [frame and plate counter flow] [finned tube water-to-air] heat exchanger, [evaporative media] water distribution header, scavenger fan and motor, and recirculating water pump, [cooling coil,] drain, overflow and makeup water.

2.7.4.1 Heat Exchanger

The unit must be constructed of stainless steel, polymeric material, or aluminum with the surface exposed to water being fully protected against corrosion by an epoxy coating. The plates must be constructed in such a way as to withstand a 1 inch water gauge differential pressure without collapsing the plates. Units having horizontal air discharge must be provided with discharge baffle to direct air upward, constructed of the same material and thickness as the casing. The unit must be at least 80 percent efficient. For cleaning purposes coils on finned tube water-to-air heat exchangers must be plugged at the return bins.

2.7.4.2 Water Distribution Header

The water distribution header must be a nonwettable, nondrip type. Water must be distributed by means of copper spray headers with brass nozzles, or PVC header and nozzles, to impart a fine water mist into the scavenger air side of the heat exchanger.

2.7.4.3 Scavenger Fan

The fan must be the centrifugal or axial type and must be complete with motor, drive equipment, and vibration-isolation supports between motor and fan housing on single-phase motors. The fan motor must be [synchronized to start and stop with the indoor fan unit] [controlled by the HVAC system controls]. Water distributor motor must be synchronized to start and stop with the scavenger fan unit. Manual or automatic reset type thermal overload protection must be provided in the starter or must be integral with the motor. Motor starters must be [manual] [magnetic] across-the-line type with [general purpose] [weather resistant] enclosure.[Remote manual switch with pilot indicating light must be provided where indicated.] Fan scroll and wheel must be constructed of galvanized steel, aluminum, stainless steel or polymeric material with stainless steel, hot-dip zinc coated steel or cadmium coated steel shaft. Fan scroll may be made of a different material than the wheel. Fans must have an air delivery rating based on AMCA 210 tests by an AMCA approved laboratory.

2.7.4.4 Water Pump

The water pump must be a self-priming centrifugal type with capacity and head characteristics for the specified operation of the unit. The motor shaft must be constructed of stainless steel, cadmium coated steel or hot-dip zinc galvanized steel. The impeller must be constructed of stainless steel or polymeric material conforming to UL 746C. Pump housing must be constructed of factory [painted] [hot-dip zinc coated] steel or polymeric material conforming to UL 746C. Pump housing bottom must be removable for impeller cleaning and must not permit galvanic action with cooler bottom. Water pump must be provided with a filter screen constructed of plastic which must project 1 inch above the high water level of the water tank.

2.7.5 Cooling Coil

Supplemental water cooling coil must be located [upstream from the direct stage] [between stages] [downstream from the second stage]. The coil must be fin-and-tube type constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to tubes. Headers must be constructed of cast iron, welded steel or copper. Casing and tube support sheets must be 16 gauge galvanized steel, formed to provide structural strength. Tubes must be correctly circuited for proper water velocity without excessive pressure drop and be drainable where required or indicated. Factory test each coil at not less than 250 psi air pressure and must be suitable for 200 psi working pressure. Install drainable coils in the units with a pitch of not less than 1/8 inch per foot of tube length toward the drain end.[Coils must conform to the provisions of AHRI 410.]

2.8 AIR WASHERS

Furnish air washers as a factory package unit, complete with fan unit, spray pump, nozzles, piping, evaporative cells, washdown cycle and eliminators. Air washers must be spray type[or sprayed cell type]. Provide a guillotine type manual winterizing damper complete with holding rack on the discharge side of each unit. Holding rack must retain damper during operating season.

2.8.1 Fan Unit

Provide a centrifugal type fan unit complete with motor, drive equipment, and vibration-isolation supports between motor and fan housing. Spray pump must be synchronized to start and stop with fan unit or on a timed cycle which allows the evaporative cells to be wetted prior to fan start.[Remote manual switch with pilot indicating light must be provided where indicated.] Provide fans and motors with vibration isolation supports or mountings. Construct fan scroll and wheel of galvanized steel, aluminum, stainless steel or polymeric material with a stainless steel, hot-dip zinc coated steel, or cadmium coated steel shaft. Fan scroll may be made of a different material than the wheel. Fans must have air delivery ratings based on tests by an AMCA approved laboratory to the AMCA 210.

2.8.2 Water-Handling Equipment

One or more banks of spray nozzles, flooding nozzles, water piping, spray pump, and strainers constitute water handling equipment. Provide the number of banks of spray nozzles required to produce the specified efficiency. Provide self-cleaning, centrifugal type spray nozzles, constructed of brass, and provided with removable caps for cleaning. Construct flooding nozzles of machined brass or low pressure PVC nozzles. Provide centrifugal type spray pumps with capacity and static pressure required for the spray equipment provided. Unless otherwise indicated, all piping materials and installations must be in conformance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.8.3 Evaporative Cells

Cells must consist of galvanized steel, stainless steel or polymeric material frames packed with [glass fiber] [bonded synthetic fiber] [nonferrous metal] screens, arranged in tiers. Media must be of the type specifically manufactured for the use with air washers. Construct non-ferrous metal media of corrosion and fungus resistant material not susceptible to decomposition by fungal or bacterial action. Each tier must be independent of the others and include separate spray headers, drain sheets and drain conduits to the tank below.

2.8.4 Eliminator

Eliminators must consist of vertical plates having a series of bends presenting a large surface area against which the water drops impinge and return down to the tank. Construct eliminator plates of galvanized steel or polymeric material, positioned at both top and bottom and designed to prevent water carryover.

2.9 WATER TANKS

Construct water tanks of stainless steel, polymeric material, or minimum G90 galvanized steel with welds coated with zinc-rich paint. Provide the tank with a means for drainage, a makeup connection, a float-operated valve, an overflow connection and, when required, a recirculating pump suction connection. The float valve must be capable of a water working pressure of 125 psi. Both valve stems and seat disks must be constructed of brass or other approved corrosion resisting material. Provide continuous bleed-off assembly or automatic flush system, adjustable to limit the concentrations from three to ten times the incoming water concentration. Where practicable install water storage tanks with access hatches in order to facilitate annual cleaning and inspections.

2.10 CABINETS

Provide cabinets constructed of galvanized steel sheets, stainless steel or polymeric material. Protect outside air inlets with bird screens that conform to ASTM E2016, Type I, Class 1, 2 by 2 mesh, 0.063 inch diameter aluminum wire or 0.031 inch diameter stainless steel wire. Provide access to all moving parts including fans, pumps, and float valves.

2.10.1 Metal Cabinets

Where possible, provide factory-assembled cabinets with either welded or bolted and screwed construction. Cabinets must be braced and reinforced. Bolts, screws, hinges, trim, and other metal appurtenances must be cadmium plated or galvanized in accordance with ASTM B696 or ASTM A123/A123M. When it is necessary to ship the unit disassembled, the cabinet sections must be designed for assembly with cadmium plated or galvanized bolts. [Clean and chemically treat the interior and exterior of the galvanized steel cabinet, including hinges, handles, and other trim, to assure paint adhesion.] [Factory][Field]coat the interior bottom of cabinet with coal tar based enamel or epoxy meeting the requirements of SSPC PS 10.01 or SSPC Paint 16.[Galvanized surfaces damaged during fabrication or handling must be given a coat of zinc-rich paint. Provide finish as specified in paragraph FIELD PAINTING AND FINISHING.] Gauge of cabinet components must be as indicated in TABLES I and II.

TABLE I. STEEL CABINET (MINIMUM THICKNESS gauge)				
Nominal Size of Industry Standard Air Rating				
Component part of cooler	0-3500 cfm	3501/5500 cfm	5501/7000 cfm	7001/16000 cfm
Water tank	22	22	20	18
Corner posts	23	23	23	20
Sides	22	22	22	22

TABLE I. STEEL CABINET (MINIMUM THICKNESS gauge)				
Nominal Size of Industry Standard Air Rating				
Component part of cooler	0-3500 cfm	3501/5500 cfm	5501/7000 cfm	7001/16000 cfm
Louver pad holder	27	27	27	27
Blower scroll	23	22	20	20
Blower wheel	22	22	22	20
Drip trough	27	26	26	26
Top	22	22	20	20

TABLE II. STAINLESS STEEL CABINET (MINIMUM THICKNESS gauge)			
Nominal Size of Industry Standard Air Rating			
Component part	0/4500 cfm	4501/6500 cfm	Beyond 6500 cfm
Corner posts	24	24	*
Bottom pan	22	20	*
Top pan	22	20	*
* In accordance with manufacturer's standards.			

2.10.2 Polymeric Material Cabinets

Construct unit cabinets of polymeric materials, such as fiberglass or polypropylene which meet the requirements of UL 746C, Figure 12.1. Polymeric cabinets are not acceptable for outdoor installations or where the unit cabinet is exposed to sunlight.

2.11 PREVENTION OF GALVANIC CORROSION

Materials that will be exposed to water during operation of the unit must be such that galvanic action will not occur in the normal operation of the equipment. Finish the interior of water tank and cabinet and the exterior of the fan housing with an enamel paint coat or epoxy coating. There will be no evidence of holidays particularly at sealing joints. Media retainer will not be coated. This paragraph does not apply to nonmetallic materials or the interior water tank and cabinet of stainless steel materials.

2.12 CONTROLS

Specify controls in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC AND Section [23 09 23.01, LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.02, BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

[2.13 THERMOSTATS

Thermostats must be the low-voltage type or line voltage heavy duty type 115 volt ac with an electrical rating greater than the cooler being controlled. Provide thermostats with a range of 45 to 85 degrees F with [an adjustable] [2 degree F] differential range. Thermostats must be UL listed and with an indicator[and a transparent cover with lock].

]2.14 FACTORY COATING

Equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish except that all components inside and outside of the evaporative cooling section must have weather resistant finishes as described in paragraph "Corrosion Coating."

[2.14.1 Corrosion Coating

For equipment located within five miles of a body of salt water and either installed outdoors or handles outside air, provide a uniformly applied [epoxy electrodeposited] [phenolic] [vinyl] type coating to all exposed surface areas. Submit product data on the type coating selected, the coating thickness, the application process used, and verification of conformance with ASTM B117 for a duration of 3,000 hours. Apply coatings at either the unit manufacturer's or coating manufacturer's factory.

]PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

During construction, cover and seal all openings to ductwork, plenums and control equipment. Uncover ductwork, plenums and control equipment prior to start-up of unit. Install all equipment as shown and in accordance with the manufacturer's approved diagrams and recommendations, in order to provide a complete and functioning system, except where otherwise indicated. Provide manufacturers data on proper maintenance schedules to avoid "scale", "micro biological infestation", and "corrosion" resistance.Connect units to the building's water supply system. Install piping as specified in Section 23 30 00 HVAC AIR DISTRIBUTION.

a. Submit installation drawings consisting of layout of equipment including assembly and installation details and electrical connection diagrams. Include on the drawings any information required to demonstrate that the system has been coordinated and will properly function and showing equipment relationship to other parts of the work, including clearances required for operation and maintenance.

b. Install a ball valve and union in the water supply line adjacent to each unit. Do not install valves with stems below the horizontal. Slope all supply piping to drain to the indicated stop and waste valve.

c. Submit proposed system diagrams, at least 2 weeks prior to start of related testing. System diagrams that show the layout of equipment, piping, controls, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system must be framed under glass or laminated plastic. After approval, post diagrams where directed.

3.2.1 Air-Supply And Distribution System

Install equipment, sheet metal work, air filters, and terminal units as specified in Section [23 30 00 HVAC AIR DISTRIBUTION][23 54 19 BUILDING HEATING SYSTEMS, WARM AIR].

3.3 FIELD QUALITY CONTROL

3.3.1 Field Painting And Finishing

Painting of surfaces not otherwise specified, including nonferrous metals, finish painting of items only primed at the factory, and field repair of factory finish, is specified in Section 09 90 00 PAINTING, GENERAL.

3.3.2 Testing, Adjusting, And Balancing

Perform testing, adjusting, and balancing as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.3.3 Performance Tests

Conduct the test with entering air at 95 degrees F, dry-bulb, plus or minus 5 degrees F and a spread between wet-bulb and dry-bulb temperature of 25 degrees F plus or minus 5 degrees F. Show the capacity in cubic feet per minute (cfm) and efficiency. Meet the following requirements:

Evaporative Cooler	Minimum Efficiency, Percent
Single Stage	80
Two Stage	Indirect Section, 60; Direct Section, 90

$$\text{Efficiency} = \frac{T1-T2}{T1-Tw} \times 100 \text{ percent}$$

where: T1 is the entering dry-bulb temperature in degrees F.
T2 is the leaving dry-bulb temperature in degrees F.
Tw is the entering wet-bulb temperature in degrees F.

After testing, adjusting, and balancing has been completed as specified, test the system as a whole to see that all items perform as integral parts of the system and that operation is as specified. Submit proposed test schedules for performance tests, at least 2 weeks prior to the start of related testing. Make corrections and adjustments as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests must be conducted by the Manufacturer's Representative. Tests must cover a period of not less than [_____] days and must demonstrate that the entire system is functioning according to the specifications. Record ambient air temperature and supply air temperature and quantity readings at hourly intervals for the duration of the test period. Submit test reports for the performance tests in booklet form, upon completion of testing. Document in the reports all phases of tests performed including initial test summary, all repairs/adjustments made, and final test results.

3.3.4 Cleaning

Thoroughly clean ducts, plenums, and casings of all debris; blow them free of all small particles of rubbish and dust before installing outlet faces. Wipe equipment clean, with all traces of oil dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction; and after all construction dirt has been removed from the building, install new filters. Properly lubricate bearings with oil or grease as recommended by the manufacturer.

3.4 OPERATIONAL TRAINING

a. Conduct operational training for operating staff as designated by the Contracting Officer. Submit proposed schedule for field training at least 2 weeks prior to the start of related training. The training period, for a total of [_____] hours of normal working time, must start after the system is functionally completed but prior to final acceptance tests.

b. The field instructions must cover all of the items contained in the approved operation and maintenance manuals. Submit [6] [_____] manuals listing step-by-step procedures required for system startup, operation, shutdown, cleaning - especially to reduce legionella, and routine maintenance, at least 2 weeks prior to field training. Include in the manuals the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and Manufacturer's Authorized Service Representative (including address and telephone number) for each item of equipment.

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SECTION 23 80 20.00 10

GAS-FIRED HEATING EQUIPMENT
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.66/CGA 6.14	(2015; R 2020) Automatic Vent Damper Devices for Use with Gas-Fired Appliances
ANSI Z21.86/CSA 2.32	(2016) Vented Gas-Fired Space Heating Appliances
ANSI Z83.4/CSA 3.7	(2017) Non-Recirculating Direct Gas-Fired Heating and Forced Ventilation Appliances for Commercial and Industrial Application
ANSI Z83.8/CSA 2.6	(2016; R 2021) Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-Fired Duct Furnaces
ANSI Z83.19/CSA 2.35	(2017) Gas-Fired High-Intensity Infrared Heaters

CSA GROUP (CSA)

CSA Directory	(updated continuously online) Product Index

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings
Installation

SD-03 Product Data

Spare Parts

SD-06 Test Reports

Testing, Adjusting, and Balancing

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions

1.3 QUALITY ASSURANCE

Submit detail drawings consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operation of the system. Detail drawings for space heating equipment, controls, associated equipment, and for piping and wiring. Show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings, and not later than [_____] months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 General

Provide materials and equipment which are standard products of a manufacturer regularly engaged in manufacturing of the products and that essentially duplicate equipment that has been in satisfactory use at least

2 years prior to bid opening. All gas fired appliances must meet the requirements of NFPA 54.

2.1.2 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. Also, affix an ENERGY STAR label as applicable.

2.1.3 Equipment Guards

Completely enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts so located that any person may come in close proximity thereto. Guard or cover high-temperature equipment and piping so located as to endanger personnel or create a fire hazard with insulation of type specified for service.

2.2 ELECTRICAL WORK

Provide electrical motor driven equipment complete with motors, motor starters, and controls. Provide motors conforming to NEMA MG 1. Provide electrical equipment and wiring accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical characteristics as specified or indicated. Provide premium efficiency integral size motors in accordance with NEMA MG 1. Provide motor starters complete with thermal overload protection and other appurtenances necessary for the motor control specified. Each motor must be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, must be provided.

2.3 HEATERS

Equip heaters for and adjust to burn [natural][liquified petroleum][dual fuel natural/liquified petroleum] gas. Provide each heater with a gas pressure regulator that will satisfactorily limit the main gas burner supply pressure. Heaters must have an intermittent or interrupted electrically ignited pilot or a direct electric ignition system. Provide safety controls that conform to the ANSI standard specified for each heater. Furnish mounting brackets and hardware by the heater manufacturer and factory finish to match the supported equipment. Seismic details must be [in accordance with UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC][as indicated].

2.3.1 Direct Fired Make-Up Air Heaters

Furnish heaters in accordance with ANSI Z83.4/CSA 3.7. Direct fired make-up air heaters use outside air directly ducted to the heater. The products of combustion generated by the heater are released into the outside air stream being heated. Equip heaters with [motorized [inlet][and][outlet]] [backdraft] dampers,[discharge air diffuser,][duct collar,][air filters,][and][bird screen]. Provide [single-stage][two stage][modulating] gas control valve. Maximum air temperature rise during minimum burner fire must be 7 degrees F. Fan must be [single-speed][two speed, with low speed approximately two-thirds of high speed][variable speed]. Provide weatherized outdoor heaters with manufacturer's standard exterior finish for outdoor units. Provide motorized [inlet][and

][outlet] dampers that close when the unit is shut down. Dampers must be interlocked to prevent burner operation when dampers are closed. Provide heaters with a [space][discharge air] thermostat, a low limit air stream thermostat, and an ambient air thermostat. The [space][discharge air] thermostat must control the gas control valve. Provide low limit air stream thermostat to shut down the entire unit if the discharge air temperature drops below the [space][discharge] thermostat setting. Provide ambient air thermostat to shut down the burner if the outside air exceeds the [discharge][space] thermostat setting.

2.3.2 Indirect Fired Make-Up Heaters

Provide heaters in accordance with ANSI and CSA Standards. Equip heaters with motorized inlet dampers, duct collar, and air filters. Provide modulating gas control valve. Maximum air temperature rise during minimum burner fire must be 7 degrees F. Fan must be two speed, with low speed approximately two-thirds of high speed. Provide motorized inlet dampers that close when the unit is shut down. Dampers must be interlocked to prevent burner operation when dampers are closed. Provide heaters with a space thermostat, a low limit air stream thermostat, and an ambient air thermostat. The space thermostat must control the modulating gas control valve. Provide low limit air stream thermostat to shut down the entire unit if the discharge air temperature drops below the space thermostat setting. Provide ambient air thermostat to shut down the burner if the outside air exceeds the space thermostat setting.

2.3.3 Unit Heaters

Provide heaters conforming to requirements of ANSI Z83.8/CSA 2.6. Provide [aluminized steel][or][stainless steel] heat exchangers. Equip air discharge section with adjustable [horizontal louvers][and][vertical louvers or fins]. Fan shafts must be either directly connected to the driving motor, or indirectly connected by multiple V-belt drive. Fans in one unit must be of the same size. Furnish power-vented heaters, suitable for sidewall vent discharge and single-wall-thickness vent piping. Provide heaters that have automatic ignition. Heaters must employ metered combustion air with enclosed draft diverter (no open flue collar). Provide heaters with a space thermostat which controls both unit's fan and burner.

2.3.4 Wall Furnace

Provide [gravity][fan] wall furnace in accordance with ANSI Z21.86/CSA 2.32 and as indicated. Provide a space thermostat which controls both the unit's fan and burner.

2.3.5 Duct Furnace

Provide duct furnace in accordance with ANSI Z83.8/CSA 2.6. Provide power-vented furnace, suitable for sidewall vent discharge and single wall thickness vent piping. Provide furnace with automatic ignition. Furnace must employ metered combustion air with enclosed draft diverter (no open flue collar). Provide [aluminized steel][or][stainless steel] furnace heat exchangers. Provide furnace with minimum steady state thermal efficiency of 80 percent at maximum rated capacity and 75 percent at minimum rated capacity that is provided and allowed by the controls. Provide furnace with a [space][discharge air] thermostat which controls the unit's burner.

2.3.6 Infrared Heaters

Furnish heaters conforming to the requirements of ANSI Z83.19/CSA 2.35 and [vented][or][unvented] type[as indicated].[Vented heaters must be vented to the outside atmosphere.] Heater style must be [surface combustion][tubular] type[as indicated]. Reflector shape must be[parabolic][horizontal][or][standard][as indicated]. Provide heaters with space thermostats which control the unit's burner. Cover thermostats located in the direct radiation pattern with a metal shield.

2.4 THERMOSTATS

Provide adjustable electric or electronic thermostats. Include control wiring required to complete the space temperature control system. Provide thermostats that have a 3 degree F differential and a set point range of [40 to 75 degrees F][0 to 100 degrees F][80 to 120 degrees F]. Provide [single][two] stage thermostats.

2.5 VENT PIPING

Provide vent piping conforming to the requirements of NFPA 54. Plastic material polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.6 ELECTRIC AUTOMATIC VENT DAMPERS

Provide electric automatic vent dampers conforming to the requirements of ANSI Z21.66/CGA 6.14 and provide in the vents of heaters [except unvented infrared heaters] using indoor air for combustion air.

2.7 INSULATION

Provide insulation for piping and equipment and application in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.8 FACTORY FINISHES

Equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming thoroughly familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

install equipment as indicated and in accordance with the recommendations of the equipment manufacturer and the listing agency, except as otherwise specified.

3.2.1 Heating Equipment

Install heaters with clearance to combustibles, complying with minimum distances as determined by CSA Directory, UL FLAMMABLE & COMBUSTIBLE and as indicated on each heater approval and listing plate. Support heaters independently from the building structure, as indicated, but not relying on suspended ceiling systems for support.

3.2.2 Vents

Locate vent dampers, piping and structural penetrations as indicated. Perform vent damper installation in conformance to ANSI Z21.66/CGA 6.14. Extend vent pipes, where not connected to a masonry chimney conforming to NFPA 211, through the roof or an outside wall and terminate, in compliance with NFPA 54. Provide vents passing through waterproof membranes with the necessary flashings to obtain waterproof installations.

3.2.3 Gas Piping

Connect gas piping as indicated, complying with the applicable requirements at Section 23 11 20 FACILITY GAS PIPING.

3.3 TRAINING

Conduct a training course for the maintenance and operating staff. The training period of [_____] hours normal working time must start after the system is functionally complete but before the final acceptance tests. Give the Contracting Officer at least two weeks advance notice of such training. Include all of the items contained in the approved operation and maintenance instructions as well as demonstrations of routine maintenance operations. Submit [6] [_____] complete copies of operating instructions outlining the step-by-step procedures required for system startup, operation and shutdown. Include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and basic operating features. Submit [6] [_____] complete copies of maintenance instructions listing routine maintenance, possible breakdowns, repairs and troubleshooting guide. Include simplified piping, wiring, and control diagrams for the system as installed.

3.4 TESTING, ADJUSTING, AND BALANCING

Perform testing, adjusting, and balancing as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate the final position of controls.

-- End of Section --

SECTION 23 81 23

COMPUTER ROOM AIR CONDITIONING UNITS
11/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 1360	(2017) Performance Rating of Computer and Data Processing Room Air Conditioners
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ANSI/AHRI 520	(2004) Performance Rating of Positive Displacement Condensing Units

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2019) Ventilation for Acceptable Indoor Air Quality
ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-6 2021; Addenda AS-BF 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 127	(2020) Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.1	(2020) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME BPVC	(2010) Boiler and Pressure Vessels Code

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM C1338	(2014) Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings
ASTM D5864	(2011) Standard Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or Their Components
ASTM D6081	(1998; R 2014) Aquatic Toxicity Testing of Lubricants: Sample Preparation and Results Interpretation
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM G21	(2015; R 2021; E 2021) Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

ETL TESTING LABORATORIES (ETL)

ETL DLP	(updated continuously) ETL Listed Mark Directory

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1424	(2016) Engineering and Design -- Lubricants and Hydraulic Fluids

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

16 CFR 1201	Safety Standard for Architectural Glazing Materials
40 CFR 82	Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 94	(2013; Reprint Apr 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL Elec Equip Dir	(2011) Electrical Appliance and Utilization Equipment Directory

1.2 DEFINITIONS

Computer Room Air Conditioner (CRAC): A single, self-contained unit or split-system unit designed and manufactured specifically for temperature and humidity control of data processing environments.

Cold Aisle: The aisle between or adjacent to rows of racks from which the computing equipment draws cool air.

Hot Aisle: The aisle between or adjacent to rows of racks to which the computing equipment ejects hot air.

Rack: Telecommunications support frame that can consist of post-and-frame or full cabinet construction. Racks are provided under Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Computer Room Air Conditioner; G[, [_____]]

Small Computer Room Air Conditioners; G[, [_____]]

Space Temperature Control System Drawings; G[, [_____]]

Filters

Refrigerants; S

[Cold][and][Hot] Aisle Containment Systems; G[, [_____]]

Rack Mounted Fans; G[, [_____]]

Leak Detection; G[, [_____]]

SD-06 Test Reports

CRAC Production Schedule and Factory Test Schedule; G[, [_____]]

Manufacturer's Factory Test Plans; G[, [_____]]

Factory Test Reports; G[, [_____]]

Field Test Schedule; G[, [_____]]

Manufacturer's Field Test Plans; G[, [_____]]

Field Test Reports; G[, [_____]]

SD-07 Certificates

Certificate of Specification Compliance; G[, [_____]]

Credentials of the Manufacturer's Field Test Representative; G[, [_____]]

Ozone Depleting Substances Technician Certification

Certified List Of Qualified Permanent Service Organizations

Seismic Certification; G[, [_____]]

SD-08 Manufacturer's Instructions

Installation Manual for Each Type of CRAC

Installation Manual for Each Type of Aisle Containment System

Installation Manual for Each Type of Rack Mounted Fan

SD-10 Operation and Maintenance Data

Computer Room Air Conditioner Operation and Maintenance Data, Data Package 4; G[, [_____]]

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.4 REFRIGERANTS

Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0. CFC-based refrigerants are prohibited. [HCFCs][and][Halons] are not permitted. Provide SDS sheets for all refrigerants.

1.5 QUALIFICATIONS

1.5.1 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.6 QUALIFICATIONS

1.6.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacturer of such products, which are of a similar material, design, and workmanship. Standard products must have been in satisfactory commercial or industrial use for two years prior to bid opening. The two-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the two-year period.

1.6.2 Alternative Equipment Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.6.3 Service Support

The equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.4 Manufacturer's Nameplate

For each item of equipment, provide a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.6.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.6.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions must be considered mandatory, the word "should" is interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" must be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" must be interpreted to mean the "lessor." References to the "permit holder" must be interpreted to mean the "Contractor."

1.6.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.7 PROJECT REQUIREMENTS

1.7.1 Verification of Dimensions

Become familiar with the details of the work, verify all dimensions in the field, and provide adequate clearance for all connections and service access. Notify the Contracting Officer of any discrepancy before performing any work.

1.7.2 Energy Efficiency

Provide equipment with minimum efficiencies [as indicated][as required by ASHRAE 90.1 - IP].

1.8 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

PART 2 PRODUCTS

2.1 COMPUTER ROOM AIR CONDITIONER (CRAC)

Provide complete working CRACs, designed, [and] factory assembled[, and factory tested]. Equipment must be listed in UL Elec Equip Dir or ETL DLP for computer room application. CRACs must have a minimum sensible coefficient of performance of [_____] in accordance with ASHRAE 127. Computer Room Air Conditioners must have [a minimum [seasonal]energy efficiency ratio ([S]EER) of [_____],] [a minimum Heating Seasonal Performance Factor (HSPF) of [_____],] [a minimum Integrated Part Load Value (IPLV) of [_____],][and][a minimum COP of [_____]]. CRACs must include room cabinet and frame, [floor stand,]fan section, filter section, cooling coil, [reheat coil,][humidifier,][compressor[s],][condenser[s],]controls, and, interconnecting piping internal to the CRAC. Provide units rated in accordance with AHRI 1360.

2.1.1 Unit Airflow Configuration

2.1.1.1 Downflow Units

The CRAC must draw return air in at the top [or sides]of the cabinet and discharge supply air at the bottom of the cabinet.

2.1.1.2 Upflow Units

The CRAC must draw return air in at the bottom [or sides]of the cabinet and discharge supply air at the top of the cabinet.

2.1.1.3 In-row Units

The CRAC must be designed and manufactured to be installed within the row of server cabinets where it must draw return air in at the back (from the hot aisle) and discharge supply air at the front (into the cold aisle). In-row units must match the height and depth of the adjacent racks and integrate into the row such that no gaps exist that would allow air to bypass from the cold aisle to the hot aisle.

2.1.1.4 Ceiling Mounted Units

The CRAC must be designed to be installed at or above the ceiling where it must draw return air in at a duct connection or integral return grille and discharge supply air at a duct connection or integral supply register.

2.1.2 Cabinet and Frame

2.1.2.1 Unit Frame

Unit frame must be manufactured of welded steel tubes and must be mill-galvanized or coated with an epoxy finish.

2.1.2.2 Unit Cabinet

Exterior panels must be steel sheet, minimum of 20 gage, mill-galvanized or coated with a corrosion-inhibiting epoxy finish in [manufacturer's standard][the specified][the indicated] color. Mill galvanized sheet metal must be coated with not less than 1.25 ounces of zinc per square foot of two-sided surface. Mill rolled structural steel must be hot-dip galvanized or primed and painted. Cut edges, burns and scratches in hot-dip galvanized surfaces must be coated with galvanizing repair coating. Manufacturer's standard cabinet materials and finishes will be acceptable if equivalent to the above requirements and approved by the Contracting Officer.

Provide removable panel for access to controls without interrupting airflow. Panels must be gasketed to prevent air leakage under system operating pressure and must be removable for service access without the use of special tools.

[Provide double deflection [supply][and][return] grille[s] integral to unit. Grilles must be factory coated the same as the unit cabinet.

][2.1.2.3 Cabinet Interiors Sound Attenuation

Provide a factory-installed sound attenuation system in the interior of the CRAC cabinet.

[CRAC cabinet panels interior must be provided with 1 inch of 1 1/2 pound per cubic foot fiber glass insulation on interior of cabinet panels. Insulation must be applied to the cabinet panels with 100 percent adhesive coverage and both the insulation and the adhesive must conform to NFPA 90A. Insulation must be rated for 6000 fpm per UL 181 and ASTM C1071. Insulation must resist the growth of microorganisms per ASTM C1338 and ASTM G21.

][CRAC cabinet panels interior must be provided with minimum two inch thick acoustical sound absorbing foam with a minimum Noise Reduction Coefficient (NRC) of 0.85.

][Compressors located in CRAC interior cabinets must be either wrapped in a sound absorbing insulating blanket or enclosed in its' own sound absorbing insulated mini-cabinet inside of the larger CRAC interior cabinet.

][Fans and compressors located in the CRAC interior cabinet must be provided with vibration isolators between their respective support frames and the cabinet framing.

] CRAC manufacturer's standard interior cabinet sound attenuation materials and finishes will be acceptable if equivalent to the above requirements and approved by the Contracting Officer.

]2.1.3 Fan Section

Provide fan(s) and fan motor(s) as integral, factory installed components of the CRAC.[Provide units with capability to lower fans into the floorstand below the raised floor. The procedure to lower the fans must be described in the manufacturer's written installation instructions.]

2.1.3.1 Fan Wheel

The supply air fan must be AMCA certified. Provide [steel][aluminum], [forward curved, double-width, double-inlet][backward curved, plenum/plug type] fan wheel. The fan must be statically and dynamically balanced. The fan must have self-aligning, permanently lubricated ball bearings with a minimum life span of 100,000 hours. Assess potential effects of lubricant on aquatic organisms in accordance with ASTM D6081 and submit aquatic toxicity reports. Assess biodegradation in accordance with ASTM D5864. In accordance with EM 1110-2-1424 Chapter 8, aquatic toxicity shall exceed 1,000 ppm at LL50 and biodegradation shall exceed 60 percent conversion of carbon to carbon dioxide in 28 days.

2.1.3.2 Motor and Drive

[Provide fan wheel directly coupled to motor shaft.] [Provide [V-belt drive][dual V-belt drive] sized for 200 percent of the motor nameplate rating. Fan speed must be adjustable with cast iron variable pitch pulleys. Sheaves must be within the middle one third of the sheave adjustment range.]

[Provide drip-proof, permanent split capacitor type, NEMA rated motor with inherent overload protection and sliding adjustable motor base.] [Provide electronically commutated motor with integrated electronic control board and direct microprocessor control signaling for speed control.]

[Provide variable frequency drive(s) in accordance with Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

]2.1.4 Cooling Coil

Provide AHRI 410 coil and slope for drainage. Coil must be manufactured of seamless copper tubes with plate [aluminum][copper] fins.[Indoor and outdoor coils must be matched and from same manufacturer.] Each coil, in the production process, must be individually tested at 320 psi with compressed air under water and verified to be air tight. Factory dehydrate and seal each coil after testing and prior to evaluation and charging.[Provide DX coil complete with a distributor and thermostatic expansion valve with external equalizer.][Provide hydronic coils complete with drain and vent connections.] Provide [double-sloped]condensate drain pan of [minimum 22 gage Type 304 stainless steel][plastic] with nonferrous connections[,[and] internal trap,][, and a condensate pump system complete with integral pump discharge check valve, integral float switch, reservoir, and pump and motor assembly.]

2.1.5 Filters

Provide UL listed [2] [4] [_____] inches thick deep pleated fiberglass throwaway type filters.[Additionally, provide [2] [_____] inches thick deep pleated fiberglass throwaway type pre-filters.] Provide filtration media with a Minimum Efficiency Reporting Value (MERV) of [6][8][13] as determined by ASHRAE 52.2. Provide one complete spare filter bank set per unit for installation prior to final acceptance testing covered in Part 3 of this section.

2.1.6 Reheat Coil

[Provide AHRI 410 reheat coils and slope for drainage. Provide coil manufactured of seamless copper tubes with plate [aluminum][copper] fins. Each coil, in the production process, must be individually tested at 320 psi with compressed air under water and verified to be air tight.

][Provide electric reheat coils with low watts density. The electric reheat coils must be enclosed in 304 stainless steel tubes and 304 stainless steel fins. Provide modulating control of the electric reheat coils by [multiple stages][or][Silicon Controlled Rectifier (SCR)]. Provide UL or ETL listed safety switches to protect system from overheating.

][2.1.7 Humidifier

Humidifier section must include liquid-level control, emergency overflow and automatic water supply system factory pre-piped for final connection.[Provide stainless steel evaporator pan with water high level and low level alarms].[Provide [copper][stainless steel] atmospheric steam dispersion tube for installation in a [vertical][or][horizontal] air stream. Dispersion tube must have integral condensate return to the steam generator.] Arrange system to be cleanable and serviceable. Provide water chemistry requirements with humidifier submittal data.

[Provide infrared type humidifier, including high intensity quartz lamps mounted above and out of water supply.

][Provide humidifier of the self-contained steam generating electrode type utilizing a [plastic][disposable] canister with full probes connected to electric power via electrode screw connectors. Provide electrodes manufactured from expanded low carbon steel, zinc plated and dynamically formed for precise current control. The humidifier assembly must include integral fill cup, fill and drain valves and associated piping. Design the canister to collect the mineral deposits in the water and provide clean particle free steam to the air stream.

][Provide humidifier of the self-contained ultrasonic type operating on the principle of ultrasonic nebulization of water. Provide 300 series stainless steel casing. The ultrasonic humidifier must not produce any unacceptable noise radiation or frequency interference with communications or other electronic equipment. Provide water chemistry requirements with humidifier submittal data.

]][2.1.8 Compressor

Provide compressor that is direct drive, [semi-hermetic][or][hermetic reciprocating,][or][scroll] type capable of operating at partial load conditions. Compressor must be capable of continuous operation down to the lowest step of unloading as specified. Provide compressors of 7.5 tons and larger with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors operate in sequence, and each compressor has an independent refrigeration circuit through the condenser and evaporator. Start each compressor in the unloaded position. Provide compressor[s] complete with vibration isolation, suction and discharge service valves, high and low pressure safety switches, protection against short cycling, and built-in overload protection. Provide refrigeration circuits including hot gas mufflers, liquid-line filter-drier, refrigerant sight glass,[lubrication pump,] and moisture indicator, externally equalized expansion valve, and liquid-line solenoid valve factory connected with refrigeration copper tubing.[Crankcase heaters are required.][Provide hot gas bypass.]

2.1.8.1 Refrigeration Circuit

Provide field-installed refrigerant tubing for split systems in accordance with Section 23 23 00 REFRIGERANT PIPING.

Refrigerant-containing components must comply with ANSI/ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged with [nitrogen][refrigerant and oil] and sealed. Provide refrigerant charging valves and connections, and pumpdown valves for each circuit.[Provide reversible-flow type filter-drier in each liquid line.][Refrigerant flow control devices must be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. Provide a refrigerant suction line [thermostatic][thermostatic and water flow switch] control to prevent freeze-up in event of loss of water flow during heating cycle.]

]2.1.9 Condenser[and][Dry Cooler]

Provide condenser circuit pre-piped with start-up and head pressure controls to maintain system operation at ambient temperatures down to [40 degrees F] [20 degrees F] [[_____] degrees F].

[Provide an integral factory wired and tested control panel for each condenser[and][dry cooler]. The factory control board must control each condenser fan speed individually to optimize overall system performance.

][2.1.9.1 Air-cooled Condenser

Provide remote air-cooled condenser arranged for [vertical][or][horizontal] air discharge, designed and manufactured specifically for permanent outdoor installation. Condenser performance must be rated in accordance with ANSI/AHRI 460. Condenser must have head pressure control to allow unit operation down to [0 degrees F] [minus 20 degrees F] [minus 30 degrees F].

2.1.9.1.1 Condenser Fans

Provide direct-driven propeller fans with factory balanced [aluminum][or][glass-reinforced polymer] blades and equipped with fan guards. Provide [permanent split capacitor][or][electronically commutated] fan motors with [drip proof][totally enclosed][explosion proof] enclosures.

2.1.9.1.2 Condenser Coils

Air-cooled condenser coils must be [seamless copper tubes with plate type [aluminum][cooper] fins][or][all aluminum microchannel type][with coating as described in [paragraph CORROSION PROTECTION FOR COASTAL INSTALLATIONS][Section 09 96 00 HIGH PERFORMANCE COATINGS]]. The coils, in the production process, must be pressure tested with compressed air at 300 psig under water and verified to be leak-free. Factory dehydrate and seal each coil after testing and prior to evaluation and charging.

2.1.9.1.3 Unit Casing

Provide air-cooled condenser casings and mounting legs manufactured from [aluminum][or][galvanized steel] with[manufacturer's standard corrosion-resistant finish][coating as described in [paragraph CORROSION PROTECTION FOR COASTAL INSTALLATIONS][Section 09 96 00 HIGH PERFORMANCE COATINGS]].

][2.1.9.2 Liquid-cooled Condenser

Provide cleanable, cast iron or steel shell and [copper][copper-nickel] tubes, [counterflow type,][water-cooled][or][glycol-cooled]condenser with removable cast iron or steel heads. The condenser must be constructed in accordance with ASME BPVC.[As an option, a coaxial [copper][copper-nickel] tube-in-copper tube type water-cooled condenser may be provided.] Select liquid cooled condensers with a fouling factor of [0.001][0.0005]. Condensers must be rated for not less than 400 psi refrigerant pressure and 125 psi water pressure at operating temperatures.

Water supply and return connections and piping internal to unit must be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement must include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Provide a separate condenser for each compressor circuit.

][2.1.9.3 Dry Coolers

Provide dry cooler arranged for vertical air discharge, designed and manufactured specifically for permanent outdoor installation.

2.1.9.3.1 Dry Cooler Fans

Provide direct-driven propeller fans with factory balanced [aluminum][or][glass-reinforced polymer] blades and equipped with fan guards. Provide [permanent split capacitor][or][electronically commutated] fan motors with [drip proof][totally enclosed][explosion proof] enclosures.

2.1.9.3.2 Dry Cooler Coils

Dry cooler coils must be seamless copper tubes with plate type [aluminum][copper] fins[with coating as described in [paragraph CORROSION PROTECTION FOR COASTAL INSTALLATIONS][Section 09 96 00 HIGH PERFORMANCE COATINGS]]. The coils, in the production process, must be pressure tested with compressed air 300 psig under water and verified to be leak-free. Factory dehydrate and seal each coil after testing and prior to evaluation and charging.

2.1.9.3.3 Dry Cooler Casing

The dry cooler casings and mounting legs must be manufactured from [aluminum][or][galvanized steel] with[manufacturer's standard corrosion-resistant finish][coating as described in [paragraph CORROSION PROTECTION FOR COASTAL INSTALLATIONS][Section 09 96 00 HIGH PERFORMANCE COATINGS]].

[2.1.9.3.4 Integral Pump Package

Provide dry cooler with a [single][double] pump package complete with an open expansion tank. The pump package must be mounted in a weatherproof enclosure.

]][2.1.10 Economizers

The factory mounted CRAC controls must control the economizer operation process to ensure coordination of all components. The conditions for economizer operation must be determined[by the factory mounted CRAC controls based on indoor and outdoor conditions][by the HVAC control system].

[2.1.10.1 Air Economizers

Provide factory mounted dampers and duct connection flanges to allow up to 100 percent outdoor air through the unit for free cooling. Dampers must meet the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

][2.1.10.2 Water Economizers

Provide factory mounted coil and condenser water changeover valve. When commanded, the changeover valve must divert condenser water flow from the condenser coil to the economizer coil.

Coil must meet AHRI 410 and be sloped for drainage. Provide coil manufactured of seamless copper tubes with plate aluminum fins. Each coil, in the production process, must be individually tested at 2200 kPa with compressed air under water and verified to be air tight.

][2.1.10.3 Refrigerant Economizer

Provide fully integrated, pumped refrigerant economizer operation. In addition to the specified CRAC and air cooled condenser, provide a refrigerant pump package from the same manufacturer. The entire system must be controlled and optimized by the CRAC controls. During cold outdoor temperatures, the compressors must reduce capacity as much as possible. As compressor capacity decreases, a variable speed pump on each refrigeration circuit must then pump the liquid refrigerant through the air cooled condenser and evaporator for free cooling.

]][2.1.11 Floorstand

Provide a[n] [adjustable] [9] [12] [18] [24] [_____] inches high [seismic rated]floorstand for each CRAC for freestanding installation on the main building structural floor. Floorstand must elevate the unit to the height of the raised computer floor and must allow for leveling and locking at the desired height. Floorstand must be retractable, or removable, for installing the unit directly on the raised floor. Unit must be fully gasketed (rubber or neoprene) to prevent air leakage at the raised floor penetration.[Provide radiused turning vane integral to floorstand.]

[For units requiring seismic certification, the floorstand must be included in the unit certification.

]]2.2 SMALL COMPUTER ROOM AIR CONDITIONERS

Provide complete working CRACs, designed and factory assembled. Equipment must be listed in UL Elec Equip Dir or ETL DLP for computer room application. CRACs must have a minimum sensible coefficient of performance of [_____] in accordance with ASHRAE 127. CRACs must include room cabinet and frame, fan, filter, cooling coil, [reheat coil,][humidifier ,][compressor[s],][condenser[s],]controls, and, interconnecting piping internal to the CRAC. Provide units rated in accordance with AHRI 1360. Provide all refrigerant piping in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.2.1 System Configuration

[Self Contained Air Cooled: Provide an indoor unit for [ducted concealed][exposed] application. Unit must have connections for supply and return ducts from the central air handling system for heat rejection. Unit must consist of a direct expansion system evaporator and an indoor, air cooled condensing unit.

][Split System Air Cooled: Provide an indoor unit for [ducted concealed][exposed] application, an outdoor condensing unit, and interconnecting refrigerant piping. Unit must consist of a direct expansion system evaporator and an outdoor, air cooled condensing unit.

][[Water][Glycol] Cooled: Provide an indoor unit for [ducted concealed][exposed] application.[Provide dry cooler as specified elsewhere in this section.][Provide [cooling tower][remote evaporatively cooled condenser] as specified in 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.] Unit must consist of a direct expansion system evaporator and an indoor, [water][glycol] cooled condensing unit.

][Chilled Water: Provide an indoor unit for [ducted concealed][exposed] application with a chilled water coil.

]2.2.2 [Evaporator][or][Cooling Coil] Cabinet Construction

Provide cabinet and chassis constructed of heavy gauge galvanized steel with all service access from a single side of the unit. Mounting brackets must be integral to the cabinet. Internal cabinet insulation must meet ASHRAE 62.1 requirements for Mold Growth, Humidity & Erosion, tested per UL 181 and ASTM C1338 standards.

2.2.3 Air Distribution Components

Provide direct-drive fan assembly equipped with double-inlet blower, self-aligning ball bearings and lifetime lubrication. Fan motor must be permanent-split capacitor, high-efficiency type, equipped with two speeds for airflow modulation. The microprocessor controller must use the lower fan speed for precise dehumidification control. Fan speed must also be user selectable from the wall controller. System must be suitable for supply and return air plenum or ducted supply and return air distribution. Provide filter rack designed to accept 4 inch thick filters. Provide pleated filters with a MERV 8 rating in accordance with ASHRAE 52.2.

[2.2.4 Direct Expansion System Evaporator Components

The evaporator section must include evaporator coil, thermostatic expansion valve and filter drier. The evaporator coil must be constructed of copper tubes and aluminum fins. Provide an externally equalized thermostatic expansion valve to control refrigerant flow. The refrigerant piping must be spun-closed and filled with a nitrogen holding charge. Evaporator and condensing unit must be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. The evaporator unit can be coupled directly with the condensing unit or mounted remote to the condensing unit. The coil assembly must be mounted in a condensate drain pan with an internally trapped drain line. The evaporator drain pan must include a factory-installed float switch to shut down the evaporator upon high water condition.

][2.2.5 Chilled Water System Components

Provide a motorized, slow-close, two-position, chilled water control valve. Valve design pressure rating must be not less than 300 psig static pressure, with a maximum close-off pressure rating of not less than 60 psig.

Provide a cooling coil constructed of copper tubes and aluminum fins with integral drain and vent. The coil assembly must be mounted in a condensate drain pan with an internally trapped drain line. The evaporator drain pan must include a factory-installed float switch to shut down the evaporator upon high water condition.

][2.2.6 Indoor, Air-Cooled Condensing Unit

Condensing unit components must include condenser coil, direct drive centrifugal blower, scroll compressor, high-pressure switch, refrigerant receiver, head pressure control valve, hot gas bypass system, and liquid line solenoid valve. Provide a factory mounted disconnect switch in the high voltage section of the electrical panel. The switch handle must be accessible from the unit front. The cabinet and chassis must be constructed of heavy gauge galvanized steel, and must be serviceable from one side of the unit. Mounting brackets must be integral to the cabinet design and be designed for ceiling mounting.

Provide hot gas bypass to reduce compressor cycling and improve operation under low-load conditions. The hot gas bypass must be completely contained in the condensing unit. Field installed third refrigerant line is not acceptable. Hot gas bypass must be automatically deactivated upon a call for dehumidification. Provide a high pressure switch to protect the unit from abnormal refrigerant pressure conditions and deactivate the compressor and annunciate an alarm at the wall controller. The blower must continue to circulate air. The wall controller must be used to manually restart the compressor function after the automatic pressure switch resets. Three high head pressure alarms in a rolling 12-hour period must lock out the manual restart feature until power is cycled to the evaporator unit. A pressure balancing valve must be factory installed to reduce the chance of high pressure cut-out due to excessive refrigerant migration to the receiver due to changing outdoor temperatures during off-cycles. The refrigerant piping must be spun-closed and filled with a nitrogen holding charge. Evaporator and condensing unit must be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. Condensing unit must be designed for 95 degrees F ambient and be capable of operation to minus 30 degrees F. The condensing unit can be mounted directly to the evaporator or can be mounted remote to the evaporator. The condensing coil must be constructed of copper tubes and aluminum fins. The condenser fan must be centrifugal type, double inlet, direct drive.

][2.2.7 Outdoor, Air-Cooled Condensing Unit

Provide condensing unit rated in accordance with ANSI/AHRI 520 and designed for permanent outdoor installation. Provide removable panels for access to all components. Condensing unit components must include condenser coil, direct drive propeller fan, scroll compressor, high-pressure switch, refrigerant receiver, head pressure control valve, hot gas bypass system, and liquid line solenoid valve. Unit casing and chassis must be constructed of heavy gauge galvanized steel.

Provide hot gas bypass to reduce compressor cycling and improve operation under low-load conditions. The hot gas bypass must be completely contained in the condensing unit. Field installed third refrigerant line is not acceptable. Hot gas bypass must be automatically deactivated upon a call for dehumidification. Provide a high pressure switch to protect the unit from abnormal refrigerant pressure conditions and deactivate the compressor and annunciate an alarm at the wall controller. The blower must continue to circulate air. The wall controller must be used to manually restart the compressor function after the automatic pressure switch resets. Three high head pressure alarms in a rolling 12-hour period must lock out the manual restart feature until power is cycled to the evaporator unit. A pressure balancing valve must be factory installed to reduce the chance of high pressure cut-out due to excessive refrigerant migration to the receiver due to changing outdoor temperatures during off-cycles. The refrigerant piping must be spun-closed and filled with a nitrogen holding charge. Evaporator and condensing unit must be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. Condensing unit must be designed for [95 degrees F] [105 degrees F] ambient and be capable of operation to [0 degrees F] [minus 30 degrees F].[Condensing unit must operate at a sound level less than 58 dbA.] The condensing coil must be constructed of copper tubes and aluminum fins.

][2.2.8 Indoor [Water][Glycol] Cooled Condensing Unit

Condensing unit components must include coaxial condenser coil, scroll compressor, high-pressure switch, water regulating valve, hot gas bypass system, and liquid line solenoid valve. Provide a factory mounted disconnect switch in the high voltage section of the electrical panel. The switch handle must be accessible from the unit front. The cabinet and chassis must be constructed of heavy gauge galvanized steel, and must be serviceable from one side of the unit. Mounting brackets must be integral to the cabinet design and be designed for ceiling mounting.

Provide hot gas bypass to reduce compressor cycling and improve operation under low-load conditions. The hot gas bypass must be completely contained in the condensing unit. Field installed third refrigerant line is not acceptable. Hot gas bypass must be automatically deactivated upon a call for dehumidification. Provide a high pressure switch to protect the unit from abnormal refrigerant pressure conditions and deactivate the compressor and annunciate an alarm at the wall controller. The blower must continue to circulate air. The wall controller must be used to manually restart the compressor function after the automatic pressure switch resets. Three high head pressure alarms in a rolling 12-hour period must lock out the manual restart feature until power is cycled to the evaporator unit. The refrigerant piping must be spun-closed and filled with a nitrogen holding charge. Evaporator and condensing unit must be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. The condenser circuit must be pre-piped with a [2-way][3-way] regulating valve which is head-pressure actuated. The condenser water/glycol circuit must be designed for a static operating pressure of [150 PSI] [350 PSI].

][2.2.9 Steam Generating Humidifier

Provide a factory mounted steam generating humidifier that is controlled by the integral unit controls. Humidifier must include disposable canister, all supply and drain valves, 1 inch air gap on fill line, inlet strainer, steam distributor and electronic controls. The need to change canister must be annunciated on the wall-mounted controller. An LED light on the humidifier assembly must indicate cylinder full, overcurrent detection, fill system fault and end of cylinder life conditions. The canister flush water must not drain into the coil drain pan. The humidifier wand must be mounted over the coil drain pan.

][2.2.10 Electric Reheat

Provide factory mounted, 304/304 stainless steel, finned-tubular electric resistance heater. Reheat must be controlled by the integral unit controls to maintain room dry bulb temperature when dehumidification is required. Provide UL listed safety switch to protect the system from overheating. Provide a factory mounted ground current detector to shut-down the entire unit if a ground fault in the reheat system is detected.[Provide Silicon Controlled Rectifier (SCR) controller to proportionally control the reheat elements to maintain the selected room temperature.]

][2.2.11 Hot Water Reheat

Provide hot water reheat coil constructed of copper tubes and aluminum fins with integral drain and vent.

]2.2.12 Controls

Provide remote mounted color touchscreen display for each unit. Provide remote mounted temperature[and humidity] sensor[s] for each unit. Controls must be organized by menus with minimum menu selection of: Alarms, Event Log, Graphics, and Status Overview. The Graphics menu must display a minimum of the following: zone temperature[and humidity], zone setpoints, fan status[, and valve position]. Controls must include a control system interface. The control system interface must meet DDC Hardware requirements of Section [23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

[Integrate CRAC control into the HVAC control system defined in Section [23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.02 BACNET DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][and][UMCS defined in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION].[HVAC control system interface point is located in [indicate room number].][UMCS interface is located in [indicate building and room number].][Refer to controls drawings for minimum points required to interface with the [HVAC control system][and][UMCS].]

][2.3 [COLD] [AND] [HOT] AISLE CONTAINMENT SYSTEMS

Provide an engineered and manufactured system of solid panels to fully enclose each [hot][cold] aisle. The system must connect to uniform rows of same-height racks. The containment system must be provided in its entirety from a single manufacturer. All components must be selected for compatibility with the equipment support frame provided under Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. All materials in the containment system must have a flame spread index not greater than 75 and a smoke developed index not greater than 450 when tested in accordance with ASTM E84 or UL 723.

Wall Panels: [Translucent][or][Transparent] 0.236 inch minimum thickness polycarbonate panels framed within 1 inch x 1 inch T-slot aluminum extrusion or extruded aluminum tube. Panels must be UL 94 listed with a minimum rating of V-1.

Roof Panels: Construction same as wall panels.

Doors: [Sliding][or][Hinged] doors of similar construction to wall panels. Doors must comply with the requirements of CPSC 16 CFR 1201.

Grommets: At each penetration through the aisle enclosure system, provide brush-type grommets to minimize air leakage. Grommets must be of ABS or polypropylene construction with nylon brush filaments and EPDM gasket.

Blanking Panels: Provide panels to blank off openings in the aisle. Panel construction must be similar to wall panel construction or rack enclosure construction.

][2.4 RACK MOUNTED FANS

Provide an engineered and manufactured fan system, designed to attach directly to the equipment support frame provided under Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. Fan system must circulate air evenly through the entire rack that it serves.

2.4.1 Cabinet

Exterior panels must be steel sheet, minimum of 20 gage, mill-galvanized or coated with a corrosion-inhibiting epoxy finish in [manufacturer's standard][the specified][the indicated] color. Mill galvanized sheet metal must be coated with not less than 1.25 ounces of zinc per square foot of two-sided surface. Mill rolled structural steel must be hot-dip galvanized or primed and painted. Cut edges, burns and scratches in hot-dip galvanized surfaces must be coated with galvanizing repair coating. Manufacturer's standard cabinet materials and finishes will be acceptable if equivalent to the above requirements and approved by the Contracting Officer.

2.4.2 Fan

Provide array of propeller type fans powered via single point cord-and-plug connection.[Provide dual power feeds for redundancy.]

]2.5 INSTRUMENTATION AND CONTROLS

All controls provided under this section must comply with the requirements of Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

[2.5.1 Unit Level Controls

Provide factory installed components and wiring to control a unit's basic functions and space ambient conditions[including [humidification][and][dehumidification]] at one factory installed and tested station. Controller modules must provide automatic centralized control of computer room critical equipment, simplifying emergency switching and unit testing. When the module recognizes an alarm condition, it must automatically switch to a stand-by device. User must be able to program a switching delay to allow time to correct emergency conditions. Provide modules with capability to balance the runtime of all connected air units. Provide clear, simplified instructions for programming and configuration of controllers, minimizing the chances of operator error. Provide an electronic temperature and humidity recorder, integral or external to the unit, readable to specified control accuracy, complete with supplies required for one year of operation. Controls must include a control system interface to an HVAC control system. The control system interface must meet DDC Hardware requirements of Section [23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]. Unit controls must comply with the requirements of Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.5.1.1 Display Panel

Provide[color LED touchscreen display with graphical menu navigation][LCD digital display with push button navigation]. Display panel must include the following minimum data: power on, power off, unit in alarm, description of alarm, filter status,[rack inlet temperature,][room temperature,][room relative humidity ,][event log,][service contact information,] and unit run hours.[Display must have capability to set up password protection].

Provide the following minimum externally accessible controls at the unit: start and stop total system functions, silence audible alarm, main power disconnect.

2.5.1.2 Alarms

Display alarms on unit display panel. Alarm for the following: high and low space temperature, high and low space humidity, dirty filters, loss of airflow,[loss of [water][or][glycol] flow,] compressor high head pressure,[custom alarms as indicated on the controls drawings,] humidifier problems, and leak detection. Provide field accessible local audible alarm with silence pushbutton. Provide push-to-test lamps or all-lamp test pushbutton.[CRACs must have local devices which provide signals for remote audible and visual alarming capability for the above specified alarm conditions.]

2.5.1.3 Leak Detection

Provide [spot][or][rope] moisture detection system for each computer room. Leak detection must be designed for installation on the subfloor below the raised floor of the computer room. Leak detection system must interface with the associated CRAC control panel to alarm upon detection of moisture on the subfloor.

2.5.1.4 Factory Wired Components

[Provide factory installed and wired[chilled][,][and][condenser][,][and][hot] water valve[s]. Valve[s] must meet the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

][Provide CRAC manufacturer's remote [room temperature sensor][,][and][rack mounted temperature sensor array][,][and][room humidity sensor]. Sensors must meet the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

][Provide factory wired discharge air temperature sensor. Sensors must meet the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

]][2.5.2 Supervisory CRAC Controls

In addition to stand alone controls, provide [a]device[s] to network together all CRACs [in each computer room][in this contract][as indicated]. The network device must integrate all data for each CRAC, as required under stand alone controls, and display it on any connected CRAC's display panel.[The network device must optimize the operation of all connected CRACs to minimize energy use.] The network device must balance runtime across all connected units. The network device must automatically switch to a standby unit upon detection of failure of a duty unit. Provide all control wiring among CRACs and network device[s] as required to meet this specification.

][2.5.3 Integration to [HVAC control system] [and] [Basewide Utility Monitoring and Control System (UMCS)]

Integrate CRAC control into the HVAC control system defined in Section [23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.02 BACNET DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][and][UMCS defined in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION].[HVAC control system interface point is located in [indicate room number].][UMCS interface is located in [indicate building and room number].]

[Refer to controls drawings for minimum points required to interface with the [HVAC control system][and][UMCS].

]][2.6 CORROSION PROTECTION FOR COASTAL INSTALLATIONS

[Coat exterior coils, exterior casings, interior coils exposed to outdoor air, and interior casings exposed to outdoor air, in accordance with Section 09 96 00 HIGH PERFORMANCE COATINGS.

][Provide the [polyelastomer][or][phenolic] finish coating system on exterior coils, exterior casings, interior coils exposed to outdoor air, and interior casings exposed to outdoor air. The coating system must not reduce the HVAC equipment's performance rating.

] Finish coating must be applied at the premises of the HVAC equipment manufacturer or at the premises of the coating manufacturer or his authorized applicator. Provide finish coating in colors gray, or aluminum, or ivory. All components of the special finish coating systems, including primers and intermediate coats, must be applied by immersion dip-coating or spray-coating in accordance with coating manufacturer's written procedures.

If special finish coatings are applied at the finish coating manufacturer's (or his authorized applicator's) premises, the equipment to be finish coated must be transported to and from the finish coating manufacturer's premises by the Contractor. The finish-coating manufacturer must be responsible for necessary disassembly of the HVAC equipment and re-assembly of final finish coated equipment.

Submit for approval a Certificate of Specification Compliance provided by the finish coating system manufacturer. Requirements for certificate include:

a. Name of firm that provided the finish coating system.

b. Project title and Navy construction contract number.

c. Listing of the pieces of equipment that were finish coated by this firm.

d. Certificate must certify that the finish coating materials and application procedures employed conform to the contract specifications.

e. Date of final inspection by this firm and printed name and signature of the inspector.

f. Printed name and signature of the officer of the firm that is responsible for firm's certification program.

[2.6.1 Polyelastomer Finish Coating System

2.6.1.1 Heat Exchanger Coil (Including Evaporator Coil) Surfaces

a. Acrylic polymer resin primer: 1 mil minimum dry film thickness.

b. Polyelastomer resin top coating: 3 coats, 1.5 mils minimum total dry film thickness.

c. In lieu of coating, provide copper tubes and copper fins

2.6.1.2 Uninsulated Interior Surfaces and Exterior Surfaces

Polyelastomer resin: 3 coats, 4 to 6 mils minimum total dry film thickness.

2.6.1.3 Insulated Interior Surfaces

Vinyl: 2 to 10 mils minimum dry film thickness.

][2.6.2 Phenolic Finish Coating System

Provide a resin base thermosetting phenolic finish.

2.6.2.1 Heat Exchanger Coil (Including Evaporator Coil) Surfaces

a. Apply phenolic finish to the entire coil. Provide a minimum of two coats. Total minimum dry film thickness must be 3 mils.

b. In lieu of coating, provide coil of copper tubes and copper fins

2.6.2.2 Uninsulated Interior Surfaces and Exterior Surfaces

Amine cured epoxy phenolic finish: 6 to 7 mils minimum total dry film thickness.

2.6.2.3 Insulated Interior Surfaces

Polyester or Vinyl Ester finish: 2 to 10 mils minimum dry film thickness.

]]2.7 FACTORY PAINTING SYSTEMS

Provide manufacturer's standard factory painting. Certify that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. The factory painting system must be designed for the anticipated temperature service.

2.8 ELECTRICAL

Provide an integral electrical panel of similar construction to the unit cabinet. Within the electrical panel, provide a single point power connection terminal block and [fused disconnect switch,][fuse block and disconnect switch]. The electrical panel must provide at least [65,000][_____] amp Short Circuit Current Rating (SCCR).[Refer to electrical drawing [_____] for Short Circuit Current Rating (SCCR).]

[2.8.1 Electrical Motors, Controllers, Contactors, and Disconnects

Provide motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors must conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors must have a maximum of 120 volt control circuits, and must have auxiliary contacts for use with the controls provided. When motors and equipment provided are larger than sizes indicated, the cost of additional electrical service and related work must be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment must be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

]
[2.8.2 Electrical Installations

Conform to IEEE C2, NFPA 70, and requirements specified herein.

2.8.2.1 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters[(except starters/controllers which are indicated as part of a motor control center)], control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors are not to be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit,[the motor control equipment forming a part of motor control centers,] and the electrical power circuits must be provided under Division 26, except internal wiring for components of package equipment must be provided as an integral part of the equipment. When motors and equipment provided are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

2.8.2.2 Modifications to Existing Systems

Where existing mechanical systems and motor-operated equipment require modifications, provide electrical components under Division 26.

2.8.2.3 High Efficiency Motors

2.8.2.3.1 High Efficiency Single-Phase Motors

Unless otherwise specified, single-phase fractional-horsepower alternating-current motors must be high efficiency types corresponding to the applications listed in NEMA MG 11.

2.8.2.3.2 High Efficiency Polyphase Motors

Unless otherwise specified, polyphase motors must be selected based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings must meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

2.8.2.4 Three-Phase Motor Protection

Provide controllers for motors rated 1 horsepower and larger with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

]2.8.3 Electrical Control Wiring

[Provide control wiring under Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.][Provide control wiring under Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.][Provide control wiring under this section in accordance with NFPA 70 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.] Provide Space temperature control system drawings which include point-to-point electrical wiring diagrams.

2.9 [HVAC WATER PIPING][AND][METAL DUCTWORK]

Requirements for HVAC water piping and metal ductwork are specified in [Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS][and][Section 23 30 00 HVAC AIR DISTRIBUTION].

[2.10 FIRE PROTECTION DEVICES

The requirements for duct smoke detectors are specified in Section [23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS].

]2.11 SOURCE QUALITY CONTROL

Provide factory test plan[s], factory test schedule[s], factory test[s] and factory test report[s] on [each of the CRAC[s];][CRAC-1 through CRAC-[_____]].

2.11.1 Manufacturer's Factory Test Plans

For [each CRAC][insert specific unit marks], submit a factory test plan which when followed during factory testing shall verify that the performance scheduled on the drawings is met by the produced CRAC models.

The manufacturer shall perform factory tests on the actual CRAC[s] produced for this project. The test reports shall document the performance tests conducted on the factory assembled computer room air conditioning units. Performance testing on the individual computer room air conditioning unit components, not factory assembled, is not acceptable.

Submit the required test plans for review and approval to the Contracting Officer at least [90][_____] calendar days before scheduled factory test date.

2.11.1.1 Test Procedure

Indicate in each test plan the factory acceptance test procedures. Procedures shall be structured to test all modes of operation to confirm that the controls are performing in accordance with the intended sequence of control.

Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

2.11.1.2 Performance Variables

Each test plan shall list performance variables that are required to be measured or tested as part of the field test. Include in the performance variables list the performance indicated on the equipment schedules on the contract design drawings.

Manufacturer must provide with each test procedure a description of acceptable performance results that shall be verified. Manufacturer shall identify the acceptable limits or tolerances within which each tested performance variable shall acceptably operate.

2.11.1.3 Test Configuration

Plans shall indicate that tests are to be performed for a minimum of four continuous hours[in a wet coil condition]. If test period is interrupted, the four hour test period shall be started over. Each test plan shall be job specific and shall address the particular CRAC[s] and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.[Tests shall include [a pressurized raised floor discharge configuration at the specified or indicated height above the floor,][with or without the air discharge elbows;][or a top air discharge configuration][and phenolic coated coils].]

2.11.1.4 Tested Variables

Plans shall provide for air side testing which includes verification of the airflow, total static pressure; fan drive motor KW, amperage and RPM; and fan RPM. Provide entering air temperatures equal to those indicated on the CRAC schedules.

2.11.1.5 Thermal Testing

Plans shall provide thermal testing utilizing [chilled water][40 percent ethylene glycol and 60 percent water solution][and][hot water] with temperatures equal to those indicated on the CRAC schedules. Thermal testing shall verify CRAC heating, sensible cooling, total cooling, and humidifying performance scheduled on the contract drawings.

2.11.1.6 Specialized Components

Include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

[2.11.1.7 Factory Test For Sound Pressure Level

Determine the A-weighted sound pressure level for the indoor portion of each of the CRACs; [CRAC-1 through CRAC-[_____]].

Each unit shall be mounted on a [raised]floor duplicating of the installation configuration indicated on the contract drawings. Unit shall be located at least 5 feet 6 inches from test room walls. No other equipment shall be operating in the test room during sound level testing of subject unit. Background sound levels shall be at least 10 dB below lowest sound pressure level measured on subject unit. Testing shall be conducted by using an ANSI Type 1 or 2 sound level meter located 3.3 feet from the unit under test and 3.3 feet above raised floor. Measure and record A-weighted sound pressure level on all four sides of unit.

]2.11.1.8 Factory Tests Reporting Forms

Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Submit factory test reports, referencing each tested CRAC serial number, and receive approval before delivery of CRAC to the project site.

[2.11.2 CRAC Production Schedule and Factory Test Schedule

The Government [will][reserves the right to] witness factory tests for [CRAC-1][and CRAC-[_____] through CRAC-[_____]].

Provide the CRAC production schedule and factory test schedule for tests to be performed at the manufacturer's test facility. Submit planned production schedule, and factory test schedule and test location, to the Contracting Officer as soon as it is scheduled but not less than 60 calendar days prior to the scheduled factory test date. Track this schedule through the production phases and if a scheduled factory test date changes, give advanced notice to Contracting Officer as soon as possible but at least 15 calendar days in advance of the scheduled test dates.

]2.11.3 Factory Tests

Conduct the factory testing in compliance with the Contracting Officer approved manufacturer's field test plan, and in accordance with additional field testing requirements specified herein. Record the required data using the test reporting forms approved of the approved field test plan. Conduct the test for each CRAC for the continuous test period in the approved test plan. A CRAC shutdown before the continuous test period is completed shall result in the test period being started again and run for the required duration.

2.11.4 Deficiency Resolution

The test requirements shall be acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections tested as specified in the paragraph FACTORY TEST PLANS.

2.11.5 Factory Test Reports

Use the test reporting forms approved in the factory test plan. Final test report forms shall be typed including data entries and remarks. Completed test report forms for each CRAC shall be reviewed, approved, and signed by the Manufacturer's test director.

[2.12 SEISMIC REQUIREMENTS

CRAC units must be seismically certified in accordance with the requirements in Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC. Provide seismic bracing in accordance with Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC.

]PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 CRAC System

Installation of each CRAC system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing, must be in accordance with ASME B31.1, ASME B31.5, NFPA 70, as modified and supplemented by the requirements of this section and the CRAC manufacturer's written installation instructions.

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

3.1.2 Installation Instructions

Provide a manufacturer's installation manual for each type of CRAC.[Provide a manufacturer's installation manual for each type of aisle containment system.][Provide a manufacturer's installation manual for each type of rack mounted fan.]

3.1.3 Operation and Maintenance Data

Submit Computer Room Air Conditioner Operation and Maintenance Data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

3.1.4 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Provide materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Provide labor and tools for making actual connections to existing systems.

3.2 FIELD QUALITY CONTROL

Upon completion and before final acceptance of work, test each CRAC subsystem in service to demonstrate compliance with the contract requirements, including field testing specified below. Adjust controls and balance systems prior to final acceptance of completed systems. Test controls through every cycle of operation. Test safety controls to demonstrate performance of required function. Correct defects in work provided and repeat tests. Provide steam, fuel, water, electricity, instruments, connecting devices, and personnel for tests. Flush and clean piping before placing in operation. Clean equipment, piping, strainers, and ducts. Prior to commencement of field testing, remove all filters and provide new filters. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided.

3.3 FIELD TESTING

Provide field test plan[s], field test schedule[s], field test[s] and field test report[s] on each of the CRAC[s]. Field test each CRAC for Contracting Officer acceptance in accordance with the CRAC manufacturer's approved field test plan.

3.3.1 Manufacturer's Field Test Plans

Submit field test plans developed by the manufacturer for each CRAC; [submit the field test plans along with the factory test plans specified herein before][submit the field test plans at least 90 calendar days prior to planned date of the field test]. Field test plans developed by the installing Contractor, or the equipment sales agency furnishing the CRAC, will not be acceptable.

The Contracting Officer will review and approve the field test plan for each of the listed CRACs prior to commencement of field testing of the equipment. The approved field test plans must be followed for the field tests of the CRAC and test reporting.

3.3.1.1 Coordinated Testing

Indicate in each field test plan when work required by this section requires coordination with test work required by other specification sections. Provide test procedures for the simultaneous or integrated testing of: CRAC controls which interlock and interface with controls factory prewired[; and external controls for the CRAC provided under [Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS][Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC]].

3.3.1.2 Prerequisite Testing

Each CRAC for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field test plan when such prerequisite work is required.

3.3.1.3 Test Procedure

Indicate in each field test plan the CRAC manufacturer's published start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

3.3.1.4 Performance Variables

Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include, in the listed performance variables, requirements indicated on the CRAC schedules on the design drawings. Manufacturer must provide, with each test procedure, a description of acceptable results that have been verified.

Manufacturer must identify the acceptable limits or tolerances within which each tested performance variable must acceptably operate.

3.3.1.5 Test Configuration

Plans must indicate that tests are to be performed for a minimum of four continuous hours[in a wet coil condition]. If test period is interrupted, the four hour test period must be started over. Each test plan must be job specific and must address the particular CRAC[s] and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.[Tests must include [a pressurized raised floor discharge configuration at the specified or indicated height above the floor,][with or without the air discharge elbows;][or a top air discharge configuration][and corrosion protection.]]

3.3.1.6 Tested Variables

Plans must provide for air side testing which includes verification of the airflow, total static pressure; fan drive motor KW, amperage and RPM; and fan RPM. Provide entering air temperatures equal to those indicated on the CRAC schedules.

3.3.1.7 Thermal Testing

Plans must provide thermal testing utilizing [chilled water][40 percent ethylene glycol and 60 percent water solution][and][hot water] with temperatures equal to those indicated on the CRAC schedules. Thermal testing must verify CRAC heating, sensible cooling, total cooling, and humidifying performance scheduled on the contract drawings.

3.3.1.8 Specialized Components

Include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.3.1.9 Field Test Reporting Forms

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives.

3.3.2 Field Test Schedule

Notify the Contracting Officer in writing at least 30 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for the review and approval of the Contracting Officer.

3.3.3 Manufacturer's Test Representative

Provide a factory trained field test representative authorized by the CRAC manufacturer to oversee the complete execution of the field testing. This test representative must also review, approve, and sign the completed field test report. Signatures must be accompanied by the person's name typed.

Submit credentials of the manufacturer's field test representative proposed, including current telephone number, to the Contracting Officer for review and approval. Submit these credentials with the written advance notice of the field tests.

3.3.4 Field Tests

Conduct the field testing in compliance with the Contracting Officer approved manufacturer's field test plan, and in accordance with additional field testing requirements specified herein. Record the required data using the test reporting forms approved of the approved field test plan. Conduct the test for each CRAC for a continuous 24-hour test period. A CRAC shutdown before the continuous 24-hour test period is completed must result in the 24-hour test period being started again and run for the required duration.

3.3.5 Deficiency Resolution

The test requirements must be acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations. Corrections must be tested again in compliance with the requirements specified in the paragraph FIELD TEST PLANS.

3.3.6 Field Test Reports

Use the test reporting forms approved in the field test plan. Final test report forms must be typed, including data entries and remarks. Completed test report forms for each CRAC must be reviewed, approved, and signed by the Contractor's test director and the QC manager.

3.4 INSTRUCTION TO GOVERNMENT PERSONNEL

Provide the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work.

Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. Provide [4][_____] hours of training for each type of CRAC specified.[Provide [2][_____] hours of training for each [aisle containment system][and][rack mounted fan] specified.]

-- End of Section --

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SECTION 23 82 00.00 20

TERMINAL HEATING UNITS
02/16, CHG 1: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z83.8/CSA 2.6 (2016; R 2021) Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-Fired Duct Furnaces

ANSI Z83.19/CSA 2.35 (2017) Gas-Fired High-Intensity Infrared Heaters

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 33 (2016) Method of Testing Forced Circulation Air Cooling and Air Heating Coils

ASTM INTERNATIONAL (ASTM)

ASTM A109/A109M (2016; R 2018) Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A240/A240M (2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

ASTM A463/A463M (2015; R 2020; E 2020) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process

ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A1011/A1011M (2018a) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2021) Standard for the Installation of Warm Air Heating and Air Conditioning Systems
NFPA 91	(2020) Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Noncombustible Particulate Solids
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

UNDERWRITERS LABORATORIES (UL)

UL 441	(2016; Reprint Jul 2016) UL Standard for SafetyGas Vents
UL 731	(2018; Reprint Nov 2021) UL Standard for Safety Oil-Fired Unit Heaters

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Unit Heaters

Infrared Heaters

SD-10 Operation and Maintenance Data

Unit Heaters, Data Package 2

Infrared Heaters, Data Package 2

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

PART 2 PRODUCTS

2.1 UNIT HEATERS

Self-contained and factory assembled, [propeller] [or] [centrifugal] fan with capacities expressed as Btu per hour output and cubic foot-per-minute air delivery, operating conditions, and mounting arrangements as indicated. Average fan bearing life must be minimum 200,000 hours at operating conditions. Provide fan motor with [direct] [or] [belt] drive. Construct fan-guard motor mount of steel wire. Equip each heater with individually adjustable package discharge louver. Louvers may be substituted by discharge cones or diffusers. Provide thermostats [as indicated]. Furnish circuit breaker disconnect switch.

2.1.1 Gas-Fired Unit Heater

ANSI Z83.8/CSA 2.6 and AGA label.

2.1.1.1 Casing

Minimum [22] [_____] gage [steel] [or] [aluminum]. Provide removable access panels.

2.1.1.2 Heat Exchanger

Minimum [20] [_____] gage all-welded steel construction with corrosion-resistant aluminum finish.

2.1.1.3 Burners

Die-formed, slot ports, and steel construction with aluminum paint.

2.1.1.4 Draft Diverter

All-welded steel construction and an integral part of each heat exchanger section. Allows backdrafts to bypass burner assembly without affecting normal operation.

2.1.1.5 Controls

Consisting of a combination pressure regulator, [two-stage gas valve in 100 percent and [55] [_____] percent of full rating,] main shutoff valve, pilot cock, pilot safety switch for 100 percent shutoff, high temperature limit switch, and time-delay fan switch. Include power and control connections in an integral junction box.

2.1.1.6 Efficiency

Unit heater must have a minimum combustion efficiency of 80 percent when tested in accordance with ANSI Z83.8/CSA 2.6.

[2.1.1.7 Accessories

Provide [propane-gas conversion kit] [automatic electric pilot recognition kit].

]2.1.2 Oil-Fired Unit Heater

UL 731 and UL labeled.

2.1.2.1 Casing

Minimum [22] [_____] gage [aluminum] [or] [[enamel] [or] [vinyl] coated steel]. Provide removable access door.

2.1.2.2 Heat Exchanger

Minimum 16 gage primary combustion chamber constructed of [perlite-clad steel] [, aluminum-clad steel] [, or] [400 series stainless steel]; minimum 14 gage secondary heating section composed of aluminized, mild, or hot-rolled steel. Provide a flame observation port on the burner side of the heater.

2.1.2.3 Burner

Provide pressure oil-atomizing burner with mechanically forced draft, suitable for fuel oil No. 2. Provide two-stage oil pump. Equip burner motor with a combustion air damper.

2.1.2.4 Controls

Include fan and limit switch, low voltage (24-volt) transformer, electronic flame safeguard with flame safety relay, and electric spark ignition.

2.1.2.5 Accessories

Provide [power exhauster,] oil filter, oil pressure regulator, and barometric damper.

2.1.2.6 Efficiency

Unit heater must have a minimum combustion efficiency of 80 percent when tested in accordance with UL 731.

2.1.3 [Steam] [or] [Hot-Water] Unit Heater

ASHRAE 33 tested for heating coils; UL listed for motor and controls.

2.1.3.1 Casing

Minimum [20] [_____] gage [steel] [or] [aluminum] with removable access panels or means to remove, service, and maintain major components.

2.1.3.2 Coil

Fin-and-tube coil constructed of [copper,] [red brass,] [90-10 copper nickel,] [or] [steel] tubes and [copper] [or] [aluminum] fins. Use maximum design pressure of [steam at [_____] pounds per square inch gage (psig)] [and] [hot water at [_____] psig and [_____] degrees F].

2.1.3.3 Controls

[Automatic controls of [modulating] [on-off-auto] [or] [combination of modulating and on-off-auto] system] [As indicated]. [Provide a three-position selector switch.]

2.1.4 Electric Unit Heater

UL listed; wattage, voltage, phase, and number of steps as indicated. Provide control-circuit terminals and single source of power supply. Heater 5 Kw and larger must be three-phase, with load balanced on each of the three phases. Limit leaving air temperature below 140 degrees F at 60 degrees F entering air.

2.1.4.1 Casing

Minimum [21] [_____] gage steel.

2.1.4.2 Heating Element

Nickel-chromium heating wire element, free from expansion noise and 60 Hz hum. Embed element in magnesium-oxide insulating refractory. Seal element in high-mass steel or corrosion-resisting metallic sheath with fins. Enclose element ends in terminal box. Space fins at maximum six fins per inch. Limit fin surface temperature 550 degrees Fat any point during normal operation.

2.1.4.3 Controls

Include limit controls for thermal overheat protection of heaters. For remote thermostatic operation, provide contactor rated for 100,000 duty cycles. [Provide a control transformer to supply 120-volt thermostat control circuit for each heater.] Provide room thermostat for pilot duty.

2.1.4.4 Wiring

Completely factory-prewired to terminal strips, ready to receive branch circuit and control connections for 140 degrees F [copper] [or] [aluminum] wiring.

[2.1.4.5 Accessories

Provide fan switching devices to independently operate fan motor for summer ventilation and winter heat recovery.

]2.2 INFRARED HEATERS

[Reflector-beam spread] [and] operating conditions as indicated. Provide pre-wired control boxes, thermostats, and reflector [and duct] hangers.

2.2.1 Sheet Metal

[a. Aluminum-Clad Steel: ASTM A463/A463M, nominal thickness of minimum 16 gage for radiant tubing between burners and vacuum pump or vent.

][b. Aluminum: ASTM B209, manufacturer's standard thickness.

][c. Stainless Steel: ASTM A240/A240M, nominal thickness of not less than 20 gage.

][d. [Ceramic-Coated] [Enamel-Coated] Steel: ASTM A1011/A1011M hot rolled or ASTM A109/A109M cold rolled, low-carbon steel. Provide coating able to withstand infrared heater operating temperatures.

]2.2.2 Unvented Gas Infrared Heater

ANSI Z83.19/CSA 2.35 and AGA approved.

2.2.2.1 Heating Element

Perforated ceramic capable of withstanding thermal shock in [3] [_____] minutes from 2000 to 32 degrees F without fatigue and of minimum 1600 degrees F operating temperature. When re-radiating screens are used to obtain operating temperature, provide [stainless-steel] [or] [chromized-steel] matching screen.

2.2.2.2 Reflector

[Polished [aluminum] [stainless steel]] [or] [approved high infrared reflector materials]. Provide reflector supports of manufacturer's standard.

2.2.2.3 Controls

Provide either an intermittent pilot ignition system or a solid-state direct ignition system. Provide automatic gas safety valve capable of withstanding a 10 percent voltage fluctuation.

2.2.2.4 Ventilation

Section 23 30 00 HVAC AIR DISTRIBUTION.

2.2.3 Vented Gas Infrared Heater

ANSI Z83.19/CSA 2.35 with AGA label, [single-burner power vented] [single-burner vacuum vented] [or] [multiple-burner vacuum vented].

2.2.3.1 Vent

NFPA 54 and NFPA 211, [Type 316 stainless steel] [or] [high-temperature corrosion-resistant plastic rated for minimum 400 degrees F]. Vent flue gas to outdoors by induced draft.

2.2.3.2 Reflector

[Polished [aluminum] [stainless steel]] [or] [approved high infrared reflector materials]. Provide manufacturer's standard reflector supports.

2.2.3.3 Heat Exchanger and Combustion Chamber

Construct heat exchanger and combustion chamber of [aluminum-clad steel] [ceramic-coated steel] [or] stainless steel.

2.2.3.4 Controls

Incorporate either an intermittent pilot ignition system or a solid-state direct ignition system. Provide safety air-flow switch for each burner.

2.2.3.5 Fan or Vacuum Pump

Heater manufacturer's standard.

2.2.3.6 Performance

Provide sufficient radiant heating surface to attain a minimum steady-state thermal efficiency of [80] [85] percent and a maximum heat release of [2,750] [2,900] [2,100] Btu per square foot.

2.2.4 Electric Infrared Heater

Self-contained, factory assembled, and UL listed and including the heating element, reflector, heater housing, mounting brackets, element holders, wire guards, and high-temperature internal wiring.

2.2.4.1 Heating Element

Minimum 3/8 inch diameter quartz tube or metal sheath with coiled resistor wire. Element operating temperature range must be 1200 to 1800 degrees F.

2.2.4.2 Heater Housing

[Weatherproof] [aluminum-clad steel] [stainless-steel] [aluminum] [or] [low-carbon steel] construction. Provide a baked enamel finish over a corrosion-resistant primer. Provide a chrome-plated or stainless-steel wire guard to prevent heating elements from accidental damage. Furnish swivel brackets to position heater in any horizontal angle.

2.2.4.3 Reflector

Polished [aluminum] [or] [stainless steel].

2.2.4.4 Wiring

Fully enclosed internal wiring. Provide minimum 6 inch slack fixture (heater) wire for connection to branch circuit wiring.

[2.2.4.5 Accessories

Provide electric-clock controller with self-starting synchronous motors and snap acting switch, rated for 125 percent of the load which it controls. Provide a 30-second time cycle with an infinitely adjustable "on-off" period each cycle. Equip controller with external indicating knob for manual adjustment from zero to 100 percent. If surface mounted, furnish steel enclosure with a baked enamel finish over a corrosion-resistant primer. If flush mounted, furnish galvanized steel enclosure with knockouts for conduit in bottom and sides. Provide a connection wiring diagram on the inside cover of the enclosure. Where loads exceed the maximum available rating of controller, provide high duty-cycle contactors serving as pilot devices.

]2.3 FAN

Provide [steel] [or] [aluminum] fans with ball or roller bearings for motors over 1/8 horsepower (hp) and sleeve bearings for motors 1/8 hp and under. Provide sleeve bearings with oil reservoir, if not permanently lubricated.

2.4 MOTOR AND STARTER

NEMA MG 1, and NEMA ICS 2, and NEMA ICS 6, respectively. [Provide explosion-proof motors and motor starters where indicated.] Provide continuous-duty motor with built-in automatic reset thermal overload protection. For motor 1/2 hp and larger, use three-phase. Provide single-phase motor of permanent split capacitor or capacitor start. Limit motor speed at 1800 r/min. Wire motor to heater power supply source.

[2.5 NOISE, VIBRATION AND SEISMIC CONTROLS

Section 22 05 48.00 20 MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL.

][2.6 GAS PIPING SYSTEM AND FLUE VENT

Comply with Section 23 11 20 FACILITY GAS PIPING, Section 33 51 15 NATURAL-GAS / LIQUID PETROLEUM DISTRIBUTION PIPELINES, for gas valves and piping. Use UL 441 flue vents [and] [gas-vent roof jacks], of [galvanized steel] [aluminum] [or] [stainless steel].

][2.7 FUEL OIL [TANK] AND PIPING SYSTEM

Section 33 52 10 FUEL SYSTEMS PIPING (SERVICE STATION).

][2.8 HOT WATER PIPING SYSTEM

Section 23 21 13.00 20 LOW TEMPERATURE WATER [LTW] HEATING SYSTEMS.

][2.9 STEAM AND CONDENSATE PIPING SYSTEM

Section 23 22 26.00 20 STEAM SYSTEM AND TERMINAL UNITS.

]2.10 SOURCE QUALITY CONTROL

Special protection is not required for equipment that has a zinc coating conforming to [ASTM A123/A123M] [ASTM A653/A653M]. Otherwise, protect affected equipment items by manufacturers' corrosion-inhibiting coating or paint system that has proved capable of withstanding salt-spray test in accordance with ASTM B117. Test indoor and outdoor equipment for 125 hours; test outdoor equipment used in a marine atmosphere for 500 hours. For each specimen, perform a scratch test as defined in ASTM D1654.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment where indicated and as recommended by manufacturer's recommendations, NFPA 54, NFPA 90A, NFPA 90B, NFPA 91 and NFPA 211.

3.1.1 Suspensions of Equipment

Provide equipment supports including beam clamps, turnbuckles and twist links or weld-wire chains, wire ropes with rope clips and rope thimbles, threaded-eye rod hangers with lock nuts and heat-duct hangers, threaded-eye bolts with expansion screws, brackets, platform and mounting frame, and vibration isolators. Locate equipment in such a manner that working space is available for servicing, such as vacuum pump and burner removal, access to automatic controls, and lubrication. Provide electrical isolation of dissimilar metals. Clean interior of casings or cabinets before and after completion of installation.

3.1.2 Vents

NFPA 54 and NFPA 211. Provide vents with weatherproofing flashings in accordance with Section 07 60 00 FLASHING AND SHEET METAL.

3.1.3 Electrical Work

NFPA 70 and Division 26, "ELECTRICAL." When replacing original control wires, provide No. 16 AWG with minimum 105 degrees C insulation.

3.2 FIELD QUALITY CONTROL

Administer, schedule, and conduct specified tests. Furnish personnel, instruments and equipment for such tests. Correct defects and repeat the respective inspections and tests. Conduct inspections and testing in the presence of the Contracting Officer.

3.2.1 Test Instruments and Apparatus

Provide instruments and apparatus currently certified as being accurate to within one percent of their full scale. Use gages with a maximum scale between 1 1/2 and 2 times test pressure.

3.2.2 Field Inspection

Prior to initial operation, inspect equipment installation to ensure that indicated and specified requirements have been met.

3.2.3 Field Tests

3.2.3.1 Fuel Piping Pressure Tests

[Pneumatically test gas piping at 1 1/2 times operating pressure and check for leakage with soap solution.] [Hydrostatically test fuel oil piping at 1 1/2 times maximum working pressure.]

3.2.3.2 Fire Tests for Nonelectrical Heating Equipment

Test combustion controls and equipment with specified fuel at 100 percent full rated load. During tests, verify proper operation of controls. Adjust burners for maximum efficiency using Orsat or similar apparatus. Maintain firing for at least four hours [, and where high-low-off combustion controls are provided, operate the heating equipment for one hour at low fire and 3 hours at high fire]. For acceptable combustion efficiency, allow maximum 4.5 percent carbon dioxide in flue gases.

3.2.3.3 Insulation-Resistance Tests for Electrical Equipment

At the completion of wiring, test 600 volt wiring to verify that no short circuits exist before or after the attachment of electrical heating equipment to the power source. Make tests with an instrument which applies a voltage of approximately 500 volts for a direct reading of insulation resistance.

3.2.3.4 Operational Tests

After completing fire tests and insulation-resistance tests, operate equipment continuously under varying load conditions to verify functioning of combustion controls, electrical controls, flame safeguard controls, safety interlocks, and specified operating sequence. Run each test for a minimum period of one hour.

-- End of Section --

SECTION 23 82 16.00 40

AIR COILS
08/22

PART 1 GENERAL

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B43	(2020) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D2247	(2015) Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D3359	(2017) Standard Test Methods for Rating Adhesion by Tape Test

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 12944-9	(2018) Paints and Varnishes - Corrosion Protection of Steet Structures by Protective Paint Systems - Part 9: Protective Paint Systems and Laboratory Performance Test Methods for Offshore and Related Structure

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a

code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Record of Existing Conditions

SD-02 Shop Drawings

Fabrication Drawings; G[, [____]]

Connection Diagrams; G[, [____]]

Controls Layout; G[, [____]]

Internal Tubing and Wiring; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Steam Heating; G[, [____]]

Hot-Water Heating; G[, [____]]

Chilled-Water Cooling; G[, [____]]

Volatile Refrigerant Cooling; G[, [____]]

SD-05 Design Data

Design Analysis and Calculations

SD-06 Test Reports

Final Test Reports

SD-07 Certificates

Certificates of Conformance

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings

1.3 QUALITY CONTROL

Submit a record of existing conditions consisting of the results of a survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite.

Provide coils that bear the ARI certification seal indicating compliance with AHRI 410. Submit Certificates of Conformance for following items showing conformance with AHRI 410:

a. Coil

b. Coil casings

c. Coil headers

d. Coil tubing

e. Coil circuiting

Indicate the general physical controls layout, and internal tubing and wiring details on the drawings. Submit design analysis and calculations for coils.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit manufacturer's catalog data for the following coil types indicating, when applicable, coil pressure and temperature ratings, coil casings, headers, tubing, circuiting, and drainable coils.

a. Steam heating

b. Hot-water heating

c. Chilled-water cooling

d. Volatile refrigerant cooling

Submit fabrication drawings for coil units consisting of fabrication and assembly details to be performed in the factory. Include connection diagrams indicating the relations and connections of the following items:

a. Coil

b. Coil casings

c. Coil headers

d. Coil tubing

e. Coil circuiting

2.1.1 Coil Pressure and Temperature Ratings

Provide coils designed for the following fluid operating pressures and temperatures:

Service	Pressure (psi)	Temperature (Degrees F)
Steam - low pressure	25	267
Steam - high pressure	150	366
Steam - superheated	350	500
Hot water	200	250
Chilled water	200	45

Service	Pressure (psi)	Temperature (Degrees F)
Volatile refrigerant	200	300

Air-pressure test coils under water at the following minimum pressures:

Service	Pressure (psi)
Steam	250
Hot water	250
Chilled water	250
Volatile refrigerant	400

2.2 COMPONENTS

2.2.1 Coil Casings

Provide coil casings that are mill-galvanized, 16-gage, minimum. Ensure sheet metal has not less than 1.25-ounces of zinc per square foot of two-sided metal surface conforming to ASTM A653/A653M. Provide a casing flanged on four sides for bolted assembly, except as otherwise specified.

Where coils are stacked, provide a double-bend construction casing.

Provide casings with end supports and top and bottom channels of rigid construction that provide allowance for thermal expansion and contraction. Coil supports, channels and blank-off plates shall be the same metal as the coil casing.

Provide duct-mounted reheat coil casings not over 36-inches in length, fabricated from a minimum 20-gage galvanized steel conforming to above specified requirements. Provide casings that are flanged or suitable for drive-slip assembly.

Provide coil mounting within the housing that is either fixed or slide-out type, except as otherwise specified. Provide slide-out type coils for ceiling-suspended package units, and for other package units whose capacity exceeds 15,000 cubic-feet per minute.

2.2.2 Coil Headers

Provide direct expansion, volatile refrigerant coils with necessary control connections.

Fit steam and water coil headers with 1/4-inch iron pipe size(ips) spring-loaded plug drains and vent petcocks. Provide automatic vents where indicated.

2.2.3 Coil Tubing

Install coils constructed of copper tubing with aluminum or copper fins. Provide helical coil fins that are wound tight to the tubes and solder-coated. Provide plate fins that have spacer collars in metallic contact with the adjacent fin. Plate fins shall be continuous. Ensure fins are mechanically bonded to the tube. Ensure bare tube surface is not visible within the finned portion of the coil.

Provide solder-coated cooling coils of helical wound copper design.

For coil tubes in water or volatile refrigerant service, provide tubes that are parallel. Ensure coil tubes have sufficient intermediate full coil depth supports to prevent sagging of unsupported span due to: working fluid pressures, temperatures, and summer and winter coil-ambient conditions. Sagging is unacceptable if tube centerline is displaced by more than 3/16-inch from centerline of tube connection at outlet header when coils are more than two rows deep and when installed in accordance with the manufacturer's instructions. Make adequate provision for expansion and contraction that precludes sagging and distortion under thermal loads applied in indicated or specified service. Slope tubes to be free draining.

Provide maximum heating-coil face tube spacing of 3-inches on center for 1-inch outside-diameter (od) tubes, 2-inches for 3/4-inch od tubes, and 1-1/2-inches for 5/8-inch od tubes.

Provide coil face tube spacing for cooling coils and for helically wound heating coils immediately followed by water-cooling coils that do not exceed 1-1/2-inches on center.

Ensure tubes are straight, with turns made through headers or return U-bends, with brazed connections and joints, except as otherwise specified.

Ensure coil tube material is seamless deoxidized copper.

Ensure coil tube material is seamless 90-10 copper-nickel with 0.035-inch wall thickness for superheated-steam service to 350-pounds per square inch (psi) at 500 degrees F.

[Provide raw coil tube stock wall with a minimum thickness of 0.025-inch.]

[Provide raw coil tube stock wall with a minimum thickness of 0.035-inch.]

Where mechanical insert devices are used to increase liquid turbulence within tubes, increase the wall thickness of these tubes by 0.010-inch over the minimum raw coil tube stock specified for the service.

Provide minimum tube outside diameter of 1/2-inch.

2.2.4 Coil Circuiting

[Provide standard or full-circuited water coils that have as many full-length tubes in each circuit as the number of tubes in the depth of the coil face.][Provide double-circuit water coils that have twice as many tubes as standard coils.][Provide half-circuit water coils that have half as many tubes as standard coils and to the next larger whole number where odd numbers are involved.]

Provide counterflow type coils when more than two rows deep, except that in the case of double- or half-circuit coils, reasonable deviation from counterflow arrangement is permitted, provided the pressure drop and capacity requirements are met.

2.2.5 Drainable Coils

Provide drainable coils that are capable of being purged free of water with compressed air.

Provide self-draining coils with a drain point at the end of every tube and sloped to that point. Provide drain provisions that include: drained headers, U-bends with integral plugs; or nonferrous plugs in cast-iron headers. Provide tubes that drain substantially dry by gravity alone when drains and vents are open.

Where necessary, fill the coil with water to the end of the manufacturer's header connections and check drainage volume against the manufacturer's data.

2.2.6 Coil Types

2.2.6.1 Steam Heating

[For Type SA, provide steam distributing, tube-in-tube with multiple-orifice distributors. Provide a tube with a minimum outside-diameter of 1-inch wherever coil is exposed to airstream at freezing temperatures. For all other applications, provide a minimum outside-diameter of 5/8-inch. Provide tubes that are sloped 1/8-inch per foot, and coil casing that is level. Provide coil with inlet and outlet connections on the same side.

][For Type SB, provide tube-in-tube type, for reheat service, with modulating control. When located in ductwork over 6-feet in total width, provide either two separate coils or one coil with supply to both ends and a single return. Provide coil with inlet and outlet connections on the same end and on opposite sides of the two-coil assembly.

][For Type SC, provide single row, single circuit, for reheat service with two-position control.

][For Type SD, provide integral damper face and bypass type. Provide coil that includes finned elements with headers. Ensure return bends are pitched within the casing; and bypasses with interlocked dampers are controlled by a damper motor and airstream thermostats.

] Provide a maximum fin spacing of 10 per linear inch. Provide tubes that are connected to supply and return headers by mechanical joints and are secured against vibration by a channel that permits expansion and contraction. Provide 16-gage cold-rolled steel damper blades. Provide graphite-impregnated nylon damper rod bearings. Provide oil-impregnated bronze linkage bearings. Proportion air such that the average temperature at any point in a plane parallel to the coil face, 3-feet downstream of the leaving side, does not vary more than 5 degrees F from the thermostat setting. Vary pressure-drop of air passing through the coil no more than plus or minus 5 percent, regardless of the position of the internal dampers.

[Casings shall be minimum 16-gauge, galvanized steel.

][Casings shall be minimum 16-gauge, 304 stainless steel.

] Coil headers shall be cast iron with tubes expanded into headers, steel pipe with brazed tube connections, or heavy seamless copper with tubes brazed to header.

2.2.6.2 Hot-Water Heating

[For Type HA, provide continuous circuit type, limited to two rows depth.

][For Type HB, provide drainable counterflow type, with more than two rows.

][Casings shall be minimum 16-gauge, galvanized steel.

][Casings shall be minimum 16-gauge, 304 stainless steel.

] Coil headers shall be Type L seamless copper conforming to ASTM B88, with tubes brazed to header.

Coil connections shall be Schedule 40 red brass conforming to ASTM B43, threaded end for 2-inch and smaller and [flanged][grooved] end for 2-1/2-inch and larger.

2.2.6.3 Chilled-Water Cooling

[For Type CA, provide continuous circuit, drainable type, limited to two rows depth.

][For Type CB, provide self-draining, counterflow type.

][For Type CC, provide self-draining, cleanable, counterflow type. Provide straight-through type tubes, rolled or brazed into steel tube sheets. Enclose headers with gasketed and bolted removable cover plates to provide access to tube internals from either one end or both ends of coil.

] Casings shall be minimum 16-gauge, 304 stainless steel.

Coil headers shall be Type L seamless copper conforming to ASTM B88, with tubes brazed to header.

Coil connections shall be Schedule 40 red brass conforming to ASTM B43, threaded end for 2-inch and smaller and [flanged][grooved] end for 2-1/2-inch and larger.

Maximum allowable fin spacing shall be 10 fins per inch. Coil depth shall not exceed [8][10] rows to allow for the cleaning of the coil in place.

2.2.6.4 Volatile Refrigerant Cooling

[For Type DX, provide counterflow type, designed for use with refrigerant specified, with equal length circuiting arrangement. Provide the number of distributors that suit indicated refrigerant and that eliminate trapping of refrigerant and oil. Obtain coil capacity with an expansion valve set for not less than 8 degrees F of superheat. Provide a refrigerant distributor that is furnished and installed by the coil manufacturer. Provide a tube outside diameter that is either 5/8-inch or 3/4-inch.

] Coils shall be constructed of 1/2-inch OD min. seamless copper tubes with aluminum fins and tested at 250 psi prior to dehydration after which they are to be purged and sealed with inert gas prior to shipment.

Suction header shall be constructed of extra heavy seamless copper tubing.

Distributors shall be low pressure drop Venturi type design with male sweat connection to distribute refrigeration equally to multiple circuits.

[Provide refrigerant distributor that is suitable for the thermostatic expansion valve recommended by the manufacturer for the service and capacity specified or indicated. Ensure arrangement is capable of stable operation down to 40 percent or less of design capacity.

][Provide refrigerant distributor suitable for use with a balanced, double-ported thermostatic expansion valve or with a pilot-operated valve where indicated. Ensure arrangement is capable of stable operation down to 15 percent of design capacity.

]2.2.6.5 Corrosion Protection Coating

[Protective coil coating shall be baked phenolic epoxy. Coil and casing shall receive a uniform coating on all surfaces including fin edges. Coating shall be by full immersion or flow coating to film thickness of approximately 1.0 mil. Coating shall be formulated to mee 5B cross-hatch adhesion rating per ASTM D3359 on coil construction materials; aluminum, copper, steel stainless, galvanized, etc.. Coating shall provide corrosion protection in not less than 6,000 hour salt spray test in accordance with ASTM B117 and humidity resistance of not less that 2,000 hours per ASTM D2247. Coating shall meet ISO 12944-9 cyclical offshore standard. Coils subjected to direct ultraviolet (UV) exposure shall have a UV-resistant topcoat.

][Protective coil coating shall be a flexible cationic epoxy polymer electro-coating uniformly applied to all metallic surfaces with no material bridging between fins. Electro-coat process shall ensure complete encapsulation of conductive surfaces with uniform dry film thickness from 0.6-1.2 mils. E-coating shall meet 4B-5B rating from cross-hatch adhesion per ASTM D3359. Corrosion durability shall be confirmed through testing to no less than 6,000 hours salt spray resistance per ASTM B117 using scribed aluminum test coupons. After e-coat cure, coil shall receive spray-applied, 2K polyurethane black topcoat to prevent UV degradation of epoxy e-coat film.

] Coating shall not impact the heat transfer performance of the coil by more than 1 percent.

PART 3 EXECUTION

3.1 INSTALLATION

Install coils in accordance with the manufacturer's recommendations.

Submit installation drawings for coil systems. Indicate overall physical features, dimensions, ratings, service requirements, equipment weights and layout and arrangement details of equipment room on drawings.

Clean oil film from coil fins with hot water/detergent as recommended by coil manufacturer.

Comb out fins when bent or crushed before enclosing coils in housing. Clean dust and debris from each coil to ensure its cleanliness.

Provide offsets in piping and physical space adjacent to the installed coil to facilitate coil removal.

Provide flexible piping connections and/or piping vibration isolation supports where specified or shown.

[Provide where indicated cooling coils with 1-1/2-inch deep welded stainless steel drain pans. Drain pans shall be an integral part of the coil support. Provide condensate drain piping with drain traps to the indicated drain location.

]3.2 FIELD QUALITY CONTROL

For drainable coils:

a. Field check coil pitch and leveling for drainability in the presence of the Contracting Officer.

b. Perform pressure tests and dehydrate coils.

c. Perform vacuum tests, purge with inert gas, and seal coils.

Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

3.3 CLOSEOUT ACTIVITIES

3.3.1 Operation and Maintenance

Submit [6] [_____] copies of the operation and maintenance manuals 30 calendar days prior to testing the coil systems. Update and resubmit data for final approval no later than 30 calendar days prior to contract completion.

3.3.2 Record Drawings

Submit record drawings for coil systems providing current factual information including deviations from, and amendments to, the drawings and concealed and visible changes in the work.

-- End of Section --

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SECTION 23 82 19.00 40

FAN COIL UNITS
05/17

PART 1 GENERAL

[Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

][Section 26 60 13.00 40 LOW-VOLTAGE MOTORS applies to this section.

]1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.23 (1989; R 2016) Method for the Designation of Sound Power Emitted by Machinery and Equipment

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 440 (2008) Performance Rating of Room Fan-Coils

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1 (2003; R 2008) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A (2021) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-810 (2019; Rev H) Environmental Engineering Considerations and Laboratory Tests

UNDERWRITERS LABORATORIES (UL)

UL 1995 (2015) UL Standard for Safety Heating and Cooling Equipment

UL Bld Mat Dir (updated continuously online) Building

Materials Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Equipment and Performance Data; G[, [____]]

Coils; G[, [____]]

Casing; G[, [____]]

Enclosure; G[, [____]]

Motors; G[, [____]]

Fan; G[, [____]]

Drain Pans; G[, [____]]

Filters; G[, [____]]

Controls; G[, [____]]

Vibration Isolation; G[, [____]]

SD-04 Samples

Manufacturer's Standard Color Chart; G[, [____]]

SD-07 Certificates

List of Product Installations

Certificates of Conformance

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Warranty

1.3 QUALITY ASSURANCE

Submit a list of product installations for fan coil units showing a minimum of five installed units, similar to those proposed for use, that have been in successful service for a minimum of 5 years. Include the name of the purchaser, address of installation, name of service organization, and date of installation.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

[Include an enclosure for cabinet models and a casing for concealed models.

] Provide a base unit complete with galvanized casing, a water coil assembly with an auxiliary water or steam heating-coil, valve and piping package, drain pans, air filter, fan motor, and motor control. Ensure that the sound power level, as measured in decibels at 10 to the minus 12 watt at the fan operating speed selected to meet the specified capacity, does not exceed the following values at the midfrequency of each octave band:

OCTAVE BANDS					
	3rd	4th	5th	6th	7th
Frequency (hertz)	250	500	1,000	2,000	4,000
Power Level (decibels)	60	55	53	50	48

Obtain values for sound power level for these units in accordance with the test procedures specified in ASA S12.23. Sound power values apply to units provided with factory-fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models are acceptable for concealed models without the need for separate tests, provided there is no variation between models as to the coil configuration, blowers, motor speeds, and relative arrangement of parts. Fasten each unit securely to the building structure. Ensure that the capacity of the units is as indicated. Ensure that room fan coil units are certified as complying with AHRI 440 and meet the requirements of UL 1995.

2.2 COMPONENTS

Provide a list of material and equipment including the manufacturer's style or catalog numbers, specification and drawing reference numbers, and warranty information.

Submit fabrication drawings for fan coil units including the fabrication and assembly details performed in the factory.

Submit equipment and performance data for fan coil units including information on the service life, system functional flows, safety features, and mechanical automated details. Also submit curves indicating that the equipment response and performance characteristics, including vibration isolation have been tested and certified. Submit certificates of conformance for the following:

a. Enclosure

b. Casing

c. Fan

d. Coils

e. Drain Pans

f. Filters

g. Motors

h. Controls

Submit product data for vibration isolation components.

Submit the manufacturer's standard color chart, indicating the manufacturer's standard color selections and finishes for fan coil units.

2.2.1 Enclosure

Construct an enclosure of 18-gage or heavier steel, properly reinforced and braced. Ensure that the front panel of the enclosure is removable. Ensure that discharge louvers are four-way adjustable and are designed to properly distribute air throughout the conditioned space. Ensure that ferrous surfaces are galvanized or treated with a rust-inhibiting finish. Ensure that exposed enclosure corners and edges are rounded. Ensure that discharge louvers are mounted in a top panel that can be removed to allow for coil cleaning. Ensure that access doors are hinged and provided for all piping and control compartments. Ensure that the finish is in the manufacturer's standard color, as selected by the Contracting Officer.

2.2.2 Casing

Ensure that the interior of the casing is acoustically and thermally insulated with insulation that is not less than 1/2-inch thick, that conforms to NFPA 90A, and that is fastened with waterproof and fire-resistant adhesive.

2.2.3 Fan

Provide a centrifugal fan made of galvanized steel or aluminum, with [_____] blades. In lieu of metal, fabricate or mold the wheels and scrolls from reinforced nonmetallic compounds certified to have passed the low-temperature, high-temperature, temperature-shock, and sand and dust tests for ground equipment, as outlined in MIL-STD-810. Ensure that the fan passes tests without showing characteristics that indicate deformation, cracking, corrosion, or loss of balance. Ensure that surfaces are smooth, that assemblies are accessible for maintenance, and that disassembly and reassembly are done by mechanical fastening devices, not adhesives. After the fan is assembled in the unit, ensure that the fan was dynamically and statically balanced to ISO 1940-1 standards at the factory.

2.2.4 Coils

Ensure that the water coil was constructed with not less than 1/2-inch outside diameter (OD) seamless copper tubing with copper or aluminum plate fins mechanically bonded or soldered to the tubes. Ensure that the coil construction includes at least 5/8-inch OD female solder connectors, an accessory piping package with terminal connections for control valves, and manual air vents on returns. Make provisions for coil removal.

2.2.5 Drain Pans

Size and locate drain pans to collect condensed water dripping from any item within the unit enclosure. Do not construct drain pans of [galvanized steel] [stainless steel] [plastic] [_____] that is lighter than 20-gage and thermally insulated to prevent condensation. Coat the thermal insulation with a waterproofing compound. Provide a copper drain connection in the drain pan that is no less than 3/4-inch National Pipe Thread (NPT) or 5/8-inch OD. Ensure that the drain pan slopes not less than 1/8-inch per foot to the drain.

2.2.6 Filters

For each unit, provide filters that are glass fiber throwaway or permanent and washable, with a 1 inch nominal thickness, in conformance with UL Bld Mat Dir. Ensure that filters can be removed without tools.

2.2.7 Motors

Provide permanent split-capacitor motors that are direct connected, two-bearing, and built-in overload protection, and that conform to NEMA MG 1. Mount motors on a resilient base. Furnish motors with three built-in speeds and with four insulated leads (common, high, medium, and low) that terminate in a control-junction box.

When specified, provide a solid-state variable speed controller capable of not less than 50 percent speed reduction in lieu of step speed control.

2.2.8 Controls
[
Ensure that applicable requirements of Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC .

] Provide a unit with factory-installed control valves furnished by the automatic temperature-control manufacturer.

Ensure that the motor speed-control switch provides for speed selection, has an off position, and is mounted for convenient use from an access door.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment in accordance with the manufacturer's recommendations. Set the dampers in a fixed position to provide outside air in the quantity scheduled.

Submit installation drawings for fan coil systems in accordance with referenced standards in this section.

Contain thermal and acoustical insulation within a double-walled enclosure or seal the insulation with a moistureproof coating impervious.

Install the controls in a unit-mounted control panel. Provide remote-mounted controllers where indicated.

3.2 FIELD QUALITY CONTROL

Hydrostatically the test coils at 250 pounds per square inch (psi) or under water at 250 psi air pressure. Ensure that the coils are suitable for 200 psi working pressure.

3.3 CLOSEOUT ACTIVITIES

Submit [six] [_____] copies of the operation and maintenance manuals at least 30 calendar days before the fan coil units are tested. Update and resubmit data for final approval no later than 30 calendar days before contract completion.

Submit the manufacturer's standard warranty to the Contracting Officer.

-- End of Section --

SECTION 23 82 23.00 40

UNIT VENTILATORS
05/17

PART 1 GENERAL

[Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

]1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.11/Part 1	(2013) Acoustics-Measurement of Noise and Vibration of Small Air-Moving Devices, Part 1: Airborne Noise Emission
ASA S12.11/Part 2	(2013) Acoustics-Measurement of Noise and Vibration of Small Air-Moving Devices, Part 2: Structure-borne Vibration
ASA S12.53/1	(2011; R 2016) Acoustics- Determination of Sound Power Levels of Noise Sources - Engineering Methods for Small, Movable Sources in Reverberant Fields - Part1: Comparison Method for Hard-Walled Test Rooms
ASA S12.53/2	(1999; R 2015) Acoustics- Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Engineering Methods for Small, Movable Sources in Reverberant Fields - Part2: Methods for Special Reverberation Test Rooms

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 840 I-P	(2015) Performance Rating of Unit Ventilators

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z83.8/CSA 2.6	(2016; R 2021) Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-Fired Duct Furnaces

ASTM INTERNATIONAL (ASTM)

ASTM A568/A568M	(2019a) Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

INTERNATIONAL CODE COUNCIL (ICC)

ICC IFGC	(2021) International Fuel Gas Code
ICC IMC	(2018) International Mechanical Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD-G-24508	(1977; Rev A; Am 4 1998) Grease, High Performance, Multipurpose (Metric)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture List; G[, [____]]

List of Product Installations; G[, [____]]

SD-02 Shop Drawings

Electrical Diagrams; G[, [____]]

Pneumatic Diagrams; G[, [____]]

SD-03 Product Data

Gas Unit Heaters; G[, [____]]

Propeller Unit Heaters; G[, [____]]

Cabinet Unit Heaters; G[, [____]]

Unit Ventilators; G[, [____]]

Casing; G[, [____]]

Heat Exchangers; G[, [____]]

Burners; G[, [____]]

Fans; G[, [____]]

Motors; G[, [____]]

Controls; G[, [____]]

Vertical Discharge Units; G[, [____]]

Horizontal Discharge Units; G[, [____]]

Heating Element; G[, [____]]

Propellers; G[, [____]]

Filters; G[, [____]]

Enclosures; G[, [____]]

Wall Sleeve; G[, [____]]

Fresh-Air Intakes; G[, [____]]

Insulation; G[, [____]]

Vibration Isolation; G[, [____]]

SD-04 Samples

Color Chart; G[, [____]]

SD-05 Design Data

Connection Diagrams; G[, [____]]

Control Diagrams; G[, [____]]

SD-07 Certificates

Records of Existing Conditions; G[, [____]]

Spare Parts List

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings; G[, [____]]

Warranty

1.3 QUALITY CONTROL

Provide a list of product installations that identifies at least five units, similar to those proposed for work, that have been in successful service for a minimum of 5 years. Provide a list that includes the name of the purchaser, address of installation, name of service organization, and date of installation.

1.4 PROJECT/SITE CONDITIONS

Submit records of existing conditions including the results of a survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work constitutes acceptance of existing conditions.

PART 2 PRODUCTS

2.1 SYSTEM DESIGN

Ensure that units are tested and certified in accordance with AHRI 840 I-P.

Provide control diagrams that show physical and functional relationships of equipment. Provide electrical diagrams that show size, type, and capacity of the systems. Submit pneumatic diagrams for air and gas systems.

Submit connection diagrams indicating the general physical layout of all controls, and internal tubing and wiring details on the drawings.

Submit equipment and performance data for [Gas Unit Heaters][Propeller Unit Heaters][Cabinet Unit Heaters][Unit Ventilators], consisting of use life, system functional flows, safety features, and mechanical automated details. Submit curves indicating the responses and performance characteristics of the tested and certified equipment.

Submit product data for vibration isolation components.

2.2 MANUFACTURED UNITS

Provide a material, equipment, and fixture list that includes the manufacturer's style or catalog numbers, specification and drawing reference numbers, and warranty information.

Submit the manufacturer's standard color chart for [Gas Unit Heaters][Propeller Unit Heaters][Cabinet Unit Heaters][Unit Ventilators], showing the manufacturer's standard color selections and finishes.

Submit a spare parts list and information meeting referenced standards within this section.

2.2.1 Gas Unit Heaters (GUH)

Provide drawings or schedules that include capacity, gas data and mounting height.

2.2.1.1 Type

Provide suspended unit heaters, arranged for discharge of air as indicated. Provide a unit that complies with ANSI Z83.8/CSA 2.6 and NEMA MG 1.

2.2.1.2 Casing

Provide a casing that is manufactured of at least 20-gage steel. Provide a casing with a phosphate pretreatment, primer, and baked enamel finish inside and outside. Provide horizontal [adjustable] [non-adjustable] louvers, completely recessed inside the casing frame.

[Provide [four-way] [_____] deflection vanes.

]2.2.1.3 Heat Exchangers

Provide welded, heavy aluminized-steel heat exchangers. Provide exchangers that are formed in a clamshell design that completely surrounds the burner. Provide individual combustion chambers for each burner.

2.2.1.4 Burners

Provide die-formed, aluminum-painted, heavy mild steel burners with long slot ports for an even supply of gas. Provide a unitized-construction burner assembly with an integral crossover for positive burner ignition. Provide a draft diverter as an integral part of each heat exchanger section to allow backdrafts to bypass the burner assembly without affecting normal operation.

2.2.1.5 Fans

Provide propeller fans, designed and manufactured for unit heater application. Provide fans with at least three aluminum blades.

2.2.1.6 Motors

Provide motors that are totally enclosed, with built-in overload protection. Mount motors to the back panel by a fan guard motor mount constructed of spring steel wire.

2.2.1.7 Controls

Provide controls that include a high-limit switch, fan controls [including a fan timer, a lockout timer [_____]], a 24-volt automatic gas valve with a 100 percent safety pilot shutoff, a pressure regulator with a leak-limiting device, and manual main and pilot valves. Provide an integral junction box for all power and control connections.

[Provide a low-voltage transformer.] [Provide a spark ignition controller.]

2.2.2 Propeller Unit Heaters (PUH) Hot Water and Steam

Provide drawings or schedule that include data on the capacity, heating media data and mounting height.

[2.2.2.1 Type

Provide suspended unit heaters, arranged for discharge of air as indicated.

]2.2.2.2 Vertical Discharge Units

[Provide vertical discharge units that operate at speeds up to 1,200 revolutions per minute (rpm), with the exception of units with an output of 50,000 British thermal units per hour or less which may operate at speeds up to 1,800 rpm. Cover the discharge opening with a fan guard.
]
[Provide louver cone diffusers.] [Provide adjustable vane diffuser.]

[2.2.2.3 Horizontal Discharge Units

Provide a maximum volume for horizontal discharge unitsin cubic feet per minute (cfm)and face velocity in feet per minute (fpm) as follows:

Volume (cfm)	Velocity (fpm)
Up to 1,000	800
1,001 to 3,000	900
3,001 and over	1,000

Provide adjustable double-deflection louvers.

]2.2.2.4 Heating Element

Provide heating elements of the manufacturer's standard construction, rated for [standard] [low output temperature] service of not less than 300 degrees F at 75 pounds per square inch (psi).

2.2.2.5 Casings

Provide casings with smoothly contoured propeller orifice rings constructed of cold-rolled carbon steel that is 20-gage or thicker. Provide casing surface finish that includes a phosphate pretreatment, prime coat, and baked enamel finish.

2.2.2.6 Propellers and Motors

Provide propellers that have at least four aluminum blades and that are dynamically balanced.

[Provide horizontal discharge units with a fan inlet safety guard.

][Mount motors on elastomer vibration isolators.

][2.2.2.7 Sound Rating

Test and sound-rate unit heater in accordance with ASA S12.11/Part 1, ASA S12.11/Part 2, ASA S12.53/1, and ASA S12.53/2.

][2.2.2.8 Control

Control unit heaters [by line-voltage thermostats] [_____].

]2.2.3 Cabinet Unit Heaters (CUH)

Provide drawings or schedules that include capacity, power rating, heating media, filter, pressure drop, size, and other pertinent data.

2.2.3.1 Type

Provide quiet-operating cabinet unit heaters, complete with heating elements, fans and drives, filters, baffles and division walls, control provisions, and enclosures with access panels.

Provide cabinets that do not exceed the dimensions given in the drawing.

Provide unit pressure components rated for service to at least 150 psi at the system working temperature.

2.2.3.2 Heating Element

Provide a [manufacturer's standard aluminum finned] [serpentine copper tube] heating element that can be drained and vented.

Provide a heating element with a constant and permanent cataloged capacity.

Construction uses seamless deoxidized copper tube material.

Provide fins that are mechanically connected to the tubes. Regard loose fins as causing a reduction in capacity at operating temperatures, requiring replacement of all such material at no additional cost to the Government. Elements with bent or damaged fins are not acceptable.

Make provisions for expansion and supports so that the element movement is strainfree and noiseless.

[Provide a coil with a face area of the coil no smaller than the dimensions specified on the drawings.

]2.2.3.3 Fan and Drive Assembly

[Provide a centrifugal, forward-curved, double-width, double-inlet fan, that has been statically and dynamically balanced at the factory.

][Provide direct fan drives.

][Provide direct fan drives, except where belt drives are indicated. Provide belt-drive motors that are fitted with adjustable rails and asheave that permits a 20-percent adjustment to the fan speed. Elastomer mount independent fan shafts in self-aligning [antifriction] [sleeve-type] bearings, with lifetime lubrication.

][Provide [two] [three] [four]-speed drives. Provide switch positions that include an off position.

] [Provide rotating elements that are statically and dynamically balanced.

Vibration-isolate the fan and drive assembly.] Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration-isolation considerations.

Ensure that the direct-drive motor's rotational speed does not exceed 1,200 rpm.

2.2.3.4 Filters

Provide replaceable, throwaway filters that are at least 1 inch thick.

Install filters in a bypass-proof frame to ensure that the moving air is filtered before entering the heating element. Ensure that filters can be removed without tools.

2.2.3.5 Enclosures

[Provide an enclosure configuration that does not deviate from drawing specifications.

][Provide an enclosure made of cold-rolled carbon steel, 16-gage, or heavier, that is conforming to ASTM A568/A568M. Provide construction that has smooth, blemish-free surfaces, without sharp edges, and with flush joints. Do not provide construction with wrinkled-metal or notched-corners. Provide an enclosure that has space for all riser pipes and controls. Provide access doors that have tamperproof latches, hinge doors, and panels to protect surface finishes and personnel.

][Provide a surface finish for the enclosure that includes the manufacturer's standard phosphate pretreatment, prime coat, and baked enamel finish. Provide the color selected by the Contracting Officer.

][2.2.3.6 Insulation

Insulate backs of recessed units with at least 1/2 inch of 3 pound per cubic foot fibrous-glass insulation conforming to NFPA 90A.

]2.2.3.7 Control Cycle

[Sequence the operation [in accordance with the manufacturer's recommendations] [_____].

][Provide control components that conform to the requirements in Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC.

]2.2.4 Unit Ventilators (UV)

Provide drawings or schedule that include capacity, power rating, heating duty and method, and other pertinent data.

2.2.4.1 Type

[Provide quiet-operating modular unit ventilators, complete with heating elements, fans and drives, filters, baffles and division walls, dampers, control provisions, and enclosures with access panels.

][Provide unit pressure components that are rated for service to at least 150 psi at system working temperature.

][Ensure that intercomponent wiring conforms to NFPA 70. Ensure that the components of the unit assembly are UL-listed and approved.

][Provide heating, fan, and control modules that have polarized, color-coded, plug-in connections.

]2.2.4.2 Heating Element

[Provide a [manufacturer's standard aluminum finned,] [serpentine copper-tube,] heating element that can be drained and vented.

][Provide a heating element with constant and permanent cataloged capacity.

][Provide a heating element made of seamless deoxidized copper tube.

][Mechanically connect the fins to the tubes. Regard loose, bent, or damaged fins as causing a reduction in capacity at operating temperatures, and replace all loose, bent, or damaged fins at no additional cost to the Government. Do not provide elements with loose, bent or damaged fins.

][Make provisions for expansion and supports so that the element can be moved without strain or noise.

][Provide a coil with a face area that is no smaller than the dimensions specified in the drawing.

]2.2.4.3 Fan and Drive Assembly

Provide a centrifugal, forward-curved, double-width, double-inlet fan that has been is statically and dynamically balanced.

[Provide belt-driven fans, mounted on a common shaft. Support the shaft by independent, elastomer-mounted, self-aligning, antifriction or sleeve bearings with lifetime lubrication. Provide an adjustable motor sheave that can vary in speed by at least 20-percent in either direction from the capacity point. Provide adjustable belt tension.

][Provide a motor that is manually controlled by a two-position on/off switch.
][
Provide a motor that is manually controlled by a [three] [four]-position switch.
]
Provide split-capacitor motors with elastomer vibration isolation mounts and with an adjustable rail mounting.

2.2.4.4 Filters

Provide replaceable, throwaway filters that are at least 1 inch thick.

Install filters in a bypass-proof frame to ensure that moving air is filtered before entering the heating element. Ensure that filters can be removed without tools.

2.2.4.5 Dampers

Provide opposed-blade dampers constructed to resist salt air. Provide galvanized steel blades, that [are mechanically attached,] [have secure sealing provisions,] and are not dependent upon adhesives. Provide high-grade commercial-quality flanged bearings with an extended race, corrosion-resistant steel balls, and [plated races] [heat-treated carbon steel] construction with factory-applied grease conforming to DOD-G-24508, suitable for salt air exposure. Provide oil-impregnated bronze sleeve bearings.

[Provide a face and bypass damper with an external bypass duct if required by the unit.

][Provide mixing dampers as an assembly within a mixing box. Provide dampers that can vary the mixed air in any proportion from 100 percent room air to 100 percent outside air.

]2.2.4.6 Enclosures

[Provide an enclosure configuration in accordance with the manufacturer's recommendations.

][Provide an enclosure made of cold-rolled carbon steel 16-gage or heavier conforming to ASTM A568/A568M. Provide construction that has smooth, blemish-free surfaces, without sharp edges, and with flush joints. Form and brace the enclosure to ensure that surfaces are plane and have no oilcan effect. Do not provide construction with wrinkled metal or notched corners. Provide pencilproof venetian louvers. Provide louvers that are constructed of metal and, when in normal position, can sustain a distributed load of up to 200 pounds. Provide an enclosure that has space for all riser pipes and controls. Provide access doors that have tamperproof latches.

][Use [heavy coatings] [non-corroding materials] to protect the internal surfaces of the enclosure that are exposed to condensation and salt air Do not provide flash chrome plating or cadmium plating.

][Provide a surface finish for the enclosure that includes the manufacturer's standard phosphate pretreatment, prime coat, and baked enamel finish. Provide the color selected by the Contracting Officer.

]2.2.4.7 Wall Sleeve

Provide a wall sleeve made of galvanized carbon steel not less than 18-gage pr heavier, with a commercial zinc weight conforming to ASTM A653/A653M. Provide a finish that consists of manufacturer's standard galvanized surface preparation and at least [two finish coats of baked enamel] [one finish coat of high-build epoxy]. Provide the color selected by the Contracting Officer.

2.2.4.8 Thermal and Acoustic Insulation

Provide insulation to prevent heat loss, heat gain, and condensation. Provide an acoustic treatment for surfaces.

2.2.4.9 Control Cycle

[Sequence the operation in accordance with the manufacturer's recommendation's.

][Provide control components that conform to the requirements in Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC.

]2.2.4.10 Fresh Air Intakes

Provide extruded-aluminum intake louvers with 16-gage, 1/2 by 1/2 inch mesh aluminum wire birdscreens for all fresh-air intakes. Provide extruded aluminum that has undergone caustic etching and been given a 0.5 micrometer anodic coating in accordance with AA DAF45. Use elastomeric seals to protect aluminum from dissimilar metals and the causticity of concrete or mortar. Provide an intake that is compatible with the penetration used in the building construction.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Equipment

Install equipment in accordance with the manufacturer's recommendations.

3.1.2 Gas Piping

Install gas piping in compliance with ICC IFGC, NFPA 54, Section 23 11 20 FACILITY GAS PIPING and Section 33 51 15 NATURAL-GAS / LIQUID PETROLEUM GAS DISTRIBUTION.

3.1.3 Combustion Air

Provide combustion air in compliance with ICC IMC.

3.1.4 Location

Install heaters in compliance with the clearance and mounting height requirements of ICC IFGC and NFPA 70.

3.1.5 Venting

Provide heaters that are vented in compliance with NFPA 54, ICC IMC, and ICC IFGC.

3.2 FIELD QUALITY CONTROL

Conduct operational tests in accordance with the manufacturer's instructions.

3.3 CLOSEOUT ACTIVITIES

Submit record drawings with current information on deviations from, and amendments to the drawings and concealed and visible changes in the work.

Submit [six] [_____] copies of the operation and maintenance manuals at least 30 calendar days before the system is tested.

Submit the manufacturer's warranty to the Contracting Officer.

Update and resubmit data for final approval at least 30 calendar days before contract completion.

-- End of Section --

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SECTION 23 82 43.00 40

ELECTRIC DUCT HEATERS
05/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

UNDERWRITERS LABORATORIES (UL)

UL 1996	(2009; Reprint Sep 2021) UL Standard for Safety Electric Duct Heaters

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Preinstallation Meetings

The Contracting Officer will schedule a preinstallation meeting within [30][_____] days of Contract Award. Provide the following for review and approval:

a. Submit fabrication drawings for duct heaters, consisting of fabrication and assembly details to be performed in the factory.

b. Submit manufacturer's instructions for duct heaters, including installation drawings showing any special provisions required to install equipment components and system packages. Clearly note impedances, hazards and safety precautions.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings

Installation Drawings; G[, [____]]

SD-03 Product Data

Performance Data; G[, [____]]

Duct Heaters; G[, [____]]

Heating Elements; G[, [____]]

Enclosures; G[, [____]]

Controls; G[, [____]]

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide duct heaters with the capacity indicated, plus or minus 5 percent. Ensure that duct heaters are factory-prewired and ready for field terminal connections.

Ensure that duct heaters conform to the requirements of UL 1996.

[Base capacity on [_____] [60] degrees F entering air and [_____] [85]-degree F discharge air at [_____] [300] cubic feet per minute.

]2.1.1 Performance Requirements

Submit performance data for duct heaters, including use life, system functional flows, safety features, and mechanical automated details.

2.2 COMPONENTS

2.2.1 Heating Elements and Enclosures

Install heating elements with a framework complete with terminal, and construct junction boxes of mill-aluminized or galvanized carbon steel. Provide with a magnetic contactor in a separate enclosure insulated from the duct at the duct heater location or at a separate, remote location.

Ensure that all gasketing is 1/16-inch thick, nonasbestos woven-cloth tape, with a flange depth suitable for the duct insulation provided. Insulate the terminal junction box to prevent elevated temperatures.

[Provide a sheathed heating element consisting of a resistance wire insulated by highly compacted refractory insulation protected by a sealed metallic-finned sheath. Provide component materials as follows:

a. Resistance wire - helix-wound alloy approximately 80 percent nickel and 20 percent chromium.

b. Refractory insulation - magnesium oxide. Subject the element to a dielectric test of twice the element rated voltage plus 1,000 volts applied between the terminal and the sheath for a period of 1 minute.

c. Sheathing - aluminum fins cast around an internal steel sheath containing refractory insulation and resistance wire or carbon-steel fins permanently attached to a tubular carbon-steel or corrosion-resistant steel sheath containing refractory insulation and resistance wire and with all external surfaces porcelainized.

d. Wattage density cannot exceed 90 watts per linear inch of heated element length or not greater than 22 watts per square inch.

]

[Provide an open heating element consisting of a helix-wound resistance wire alloy approximately 80 percent nickel and 20 percent chromium. Wattage density is not to exceed 50 watts per linear inch of heated element. Ensure that the element support minimizes abrasion and sagging. Provide safety screens on both the upstream and downstream sides of the heater elements.

Provide dummy elements or include other provisions similar to open-area perforated screens if required to uniformly distribute airflow across the heater face.

]2.2.2 Controls

Provide units with integral overheat cutouts for primary and secondary protection, with a disk-type automatic-reset primary cutouts suitable for 277-volt, 60-hertz service.

[Provide a disk-type manual-reset secondary cutouts wired in series with each circuit.

][Provide bulb-type manual-reset secondary cutouts that actuate integral magnetic backup contactors.

][Provide bulb-type manual-reset secondary cutouts that de-energize each circuit directly.

] Provide indicating lights to show:

a. Heater on

b. Each circuit on

[Locally provide a pilot switch to cut off the heater through integral magnetic contactors.

] For heater assemblies rated at 45 amperes and larger, provide a heater assembly that is subdivided and fused. Fuse each subdivided 45-ampere heater load section. In circuits of less than 45 amperes, fuse appropriate sections.

Provide UL-approved magnetic contactors, (other than integral overheat-cutout associated units), and remotely locate as indicated.

[Provide step controllers for sequencing heater loads of UL-approved components, and include the following:

a. A delay to prevent line surge when energizing loads

b. Individual fusing of each step

c. Intercomponent wiring to terminals for a field connection cabinet

][Provide [single-] [two-] [three-] stage, wall-mounted thermostats.

][Provide thermostats complete with thermometer, mechanical high-limit stop, calibrated operator, and an adjustable heater to prevent override of space temperature. Ensure that the range is between 55 and 105 degrees F, with differential not to exceed 1.5 degrees F, rated for operation at 24 volts, 60 hertz. Provide any necessary transformers, wiring, and devices to meet this requirement. Finish cases in brushed or satin chrome.

]
[Provide control of power to the unit by a UL-listed solid-state silicon-controlled rectifier (SCR) system such that voltage is continuously impressed and varied in minute increments over a range of zero to [the rated voltage] [105 percent of the rated voltage].

]PART 3 EXECUTION

3.1 INSTALLATION

Install duct heaters in accordance with the manufacturer's instructions, and locate duct heaters to permit access to the heater after installation.

[Install [status point][temperature probe] routed to the building controller to indicate when the unit is in heating mode.

][For duct heaters inside a VAV, display the fan status at the building controller.

]3.2 FIELD QUALITY CONTROL

Demonstrate that duct heaters operate satisfactorily in the presence of the Contracting Officer.

Conduct an operational test for a minimum of [6] [_____] hours.

Cycle duct heaters five times, from start to operating thermal conditions to off, to verify adequacy of construction, system controls, and component performance.

-- End of Section --

SECTION 23 82 46.00 40

ELECTRIC UNIT HEATERS
05/17

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

UNDERWRITERS LABORATORIES (UL)

UL 1996	(2009; Reprint Sep 2021) UL Standard for Safety Electric Duct Heaters

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Preinstallation Meetings

The Contracting Officer will schedule a preinstallation meeting within [30] [_____] days of Contract Award. Provide the following for review and approval:

a. Submit fabrication drawings for electric heaters, indicating the fabrication and assembly details to be performed in the factory.

b. Submit manufacturer's instructions for electric heaters, stating the special provisions necessary to install equipment components and system packages. Detail the impedances, hazards and safety precautions within the special notices.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings

SD-03 Product Data

Performance Data; G[, [____]]

Electric Unit Heaters; G[, [____]]

Heating Element; G[, [____]]

Controls; G[, [____]]

Casings; G[, [____]]

Propellers and Motors; G[, [____]]

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide suspended electric unit heaters, and arrange for the discharge of air as indicated.

Provide electric unit heaters with at least the indicated capacity and ensure that they conform to the requirements specified herein. Ensure that the electric unit heaters are factory-prewired and ready for field terminal connections.

Ensure products conform to the requirements of UL 1996 for electric unit heaters.

Submit performance data for electric heaters, including use life, test, system functional flows, safety features, and mechanical automated details.

2.2 COMPONENTS

2.2.1 Heating Element

Provide a heating element constructed of a resistance wire insulated by highly compacted refractory insulation protected by a sealed metallic-finned sheath. Provide component materials as follows:

a. Provide a resistance wire of not less than 20-helix wound alloy of approximately 80-percent nickel and 20-percent chromium.

b. Provide a refractory insulation of magnesium oxide with a resistance of not less than 50,000 ohms after exposure to an ambient temperature and humidity of 90 degrees F and 85 plus or minus 5-percent relative humidity, respectively, for not less than 24 hours.

c. Provide a sheathing consisting of aluminum fins cast around an internal steel sheath containing refractory insulation and resistance wire or carbon-steel fins permanently attached to a tubular carbon-steel sheath containing refractory insulation and resistance wire and with external surfaces porcelainized.

[Ensure that the maximum surface temperature of porcelain-protected steel sheathing is [700] [_____] degrees F.

][Ensure that the maximum surface temperature of cast-aluminum sheathing is [500] [_____] degrees F.

]2.2.2 Controls

[Fit units up to and including 5 kilowatts with integral controls, including thermal overload cutout switches, necessary transformers, a liquid-vapor system, and low-mass bimetal thermostat as required. Provide a cutout switch that can be automatically reset.

][Provide the unit with a remote unfused disconnect switch that opens ungrounded conductors in the OFF position and a thermostat with integral controls, including thermal overload cutout switches, magnetic contactors, necessary transformers, and thermostat protection as required. Provide cutout switches that can be automatically reset.

] Provide wall-mounted thermostats complete with thermometer, mechanical high-limit stop, calibrated operator, and an adjustable heater to prevent override of space temperature with a range between 55 and 105 degrees F and a differential not exceeding 1.5 degrees F. Provide a thermostat rated for operation at 24 volts, 60 hertz. Provide transformers, wiring, and devices necessary to meet this requirement. Provide a casing finish in [brushed chrome] [satin chrome] [_____].

2.2.3 Propellers and Motors

Provide propellers with[mill-aluminized][galvanized-steel][all-aluminum] blades statically and dynamically balanced to within 0.5 percent. Provide units with fan-inlet safety guards.

Ensure that propellers and motors are AMCA-certified for air performance and noise level.

Protect motors against damage by the heating element and resilient mount.

Ensure that propellers and motors conform to Section 26 60 13.00 40 LOW-VOLTAGE MOTORS for motors, except that load-matched and custom-designed motors may be used and be so identified on the shop drawings. For motors not so identified, conform to the requirements specified.

Subfractional and fractional custom-designed or applied motors may deviate from the preceding motor requirements as follows:

a. Shaded-pole motors rated less than 1/6 horsepower may be used for direct-drive service.

b. Permanent split-capacitor, split-phase, and capacitor-start motors rated 1/4 horsepower or less may be used for direct-drive service.

c. Split-phase and capacitor-start motors, rated 1/4 horsepower or less, may be used for belt-drive service.

d. Motor bearings may be the manufacturer's standard prelubricated sleeve type but provide the motor with antifriction thrust bearings, when specified. Ensure that the lubricant provisions are for extended service, requiring replenishment not more than twice per year of continuous operation.

Provide the manufacturer's standard motor identification plate.

Provide the manufacturer's standard motor speed and control.

PART 3 EXECUTION

3.1 INSTALLATION

Install unit heaters in accordance with the manufacturer's instructions at the mounting heights indicated.

3.1.1 Casings

Provide casings with smoothly contoured propeller orifice rings of at least 20-gage cold-rolled carbon steel. Provide a casing surface finish with phosphate pretreatment, prime coating, and baked-enamel finish.

3.1.2 Air Distribution

[Fit vertical discharge units with louver-cone diffusers.

][Provide horizontal units with adjustable single- or double-deflection louvers.

]3.2 FIELD QUALITY CONTROL

Demonstrate in the presence of the Contracting Officer that the unit heaters operate satisfactorily.

Cycle unit heaters five times, from start to operating thermal conditions to off, to verify adequacy of construction, system controls, and component performance.

Conduct an operational test for a minimum of 6 hours.

-- End of Section --

SECTION 23 83 00.00 20

ELECTRIC SPACE HEATING EQUIPMENT
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA DC 3	(2013) Residential Controls - Electrical Wall-Mounted Room Thermostats
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1025	(1980; R 1990, Bul. 1991) Electric Air Heaters
UL 1042	(2009; Reprint Feb 2021) UL Standard for Safety Electric Baseboard Heating Equipment

1.2 GENERAL REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heater Installation Drawing

SD-03 Product Data

Electric [Unit][and][Cabinet] Heaters

Electric [Baseboard] [Sill] [Pedestal] Units

[Electric Infrared Heater

] Thermostat

Unit Thermostat

[Infrared Heater Thermostat

] SD-10 Operation and Maintenance Data

Electric [Unit][and][Cabinet] Heaters, Data Package 5

Electric [Baseboard] [Sill] [Pedestal] Units, Data Package 5

[Electric Infrared Heater, Data Package 5

] Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

PART 2 PRODUCTS

2.1 ELECTRIC [UNIT][AND][CABINET] HEATERS

UL 1025; wattage, voltage, phase, number of steps, Btu/hr and CFM as indicated. Provide control-circuit terminals and single source of power supply. Heaters 5 Kw and larger shall be 3-phase, with load balanced on each of the three phases. Limit leaving air temperature to 140 degrees F with entering air of 60 degrees F.

[2.1.1 Enclosure

Minimum [20] [_____] gage steel.

]2.1.2 Heating Element

Nickel chromium heating wire element, free from expansion noise and 60 Hz hum. Embed element in magnesium-oxide insulating refractory. Seal element in high-mass steel or corrosion-resisting metallic sheath with fins. Enclose element ends in terminal box. Provide not more than six fins per inch. Limit fin surface temperature 550 degrees F at any point during normal operation.

2.1.3 Controls

Include limit controls for overheat protection of heaters. For remote thermostatic operation, provide contactor rated for 100,000 duty cycles.[Provide a control transformer to supply 120-volt thermostat control circuit for each heater.]

2.1.4 Wiring

Completely factory-prewired to terminal strips, ready to receive branch circuit and control connections for 140 degrees F [copper][or][aluminum] wiring.

[2.1.5 Accessories

Provide fan switching devices to independently operate the fan motor for summer ventilation and winter heat recovery.

]2.1.6 Thermostat

Provide tamper resistant [integral] [space] thermostat, adjustable without requiring removal of heater components. Thermostat operating range shall be approximately 50 degrees F to a maximum of [75] [_____] degrees F with operating differential of 3 degrees F or less.

2.1.7 Disconnect Means

Provide factory-installed safety disconnect switch [in the housing or in an auxiliary matching control section] [in combination with thermostat] with "off" position marking on the face plate.

[2.1.8 Outdoor Sensor

Provide outdoor sensor with sunlight-and-rain protection shield. The sensor shall provide a positive heater shut off when outdoor air temperature is 65 degrees F or higher.

]2.2 ELECTRIC [BASEBOARD] [SILL] [PEDESTAL] UNITS

UL 1042; wattage, voltage, phase, Btu per houroutput indicated. Provide units complete with heating elements, mounting brackets, end closures, splice plates, interior and exterior corners and accessible wiring compartment. Limit outlet air temperature and enclosure surfaces to 200 degrees F under continuous operating conditions.

2.2.1 Enclosure

Fabricate from [steel][or][aluminum] [not less than [18] [_____] gage.] Provide [galvanized] [factory applied rust-inhibiting paint] [factory primed for field painting] [manufacturer's standard] [_____] finish. Locate terminal blocks for branch circuit conductor [and control wiring] connections from the [bottom] [rear] [[right] or [left] side] [as required]. Wiring shall conform to NFPA 70.

2.2.2 Accessories

Where continuous wall-to-wall installations are indicated, provide accessories; including corner fittings, fillers, splice plates, and end caps. Accessories shall have the same profile as the basic unit, and contain no sharp edges.[Provide for expansion of enclosure.]

2.2.3 Limit Control

Provide thermal overload and over voltage protection.

2.2.4 Disconnect Means

Provide factory-installed safety disconnect switch [in the housing or in an auxiliary matching control section] [in combination with thermostat] with "off" position marking on the face plate.

2.2.5 Unit Thermostat

Provide tamper resistant [integral] [space] tool adjustable thermostat, without requiring removal of cabinet parts. Thermostat, operating range shall be approximately 50 degrees F to a maximum of [75] [_____] degrees F with operating differential of 3 degrees F or less.

[2.2.6 Outdoor Sensor

Provide outdoor sensor with sunlight-and-rain protection shield. The sensor shall provide a positive heater shut off when outdoor air temperature is 65 degrees F or higher.

][2.3 ELECTRIC INFRARED HEATER

Comply with Section 23 82 00.00 20 TERMINAL HEATING UNITS.

][2.4 INFRARED HEATER THERMOSTAT

NEMA DC 3.

][2.5 CONTACTORS

NEMA ICS 2, Enclosure Type [1] [_____].

][2.6 DISCONNECTS

Disconnect. UL listed. [Enclosed [fused] [non-fusible] switch, rated [_____] volt, [_____] phase, [_____] wire, NEMA Type [1] [3R] enclosure.] [Enclosed molded case circuit breaker, rated [_____] ampere, [_____] volt, [_____] poles, NEMA Type [1] [3R] enclosure.] [Disconnect shall be capable of being locked in the open position.]

]PART 3 EXECUTION

3.1 INSTALLATION

Install in conformance with the approved heater installation drawing, NFPA 70, UL listing, and manufacturer's instructions, with necessary clearances for air circulation, maintenance, inspection, service testing and repair. Connect to electrical supply in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.1 Unit Heaters

Mount units plumb, square and level with ceiling and walls.

3.1.2 Cabinet Heaters

Where recessed mounting is indicated, seal entire recessed opening from exterior wall cavities, and provide a minimum 1/2-inch thick rigid fire resistant insulation on the wall behind the cabinet.[Verify manufacturer's clearance requirements from electrical cords, drapes, and other furnishings.]

3.1.3 Remote Thermostat

Mount remote room space thermostats [4 feet 6 inches above finished floor on wall] [or as indicated].[Connect remote thermostats with conduit and wiring to heaters as indicated.]

[3.1.4 [Baseboard] [Sill] [Pedestal] Heaters

Verify manufacturer's clearance requirements from electrical cords, drapes, and other furnishings.

][3.1.5 Electric Infrared Heaters

Comply with Section 23 82 00.00 20 TERMINAL HEATING UNITS.

]3.2 FIELD QUALITY CONTROL

Provide necessary personnel, instruments, and equipment to perform tests. Notify the Contracting Officer [5] [_____] working days prior to scheduled testings and locations.

3.2.1 Field Inspection

Prior to initial operation, inspect installed equipment for conformance with drawings and specifications.

3.2.2 Insulation Resistance Tests

Test 600-volt wiring to verify that no short circuits or grounds exist. Tests shall be made using an instrument which applies a voltage of approximately 500 volts and provides a direct reading of resistance in ohms.

3.2.3 Operational Tests

Test equipment circuits and devices to demonstrate proper operation.Test each item of control equipment not less than 5 times.

-- End of Section --

SECTION 25 08 10

UTILITY MONITORING AND CONTROL SYSTEM TESTING
05/21

PART 1 GENERAL

1.1 DEFINITIONS

In addition to the definitions provided in this Section, 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and 25 10 10 UTILITY MONITORING AND CONTROL (UMCS) FRONT END AND INTEGRATION contain definitions related to this Section.

1.1.1 Algorithm

A set of well-defined rules or procedures for solving a problem or providing an output from a specific set of inputs.

1.1.2 Analog

A signal that can take on continuous (as opposed to discrete) values. Sensors (e.g. temperature, pressure, flow) typically provide analog signals as outputs to represent the measured variable. Within the UMCS, analog signals are generally represented by either 0-10 volt or a 4-20 milliamp signal.

1.1.3 Binary

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level.

1.1.4 Change-Of-Value (COV)

A type of data transmission over the network where the point value is transmitted over the network only when its value changes. COV is an efficient use of network bandwidth.

1.1.5 Control Wiring

This includes conduit, wire, and wiring devices to install complete HVAC control systems, including motor control circuits, interlocks, sensors, PE and EP switches, and like devices. This also includes all wiring from node to node, and nodes to all sensors and points defined in the I/O summary shown on drawings or specified herein, and required to execute the sequence of operation. Does not include line voltage power wiring.

1.1.6 Demand

The maximum rate of use of electrical energy averaged over a specific interval of time, usually expressed in kW.

1.1.7 Graphical User Interface (GUI)

Human-machine interfacing allows the operator to manage, command, monitor, and program the system.

1.1.8 Integration

Establishing communication between two or more systems to create a single system.

1.1.9 Protocol

In control systems, "protocol" is generally shorthand for "communication protocol"; a defined method by which digital information is exchanged electronically. Often more than one protocol is used in a BAS, for example, a typical BACnet system will use at a minimum (in addition to BACnet/IP and BACnet MS/TP) IP, UDP, ARP, Ethernet, and RS-485 protocols (and this does not include any protocols used internally in the front end or for communication with front end client workstations).

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Sequencing

Performance Verification Testing required by this Section must be proceeded by successful and accepted "contractors field testing" or "start-up and start-up testing" of the control system to be tested.

1.2.2 Scheduling

Coordinate testing schedules with the Government and with work in other Sections performed on the components or systems to be tested.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

- PVT Plan; G
- PVT Phase I Report; G
- PVT Phase II Report; G

SD-07 Certificates

- Test Instrumentation Calibration Certificates; G

1.4 TEST EQUIPMENT

Provide all test equipment unless otherwise noted in the contract documents. Use only test equipment with current calibration traceable to the National Institute of Science and Technology (NIST). For each test instrument, submit Test Instrumentation Calibration Certificates demonstrating calibration traceable to NIST. Use test equipment and test methods such that the overall accuracy of the test method, including all test instrumentation and any errors inherent in the test procedure, is at least 50 percent better than the accuracy specified for the sensor. For example, if a temperature sensor has an accuracy requirement of plus or minus 1 degree Farenheit degree overall accuracy of the test method, must be 0.5 degree Farenheit or better.

When validating sensor accuracy, the test instrument is treated as if it is perfectly accurate; that is, the measured value from the test instrument must lie within the bounds of the specified accuracy of the sensor. Expressed mathematically:

Given:
Sensor accuracy: Plus or minus X
Sensor reading: Y
Test equipment reading: Z
Where X, Y and Z are real numberts.

Then
Sensor passes if: (Y-X) <= Z <= (Y+X)
otherwise, sensor fails

PART 2 PRODUCTS

Not applicable

PART 3 EXECUTION

3.1 PERFORMANCE VERIFICATION TEST (PVT)

Perform a Performance Verification Test (PVT) to demonstrate that the installed control system meets all requirements of the project specifications. Coordinate scheduling of the PVT with the Government, and do not begin the PVT until the PVT Plan submittal is accepted.

3.1.1 PVT PLAN

Provide a PVT Plan including system documentation and PVT Procedures.

3.1.1.1 PVT Plan System Documentation

Include the following system documentation in the PVT Plan:

a. Copies of the most recent as-built drawings for the system, including but not limited to one-line drawings and Points Schedules showing device address, point descriptions, network point names and types, hardware point types, settings and ranges including units.

b. Copies of manufacturer's product data sheets when needed to demonstrate compliance with project requirements. In particular, provide data sheets showing that surge protection requirements have been met.

c. Operation or user manuals for all software and all DDC Hardware to be tested.

d. List of test equipment.

3.1.1.2 PVT Equipment List

Include in the PVT procedures a control system performance verification test equipment list that lists the equipment to be used during performance verification testing. For each piece of equipment include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration

3.1.1.3 PVT Procedures

Develop PVT procedures using the test procedures in this Section, modifying the procedures and adding tests as appropriate to develop procedures that test all requirements of the project specifications. The test procedures must consist of detailed instructions for test setup, execution, and evaluation of test results.

When developing additional procedures, provide the same information and fields as shown in the Test Template.

3.1.2 PVT Phases

Conduct PVT testing in two phases:

I. Field testing for devices, components, subsystems and the overall system using the approved PVT Procedures.

II. A one-week endurance test during which the system is operated continuously.

3.1.2.1 PVT Phase I (Field Tests)

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures approved by the Government, demonstrate all physical and functional requirements of the project. Show, step-by-step, the actions and results demonstrating that the control systems fully and correctly implement the sequences of operation. PVT for surge protection is not required to include introducing a surge to the equipment; surge protection may instead be demonstrated through product documentation.

Do not start the performance verification test until after receipt of written permission by the Government, based on Government approval of the PVT Plan and Draft As-Builts and completion of balancing of the HVAC System. Do not conduct tests during scheduled seasonal off periods of base heating and cooling systems. At the completion PVT Phase I and in accordance with the project schedule and project sequencing provide a PVT Phase I Report documenting all PVT testing including all approved test procedures with test results indicated on the procedures, and a record of all actions taken to address PVT test failures.

3.1.2.2 PVT Phase II (Endurance Test)

Complete an endurance test as part of the PVT in which the system is operated contuinuously for one-week without failure. During the endurance test trend all points shown as requiring a trend on the Points Schedule for the entire duration of the endurance test. If insufficient buffer or storage capacity exists to trend the entire endurance test, offload trend logs during the course of the endurance test to ensure that no trend data is lost. If the control system specification includes bandwidth requirements for bandwidth usage on a non-IP network, measure and record the network bandwidth usage on each non-IP channel during the endurance test.

If the system experiences any failures during the endurance test portion of the PVT, repair the system and repeat the endurance test portion of the PVT until the system operates continuously and without failure for the specified endurance test period. At the completion of PVT Phase II and in accordance with the project schedule and project sequencing provide a PVT

Phase II Report documenting failures and repair actions taken during PVT Phase II.

3.1.2.2.1 Temporary Trending Capability

Unless trending capability exists, either within the building control system or through a connected Utility Monitoring and Control System (UMCS) Front End, temporarily install hardware on the building control network to perform trending during the endurance test as indicated. Remove the temporary hardware at the completion of all testing and commissioning activities.

3.2 FACTORY TEST

Perform a Factory Test to demonstrate the capability of the proposed control system solution to meet the requirements of project specifications. Coordinate scheduling of the Factory Test with the Government, and do not begin the Factory Test unil the Factory Test Plan submittal is accepted.

3.2.1 Factory Test Setup

Design the Factory Test Setup to represent the system as it will be fielded and to demonstrate the capability of the system to meet the requirements of the project specification. At a minimum:

a. Include at least one of each model of DDC hardware, instrumentation and control device to be used on the project.

b. Include at least one network of each type to bue used on the project.

c. Include a programmable controller programmed as it will be installed, or, if no programmable controller is to be installed on the project, include a programmable controller with a sample application.

d. Include sample hardware to provide a mock field control system for the front end to communicate with if the project requires a front end but does not require a field control system.

3.2.2 Factory Test Plan

Provide a Factory Test Plan documenting the test setup and procedures.

3.2.2.1 Factory Test Plan Setup Documentation

Include the following information, at a minimum, to document the factory test setup:

a. System one-line block diagram of equipment used in the factory test identifying computers (servers and workstations), network hardware, DDC hardware, and other instrumentation including, but not limited to, sensors, actuators, test signal generators, and meters.

b. System hardware description used in the factory test.

c. System software description used in the factory test.

d. Points Schedules for each controller showing the configuration to be used during the test. Points Schedules must include the following information at a minimum: device address, point descriptions, network point names and types, hardware point types, settings and ranges including units.

e. Required passwords for each operator access level.

f. List of other test equipment.

3.2.2.2 Test Procedures

Develop factory test procedures using the Test Procedures in this Section, modifying the procedures and adding tests as appropriate to develop test procedures that test all requirements of the specification. The test procedures must consist of detailed instructions for test setup, execution, and evaluation of test results. Factory test procedures must include testing of surge protection by introducing a surge to the equipment and demonstrating that the equipment survives.

When developing additional procedures, provide the same information and fields as shown in the Test Template.

3.2.3 Factory Test Report

Upon completion of the Factory Test provide a complete test report, consisting of a short summary of the factory test, a copy of the Factory Test Plan, and copies of the executed test procedures separated by test. For each test, include date performed and identify the Government representative who witnessed and approved the test.

If a portion of any test failed, document the failure and corrective action.

3.2.4 Fatory Test Execution

Conduct the Factory Test at a location and time approved by the Government. The Government will witness the factory test.

If the system fails a portion of a test, the Government will determine whether the entire test or only the portion that failed must be repeated.

3.3 TEST PROCEDURES

APPENDIX A

TEST TITLE: Test Index
OBJECTIVE: The following is an index of tests.

NOTES: Tests one through twenty contain specific "item(s)" that apply to Sections 25 10 10 Utility Monitoring and Control Systems (UMCS) and the control section. The following index of tests provides a summary of which "items numbers" apply to which specification.

Test Procedures Index			
Test No.	Test Title	Section 23 09 23, Sectoin 25 10 10, UMCS	DDC for HVAC
1	System Equipment Verification	Items 1 thru 15	Items 16 thru 32
2	System Start-up	Items 1 thru 4	Items 5 and 6
3	Monitoring and Control (M&C) Software Passwords	Items 1 thru 5	Not Applicable
4	Graphic Display of Data	Items 1 thru 18	Not Applicable
5	Graphic Navigation Scheme	Items 1 and 2	Not Applicable
6	Command Functions	Items 1 thru 6	Not Applicable
7	Command Input Errors	Items 1 thru 6	Items 1 thru 6
8	Special Functions	Item 1	Not Applicable
9	Software Editing Tools	Items 1 thru 42	Items 1 thru 42
10	Scheduling	Items 1 thru 7	Items 8 thru 10
11	Alarm function	Items 1 thru 15	Item 1
12	Trending	Items 1 thru 8	Not Applicable
13	Demand Limiting	Items 1 thru 8	Not Applicable
14	Report Generation	Items 1 thru 6	Not Applicable
15	Uninterruptable Power	Items 1 thru 5	Not Applicable
16	EIA-709, 1B to IP Router Test	Items 1 thru 3	Not Applicable
17	EIA-709, 1B Router and Repeater	Not Applicable	Items 1 thru 4
18	Gateways (Device Level)	Items 1 thru 5	Items 1 thru 5
19	Local Display Panel (LDP)	Not Applicable	Items 1 thru 5
20	Open Network Point Verification	Items 1 thru 8	Items 1 thru 8

Test Procedures Index			
Test No.	Test Title	Section 23 09 23, Sectoin 25 10 10,	DDC for HVAC
21	Custom Test Template	Items 1 and 2	Items 1 and 2

PVT Checklist

OBJECTIVE:

1. Inspect/test/verify that building-level DDC system is compliant with UFGS-23 09 23 and capable of integration with UMCS.

INITIAL REQUIREMENTS/CONDITIONS

1. The following tests shall be completed and documentation shall be submitted by the contractor to the Government.

   1) Date of Checklist: __________
   2) Time of Checklist: __________
   3) Contractor's Representative: ____________________
   4) Government's Representative: ____________________

CHECKLIST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Draft or Final As-Built Drawings	Drawings submitted and approved.	
Notes:			
2	Network Bandwidth Test Report	Test completed, accepted, and a report documenting results submitted	
Notes:			
3	Programming Software	Most recent version of the programming software for each type of GPPC has been submitted	
Notes:			
4	XIF Files	External interface files (XIF) files for each model of LONWORKS-based DDC hardware	
Notes:			
5	LNS Database	Copies of the LNS database for the completed control network has been submitted	

Item	Action Item	Expected Results	Approved
6	LNS Plug-in	LNS Plug-ins for each application specific controller has been submitted	
7	Start-up testing report	Start-up has been successfully completed and testing report submitted	
		Controller tuning has been completed and document on point schedule	
		Calibration accuracy check completed and documented in test report	
		Actuator range check completed and documented in test report	
		Functional test to demonstrate control sequence completed and documented in test report	
8	Software License	Software licenses received for all software on the project	

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: One
TEST TITLE: Initial System Equipment Verification

OBJECTIVE:

1. To verify that the hardware and software components of the systems provided by the contractor are in accordance with the contract plans and specifications and all approved submittals.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals
   a. Submit a detailed list of all approved hardware with Manufacturer, model number and location. This list is based on the contract plans, specifications, change orders (if any)and approved submittals which must be available for reference purposes during the test.
   b. Submit a detailed list of all approved software with revision number and purpose of software. This list is based on the contract plans, specifications, change orders (if any) and approved submittals which must be available for reference purposes during the test.

2. Equipment
   a. Verify all equipment is functional.

3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: __________
   5. Time of Test: __________
   6. Contractor's Representative: ____________________
   7. Government's Representative: ____________________

TEST PROCEDURES:

UCMS			
Item	Action Item	Expected Results	Approved
1	The workstation hardware is installed and complies with specification paragraph titled "Workstation Hardware".	Installation in compliance with the specifications.	
Notes:			
2	The Server hardware is installed and complies with specification paragraph titled "Server Hardware".	Installation in compliance with the specifications.	
Notes:			
3	The fiber optic patch panel is installed and complies with specification paragraph titled "Fiber Optic Patch Panel".	Installation in compliance with the specifications.	
Notes:			

UCMS			
4	The fiber optic media converter is installed and complies with specification paragraph titled "Fiber Optic Media Converter".	Installation in compliance with the specifications.	
Notes:			
5	The Ethernet switch is installed and complies with specification paragraph titled "Ethernet Switch".	Installation in compliance with the specifications.	
Notes:			
6	The IP router is installed and complies with specification paragraph titled "IP Router".	Installation in compliance with the specifications.	
Notes:			
7	The EIA-709.1B to IP router is installed and complies with specification paragraph titled "EIA-709.1B to IP Router".	Installation in compliance with the specifications.	
Notes:			
8	The EIA-709.1B gateway is installed and complies with specification paragraph titled "EIA-709.1B Gateway".	Installation in compliance with the specifications.	
Notes:			

UCMS			
9	The alarm printer is installed and complies with specification paragraphs titled "PRINTERS" and "Alarm Printer".	Installation in compliance with the specifications.	
Notes:			
10	The laser printer is installed and complies with specification paragraphs titled "PRINTERS" and "Laser Printer".	Installation in compliance with the specifications.	
Notes:			
11	The color printer is installed and complies with specification paragraphs titled "PRINTERS" and "Color Printer".	Installation in compliance with the specifications.	
Notes:			
12	The operating system is installed and complies with specification paragraph titled "Operating System (OS)".	Installation in compliance with the specifications.	
Notes:			
13	The office automation software is installed and complies with specification paragraph titled "Office Automation Software".	Installation in compliance with the specifications.	
Notes:			

UCMS			
14	The virus protection software is installed and complies with specification paragraph titled "Virus Protection Software"	Installation in compliance with the specifications.	
Notes:			
15	The configuration server is installed and complies with specification paragraph titled "CEA-852-A Configuration Server".	Installation in compliance with the specifications.	
Notes:			
DDC FOR HVAC			
16	The CEA-709.1B and complies with specification Router is installed paragraph titled " CEA-709.1B Router".	Installation in compliance with the specifications.	
Notes:			
17	The CEA-709.3 and complies with specification Repeater is installed paragraph titled "CEA-709.3 Repeater"	Installation in compliance with the specifications.	
Notes:			
18	The TP/FT-10 network is installed in accordance with CEA-709.3, with double-terminated bus topology.	Installation in compliance with the specifications.	
Notes:			
19	Network wiring extends to the location of UMCS BPOC.	Installation in compliance with the specifications.	

UCMS			
Notes:			
20	The Gateway is installed and complies with specification paragraph titled "Gateway".	Installation in compliance with the specifications.	
Notes:			
21	All control valves are installed and comply with their associated specification paragraph under the section titled "Control Valves".	Installation in compliance with the specifications.	
Notes:			
22	All dampers are installed and comply with their associated specification paragraph under the section titled "Dampers".	Installation in compliance with the specifications.	
Notes:			
23	All sensors are installed and comply with their associated specification paragraph under the section titled "Sensors".	Installation in compliance with the specifications.	
Notes:			
24	All indicating devices are installed and comply with their associated specification paragraph under the section titled "Indicating Devices".	Installation in compliance with the specifications.	
Notes:			

UCMS			
25	All user input devices are installed and comply with their associated specification paragraph under the section titled "User Input Devices".	Installation in compliance with the specifications.	
Notes:			
26	All output devices are installed and comply with their associated specification paragraph under the section titled "Output Devices".	Installation in compliance with the specifications.	
Notes:			
27	All multifunction devices are installed and comply with their associated specification paragraph under the section titled "Multifunction Devices".	Installation in compliance with the specifications.	
Notes:			
28	All compressed air equipment is installed and complies with their associated specification paragraph under the section titled "Compressed Air".	Installation in compliance with the specifications.	
Notes:			

UCMS			
29	All ASCs are installed and comply with the specification paragraph titled "Application Specific Controller".	Installation in compliance with the specifications.	
Notes:			
30	All LDPs and laptop computers are provided and comply with the specification paragraph titled "Local Display Panel".		
Notes:			
31	All GPPCs are installed and comply with the specification paragraph titled "General Purpose Programmable Controller"	Installation in compliance with the specifications.	
Notes:			
32	LNS-based system used to address nodes, bind variables, and LNS database of network exists on system.	Installation in compliance with the specifications.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Two
TEST TITLE: System Start-up

OBJECTIVE:

1. To validate that the system properly initializes and that the GUI properly reconnects to all communicating devices.

2. To validate that both application specific and programmable devices retain all vital information upon a power cycle.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. Contractor shall provide a list of all software that will be used to verify point connection at field level controllers and user interface.
   b. Contractor shall provide a list of all software need to verify application specific and programmable controller start-up.

2. Equipment:
   a. All peripherals and cables shall be connected per manufacturer's requirements.
   b. The workstation shall be in the off mode.
   c. All controls shall be fully functional and tested.
   d. A programmable and application specific controller shall be randomly selected for the test.
3. Date of Test: ___________
4. Time of Test: ___________
5. Contractor's Representative: ______________________
6. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected results	Approved
UCMS			
1	Energize the workstation.	The workstation will power-up and perform its start-up procedure without generating any errors or problems.	
	a) Operating system	Operating system shall be latest version of windows.	
	b) Start Network Configuration Tool.	The Network Configuration Tool drawing will open.	
	c) Start the System Plug-in.	The System plug-in will open.	
	d) Start the Server.	The Server will start.	
	e) Start the Workstation.	The Workstation will start. The operator shall now have the ability to view data from any device on the network.	
Notes:			

Item	Action Item	Expected results	Approved
2	Check the communication from the server to the controllers.	Within the workstation software, when a device is selected, dynamic points lists become visible. Dynamic data represents success. A completion event failure message represents failure.	
Notes:			
3	Verify on-line status.	All devices shall have on-line status indicated by the workstation software (green indicator).	
Notes:			
4	View data from the graphical environment.	When a graphics page is opened, the points on the page should update. Question marks in lieu of data reflect failure.	
Notes:			
DDC FOR HVAC			
5	Verify that configuration data in application specific controllers is written to EEPROM.	All configuration parameters should be accessible.	
	a) Open the LONWORKS plug-in.	Software should open without errors.	
	b) Note several parameters such as temperature setpoints and flow settings.	Operator is able to view a sample of parameters (data values and setpoints).	
	c) Remove power from the controller for a minimum of 3	Device should go off-line in Network Configuration Tool and workstation/server.	
	d) Replace power to the controller.	Device should return to on-line status.	
	e) Using the plug-in, verify that the configuration parameters and note the	Parameters values shall not have changed.	

Item	Action Item	Expected results	Approved
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Three
TEST TITLE: Monitor and Control (M&C) Software Passwords

OBJECTIVE:

1. To validate that the system utilizes four basic password levels
2. To validate that each password level has the specified authority

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The Contractor shall provide documentation of M&C user password capacity in comparison with specification.
   b. The Contractor shall provide a complete list of all users along with their passwords and user level prior to testing.

2. Equipment
   a. Server and Workstation

3. Reference Documentation
   a. Provide user manual documentation for setting up passwords

4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS			
1	Create password for new users.	New users shall exist in the server Database.	
	a) Set-up 4 users.		
	b) Assign different levels to each.		
Notes:			
2	Demonstrate level 1 authority.		

Item	Action Item	Expected Results	Approved
	a) Sign in as the level 1 user.	Sign in shall be successful.	
	b) Attempt to view a system graphic.	Action shall be possible	
	c) Attempt to acknowledge an alarm.	Action shall be denied.	
	d) Attempt to configure a trend.	Action shall be denied.	
	e) Attempt to configure a report.	Action shall be denied.	
	f) Attempt to override a point.	Action shall be denied.	
	g) Attempt to configure an alarm.	Action shall be denied.	
	h) Attempt to configure a schedule.	Action shall be denied.	
	i) Attempt to configure a demand limiting parameter.	Action shall be denied.	
	j) Attempt to modify a graphic page.	Action shall be denied.	
	k) Attempt to create a custom program.	Action shall be denied.	
Notes:			
4	Demonstrate level 3 authority.		
	a) Sign in as the level 3 user.	Sign in shall be successful.	
	b) Attempt to view a system	Action shall be possible	
	c) Attempt to acknowledge an alarm.	Action shall be possible	
	d) Attempt to configure a trend.	Action shall be possible	
	e) Attempt to configure a	Action shall be possible	
	f) Attempt to override a point.	Action shall be possible	
	g) Attempt to configure an	Action shall be possible	

Item	Action Item	Expected Results	Approved
	h) Attempt to configure a schedule.	Action shall be possible	
	i) Attempt to configure a demand limiting	Action shall be possible	
	j) Attempt to modify a graphic page.	Action shall be possible	
	k) Attempt to create a custom program.	Action shall be possible	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Four
TEST TITLE: Graphic Display of Data

OBJECTIVE:

1. To validate that floor plans and equipment can be graphically displayed through GUI.
2. To validate the proper display of alarms on GUI.
3. To validate the proper display of trend data on GUI.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The contractor shall provide hard copies of "snap shots" of sample graphics pages prior to testing.
2. Equipment
   a. The contractor shall have all graphics completed.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Notes
   a. Different types of data and states should be clearly distinguishable from each other.
5. Date of Test: ___________
6. Time of Test: ___________
7. Contractor's Representative: ______________________
8. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
1	Demonstrate the use of a three dimensional representation of a mechanical system.	Equipment shall be represented in a three dimensional manner.	
Notes:			
2	Demonstrate the presentation of real time data.	Dynamic real time data shall be presented on a graphics page.	
Notes:			
3	Demonstrate the presentation of user entered data.	A user defined parameter such as a setpoint shall be presented on a graphics page. Different types of data and states should be clearly distinguishable from each other.	
Notes:			
4	Demonstrate the presentation of a point in override.	An indication of override condition shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	
Notes:			
5	Demonstrate the presentation of a device in the alarm state.	An indication of the alarm state shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	
Notes:			
6	Demonstrate the presentation of data that is out of range.	An indication of out of range condition shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	
Notes:			

Item	Action Item	Expected Results	Approved
7	Demonstrate the presentation of missing data (controller is offline).	An indication of missing data shall be viewable on the graphic page. Different types of data and statesshould be clearly	
Notes:			
8	Demonstrate an error message when the operator attempts to execute in	An error message shall be displayed.	
Notes:			
9	Demonstrate point and click access to context	Operator shall be able to easily access context sensitive help using the mouse.	
Notes:			
10	Demonstrate point and click access to an engineering	Operator shall be able to access an engineering diagram using the mouse.	
Notes:			
11	Demonstrate the creation of an engineering diagram.	Operator shall be able to create an engineering diagram.	
Notes:			
12	Demonstrate the printing of a prepared report.	Operator shall be able to print a report using the mouse.	
Notes:			
13	Demonstrate the display of one or more points.	Operator shall be able to request the display of one or more points.	
Notes:			
14	Demonstrate the operator override of a	Operator shall be able to override a point.	
Notes:			
15	Demonstrate the modification of a time schedule.	Operator shall be able to modify a time schedule.	

Item	Action Item	Expected Results	Approved
Notes:			
16	Demonstrate the execution of a report.	Operator shall be able to initiate a report.	
Notes:			
17	Demonstrate the presentation of an alarm to include:	Operator shall be able to view an alarm with all of the required data.	
	a) Identification		
	b) Date and time		
	c) Alarm Type		
	d) Set Points		
	e) Units		
	f) Current Value		
	g) Priority		
	h) Associated message & Secondary message		
Notes:			
18	Demonstrate the presentation of real time trend data.	Operator shall be able to view real time trend data as a function of time.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Five
TEST TITLE: Graphic Navigation Scheme

OBJECTIVE:

1. To validate hierarchical graphic displays from main screen to end devices.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:

a. The contractor shall provide a hierarchical block diagram of the system network prior to testing.

2. Equipment
   a. The contractor shall have all programming completed to demonstrate graphic display.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS			
1	Demonstrate the creation of a hierarchical tree structure for the presentation of point data with at least five levels.	Operator shall be able to organize point data graphic display in a hierarchical organization desired.	
		A typical organization could be:	
		- Installation	
		- Building	
		- Building sub area	
		- Main System-Unit	
		- Terminal Unit	
2	Demonstrate the creation of a hierarchical navigation structure for the graphic pages.	Operator shall be able to organize the graphical navigation from page to page using any hierarchical structure desired.	
		Examples:	
		-Home page to building 1	
		-Building 1 to AHU 1	
		-Building 1 back to Home Page	
		-Building 1 to 1st Floor Plan	

Item	Action Item	Expected Results	Approved
		-AHU 1 back to Building 1	
		-AHU 1 back to Home Page	
		-AHU 1 to Terminal Unit	
		-Summary	
		-1st Floor Plan back to Building 1	
		-1st Floor Plan back to Home Page	
		-1st Floor Plan to Any Terminal Device	
		-Terminal Unit Summary back to AHU 1	
		-Terminal Unit Summary back to Building 1	
		-Terminal Unit Summary back to Home Page	
		-Terminal Unit Summary to Individual Device	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Six
TEST TITLE: Command Functions

OBJECTIVE:

1. To demonstrate the functionality and ability to execute command to the end devices.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The Contractor shall provide documentation of all command functions prior to testing.
2. Equipment
   a. The contractor shall have all command functions programmed and functional.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	From the tree structure, modify a parameter such as a set point.	The modified value shall be downloaded to the controller without delay and the controller performance shall be viewable by the monitoring of other dynamic points.	
Notes:			
2	From a graphic page, modify a parameter such as a set point.	The modified value shall be downloaded to the controller without delay and the controller performance shall be viewable by the monitoring of dynamic points.	
Notes:			
3	From the tree structure, place an analog output point under operator override and assign a fixed value.	The analog output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	
Notes:			
4	From a graphic page, place an analog output point under operator override and assign a fixed value.	The analog output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	
Notes:			
5	From the tree structure, place a digital output point under operator override and assign a fixed value.	The digital output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	
Notes:			

Item	Action Item	Expected Results	Approved
6	From a graphic page, place a digital output point under operator override and assign a fixed value.	The digital output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Seven
TEST TITLE: Command Input Errors

OBJECTIVE:

1. To validate that the system ensures the necessary authority for command inputs.
2. To validate that the system can control the range of command input values.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The contractor shall provide all command input error messages prior to testing.
2. Equipment
   a. UMCS and DDC hardware and software.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Login using a password with point command.	Login occurs.	
Notes:			
2	Request a display of a	The system displays the controllers SNVT value.	

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
Notes:			
3	Override the SNVT point to a selected value.	The SNVT value override changes the value in the controller.	
Notes:			
4	Release the override of a SNVT.	The SNVT value returns to normal.	
Notes:			
5	For an nvi to a controller with a limit of 50 to 80, command the nvi to a value of 90.	The value will go the maximum of 80.	
Notes:			
6	For an nvi to a controller for which the operator only has read privileges, command the nvi to a value of 90	The operator will be denied the ability to command the nvi to any value.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eight
TEST TITLE: Special Functions

OBJECTIVE:

1. Verify system has special integration as defined.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The Contractor shall provide documentation of all integrations prior to testing.
2. Equipment
   a. The contractor shall have all UMCS and DDC hardware and software programmed, integrated, and completed.
3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Items	Action Items	Expected Results	Approved
UMCS			
1	Verify that a building that uses controls from a vendor other than the one being installed can be integrated into the GUI without any loss of functionality. (A simulated building will be set up using an IP-L router and controllers from Honeywell, TAC, Trane, etc.)	Data from the other vendors controllers shall be integrated into the GUI and the same functionality that would exist if the controllers were from the same manufacture shall exist.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Nine
TEST TITLE: Software editing tools

OBJECTIVE:

1. To validate the performance of the M & C application programming tool for the GPPC.
2. To validate the performance of the display editing tool.
3. To validate the performance of the report generation display tool.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The contractor shall provide documentation and a backup softcopy of the editing tool prior to testing.

   b. The contactor shall provide documentation of any future software upgrade versions that pertain to the software-editing tool.
2. Equipment
   a. The contractor shall have working knowledge of the full capability of the software-editing tool.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Demonstrate the programming of an override function in a	Operator shall be able to use the programmed function to override an output point in a GPPC.	
Notes:			
2	Demonstrate software that enables the monitoring of data from a GPPC.	Operator shall be able to monitor points from a GPPC.	
Notes:			
3	Demonstrate timer functions within applications of	Control logic shall honor the built in timers.	
	a) delay on	Control logic shall honor the built in timers.	
	b) delay off	Control logic shall honor the built in timers.	
	c) one second delays	Control logic shall honor the built in timers.	
	d) interval timers	Control logic shall honor the built in timers.	
Notes:			
4	Demonstrate logic loops ("for" and	Control logic shall honor the criteria.	
Notes:			
5	Demonstrate if-then-else logic in GPPC.	Control logic shall properly follow the if, then, else requirements.	
Notes:			

Item	Action Item	Expected Results	Approved
6	Demonstrate basic math functions in	Control logic shall properly execute math functions.	
Notes:			
7	Demonstrate Boolean math functions in	Control logic shall properly execute the functions.	
Notes:			
8	Demonstrate exponential math functions in	Control logic shall properly execute the functions.	
Notes:			
9	Demonstrate trigonometric math functions in GPPC.	Control logic shall properly execute the functions.	
Notes:			
10	Demonstrate bitwise math functions in GPPC.	Control logic shall properly execute the functions.	
Notes:			
11	Create a user defined subroutine/functi in GPPC.	Subroutine/function shall work correctly and be easily reused.	
Notes:			
12	Create alarm conditions in GPPC.	Alarm variables shall be created according to the criteria.	
Note:			
13	Create and save a graphic symbol at the server.	Symbol shall be reusable on a new graphic.	
Notes:			
14	Modify a graphic symbol at the server.	Operator shall be able to open an existing symbol and make changes.	
Notes:			
15	Save a graphic symbol to a library at the server.	Symbol shall be available from the library for reuse.	

Item	Action Item	Expected Results	Approved
Notes:			
16	Delete a graphic symbol at the server.	Symbol shall no longer exist for use.	
Notes:			
17	Place a graphic symbol on a new graphic page at server.	When the new page is opened, the symbol shall be there.	
Notes:			
18	Associate particular conditions with particular displays at the server.	When the conditional variable changes, the display should change.	
Notes:			
19	Overlay alphanumeric text on a graphic at	Text shall properly display.	
Notes:			
20	Create a new graphic from an old one at the server.	New graphic shall properly display.	
Notes:			
21	Place dynamic data on a graphic at the	The dynamic data shall be viewable on the graphic.	
Notes:			
22	Define the background color of a new graphic at the server.	The new graphic shall show the selected background color.	
Notes:			
23	Define a foreground color for an element on a graphic to distinguish it from the background color at the server.	The color of the dynamic data that uses the foreground color shall display in the foreground color.	

Item	Action Item	Expected Results	Approved
Notes:			
24	Position a symbol on a graphic at the	The operator shall be able to place a symbol at any location on a graphic.	
Notes:			
25	Position and edit alphanumeric descriptors at	The alphanumeric display shall be as designed.	
Notes:			
26	Draw lines on a graphic at the server.	Lines shall display as drawn.	
Notes:			
27	Associate source of dynamic data for presentation on a graphic at the server.	Correct data shall be displayed.	
Notes:			
28	Display analog data on a graphic page at the server.	Correct data shall be displayed.	
Notes:			
29	Demonstrate the movement of the curser(crosshairs) by the use of the mouse at the server.	Crosshairs shall follow the commands from the mouse.	
Notes:			
30	Demonstrate the simultaneous use of multiple graphics (coincident graphics)at the server.	Operator shall see the use of the tile function and the use of the tab function to manage multiple graphics.	
Notes:			

Item	Action Item	Expected Results	Approved
31	Associate graphic properties such as color with the values from dynamic variables at the server.	Graphic properties shall change as the value of the dynamic variable changes.	
Notes:			
32	Create conditional displays based on the value of a dynamic variable at the server.	The graphic display shall change as the dynamic variable changes.	
Notes:			
33	Review the standard symbol library at the server.	Operator shall see how to access symbols from the standard symbol library.	
Notes:			
34	Demonstrate how to move data from the database to a report at the	The executed report shall contain data from the database.	
Notes:			
35	Add comments and headers to a report at the server.	The executed report shall contain the comments and headers.	
Notes:			
36	Demonstrate the time stamping of data in a report at the server.	Data presented in a report shall include the date and time the data was sampled.	
Notes:			
37	Demonstrate the time stamping of the report generation at the server.	A report shall include the date and time it executed.	
Notes:			

Item	Action Item	Expected Results	Approved
38	Demonstrate basic mathematical manipulation of data within a report (daily averages, highs, lows, etc.) at the server	Report shall display the results of the mathematical manipulations.	
Notes:			
39	Demonstrate the operator's ability to select either automatic or manual generation of a report	Reports shall execute per the operator's instructions.	
		Report one shall execute per the operator's instructions.	
		Report two shall execute automatically on a time basis per operator's instructions.	
Notes:			
40	Demonstrate the selection of either display, print to printer or print to file.	Reports shall execute per the operator's instructions.	
		Report one is printed to printer.	
Notes:			
41	Demonstrate how a modified application program is imported into the server database for presentation to the workstations.	Modified list of variables shall be available from a workstation.	
Notes:			
42	Demonstrate how a new device is added to the server database for presentation to the workstations.	New list of variables from the new device shall be available from a workstation.	

Item	Action Item	Expected Results	Approved
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Ten
TEST TITLE: Scheduling

OBJECTIVE:

1. Verify that M&C software has ability to operate end devices off a time of day schedule utilizing defined parameters.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The contractor shall provide documentation of the minimum programmable schedules in comparison to the specification requirement prior to testing.
   b. The contactor shall provide documentation of of all schedules programmed in the UMCS prior to testing.
   c. The contractor shall provide a trend or report log of all equipment on a schedule prior to testing.
2. Equipment
   a. The contractor shall have GPPC and ASC with all scheduling completed for testing.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS			

Item	Action Item	Expected Results	Approved
1	Demonstrate the basic functionality of a time schedule by monitoring the value of SNVT_occupancy as the time changes through a start time or a stop time.	The value of SNVT_occupancy shall properly track the time schedule.	
Notes:			
2	Setup a weekly time schedule for a demo system with independent times for each day of the week and with up to 6 events per	Scheduling software shall accommodate the described requirements.	
Notes:			
3	Setup a special event or date specific time schedule and verify that this schedule takes precedence over the weekly schedule.	The special event schedule shall take precedence.	
Notes:			
4	Setup a group time schedule for a collection of systems. This group schedule shall take precedence over the individual time schedules.	The group schedule shall take precedence.	
Notes:			
5	Demonstrate operator access to a time schedule from a graphic page.	Operator shall be able to access the time scheduling editor from a graphic page.	
Notes:			

Item	Action Item	Expected Results	Approved
6	Display the current date and time on a graphic page.	Operator shall be able to view the current date and time from a graphic page.	
Notes:			
7	Demonstrate automatic daylight savings time	Time of day shifts automatically.	
Notes:			
8	Demonstrate the ability of GPPC to accept an occupied, unoccupied and standby command from the UMCS.	Equipment shall change modes based on the UMCS or from "system scheduler" SNVT schedule data.	
Notes:			
9	Demonstrate the ability of ASC to accept an occupied, unoccupied and standby command from the UMCS.	Equipment shall change modes based on the UMCS SVNT schedule data.	
Notes:			
10	Demonstrate use of the default schedule when communication is lost to the	Equipment should use the default schedule until communication is reestablished.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eleven
TEST TITLE: Alarm Function

OBJECTIVE:

1. Verify that M&C software has ability to operate end devices off a time of day schedule utilizing defined parameters.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The contractor shall provide documentation of the minimum programmable schedules in comparison to the specification requirement prior to testing.
   b. The contractor shall provide documentation of all schedules programmed in the UMCS prior to testing.
   c. The contractor shall provide a trend or report log of all equipment on a schedule prior to testing
2. Equipment
   a. The contractor shall have GPPC and ASC with all scheduling completed for testing.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS			
1	Initiate a basic binary alarm condition such as a fan fail to start.	The nvo (SNVT) displayed on designated server/workstation shall change from a value of 0 to a value of 1.	
		The alarm shall be presented in the alarm window.	
		The alarm shall define the source of the alarm.	
		The alarm shall define the time of the alarm.	
		The alarm shall present its assigned priority.	
		The alarm shall be presented in the alarm window.	
		The alarm shall display a text message.	
Notes:			
2	Demonstrate the capability of associating a secondary text message with the alarm.	With a simple point and click, the operator shall have access to the secondary text message.	
Notes:			

Item	Action Item	Expected Results	Approved
3	Acknowledge the alarm.	The status of the alarm shall changed to acknowledged. The user that acknowledged the alarm shall be recorded along with the date and time of the action.	
Notes:			
4	Demonstrate the "pop up" of the alarm window when an alarm occurs.	When the alarm occurs, the alarm window shall automatically open.	
Notes:			
5	Demonstrate the capability to send a numeric page when an alarm	The numeric page is received.	
Notes:			
6	Demonstrate the capability to send an email when an alarm<BRK/>occu	The email shall be received.	
Notes:			
7	Demonstrate the printing of an alarm on the alarm	The printer shall print the alarm.	
Notes:			
8	Identify the file on the hard disk that contains all of the alarms.	Opening the file shall display a list of all of the alarms.	
Notes:			
9	Execute a user sort on the alarm file.	The presentation shall follow the defined sort.	
Notes:			
10	Print the alarm file.	Paper copy shall be printed.	
Notes:			

Item	Action Item	Expected Results	Approved
11	Take an application specific controller<BRK/	An alarm should be generated.	
Notes:			
12	Take a programmable controller off line.	An alarm should be generated.	
Notes:			
13	Simulate a data circuit going off line.	An alarm should be generated	
Notes:			
14	Simulate a point not responding to a command.	An alarm should be generated	
Notes:			
15	Simulate a change of state without	An alarm should be generated.	
Notes:			
16	Initiate an alarm condition such as a fan fail	DDC system shall dial a pager and send a numerical alarm.	
		DDC system shall dial an e-mail server. The node shall be able to dial and connect to a remote server and send an e-mail via Simple Mail Transfer Protocol (SMTP).	
		DDC system shall send an e-mail over IP Network. The alarm handling node shall be capable of connecting to an IP network and sending e-mail via Simple Mail Transfer Protocol (SMTP).	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No

NA = Not Applicable

TEST NUMBER: Twelve
TEST TITLE: Trending

OBJECTIVE:

1. To validate the capability for historical trend data collection and presentation.
2. To validate the capability for real time trend data collection and presentation.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The Contractor shall provide documentation of trending capability in comparison with specification.
2. Equipment
   a. Provide GPPC or ASC and workstation/server programmed with trend data.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS			
1	Set up a trend with a 1 second sample rate.	It shall be possible to collect data on a 1 second sample rate.	
Notes:			
2	Set up a trend to start and stop at	It shall be possible to start and stop a trend based on time.	
Notes:			
3	Open a trend data display that has 8 values trended	Trend plots shall show all 8 variables as a function of time.	
	a) historical data		
	b) instantaneous data		

Item	Action Item	Expected Results	Approved
Notes:			
4	Open a pre-programmed trend data presentation.	Trend plot shall open without operator programming.	
Notes:			
5	Open the trend configuration dialog box	Operator shall be able to configure a trend plot.	
Notes:			
6	Set up a trend for a randomly selected binary value and a randomly selected	Any binary or analog variable shall be trendable.	
Notes:			
7	Verify that historical trend data is stored on the hard drive.	With the controller offline, historical trend data from that controller shall be presented in a graphical form.	
Notes:			
8	Export trend log data to Microsoft Excel for manipulation and printing by the operator.	Data shall be presented in a ****.xls form.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Thirteen
TEST TITLE: Demand Limiting

OBJECTIVE:

1. Verify M&C software has the capability of performing

demand-limiting strategies

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The contractor shall provide documentation of the specific equipment being monitored.
   b. The contractor shall provide documentation of the load shed priority and the equipment associated with the priorities.
2. Equipment
   a. The Contractor shall provide GPPC and ASC programmed for demand-limit strategies.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UCMS			
1	From the home page of the M&C go to or click on the graphical demand-limiting page.	The demand-limiting page will open without any errors.	
Notes:			
2	Document the present kW load__________.	The M&C will display the actual kW.	
Notes:			
3	Set kW limit setpoint to cause program to shed load.		
Notes:			
4	Turn off 25% of the mechanical equipment	The kW usage will decrease.	
Notes:			

Item	Action Item	Expected Results	Approved
5	Allow the building(s) to remain at 75% for a given time as to generate a temperature load.	The building(s) will warm-up/cool down.	
Notes:			
6	After time period has expired, turn all equipment on at the same time.	The kW usage will greatly increase.	
		The M&C will stop other pieces of equipment as to shed the load. The equipment shut down will be priority based. After the building(s) come under temperature control the M&C will start all of the equipment. The equipment start up will be priority based.	
Notes:			
7	Verify the building(s) remain under temperature control and go back to the home page.	The building(s) will come under control.	
		The home page will be displayed.	
Notes:			
8	Reset kW setpoint to normal limits.	The UMCS goes back to normal control.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Fourteen
TEST TITLE: Report Generation

OBJECTIVE:

1. To demonstrate that M&C software has ability to generate reports in a fixed format initialized by operator request.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. The contractor shall provide documentation of the specific equipment being monitored.
2. Equipment
   a. The contractor shall provide server/workstation, GPPC, ASC and I/O to create reports.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS			
1	Manually generate a report for viewing on the	Report shall present itself for viewing without disrupting the operation of the control system.	
Notes:			
2	Manually generate a report and direct it to a specific printer.	Report shall print on the specified printer.	
Notes:			
3	Verify that the report contains the date and time associated with the raw data.	Data samples listed in the report shall have the associated date and time the samples were collected.	
Notes:			

Item	Action Item	Expected Results	Approved
4	Verify that the report has the date and time the report was generated.		
Notes:			
5	Save a report to a file that is compatible with Microsoft	The report shall be saved in a ***.xls format.	
Notes:			
6	Generate a comma delimited file with trend log	The comma delimited data shall be produced.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Fifteen
TEST TITLE: UPS Test

OBJECTIVE:

1. Validate UPS requirements.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
a. The contractor provides documentation on UPS.
2. Equipment
   a. The server/workstation and the UPS needs to be on and operating for a minimum of one week.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS			
1	The UMCS home graphic page is called up.	The home page is displayed.	
Notes:			
2	Unplug the UPS from the wall outlet.	The UMCS home page remains displayed.	
Notes:			
3	Log out of the home page of the M&C and then log back into it.	The UPS will not affect the UMCS hardware and all associated software.	
Notes:			
4	Allow the UPS to be unplugged for 20 minutes.	The UPS will not affect the UMCS hardware and all associated software.	
Notes:			
5	Return the UPS plug to the wall	The UPS will not affect the UMCS hardware and all associated software.	
Note:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Sixteen
TEST TITLE: EIA-709.1B to IP Router Test

OBJECTIVE:

1. Validate EIA-709.1B to IP Router requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. Submittal information on router and O&M manual on network analysis tool.
2. Equipment
   a. The router needs to be on and operating.
   b. Provide a LONWORKS® network analysis tool and router configuration tool.
3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS			
1	Connect and open network analysis tool and verify router and repeater.	Tool shall identify function, network address, and identifier of the devices.	
Notes:			
2	Using router configuration tool, open the properties dialog box. Verify what data is configured to pass through router.	Only the data that is configured to pass through the router is being sent.	
Notes:			
3	Using repeater configuration tool, open the properties dialog box.	Dialog box opens.	
Notes:			
4	Verify that repeater is configured as a repeater and that all data is being sent.	Verify that all data is being sent through the repeater.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Seventeen
TEST TITLE: EIA-709.1B to IP Router Test

OBJECTIVE:

1. Validate EIA-709.1B to IP Router and Repeater requirements.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. Submittal information on on router/repeater and O&M Manual on network analysis tool.
2. Equipment
   a. The router needs to be on and operating for a minimum of one week.
   b. The repeater needs to be on and operating for a minimum of one week.
   c. Provide a LONWORKS® network analysis tool and router/repeater configuration tool.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
1	Connect and open network analysis tool and verify router and repeater	Tool shall identify function, network address, and identifier of the devices.	
Notes:			
2	Using router configuration tool, open the properties dialog box. Verify what data is configured to pass through router.	Only the data that is configured to pass through the router is being sent.	
Notes:			

Item	Action Item	Expected Results	Approved
3	Using repeater configuration tool, open the properties dialog box.	Dialog box opens.	
Notes:			
4	Verify that repeater is configured as a repeater and that all data is being sent	Verify that all data is being sent through the repeater.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eighteen
TEST TITLE: EIA-709.1B Gateway Test

OBJECTIVE:

1. Validate EIA-709.1B Gateway requirements.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
   a. Contractor shall provide a list of all software that will be used to verify ANSI-709.1 Gateway configuration.
   b. Provide a LonMark external interface file (XIF) for the gateway.
2. Equipment
   a. The gateway needs to be on and operating.
   b. Provide a LonWorks® network analysis tool and gateway configuration tool.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS and DDC FOR HVAC			
1	Connect a LONWORKS Network Analysis Tool to the	a. Tool shall identify function, network address, and identifier of the device.	
		b. All network traffic from gateway shall be utilizing the ANSI/EIA-709.1 protocol.	
Notes:			
2	Use gateway configuration tool to verify or create a binding from gateway to a LONWORKS controller on the network.	a. Gateway allows binding of the Standard Network Variable Types from the gateway to a LONWORKS controller.	
		b. Information from gateway should be bounded and LONWORKS controller should be receiving data.	
Notes:			
3	Using gateway or network configuration tool verify the following:		
	Open the properties dialog box for one of the configured	Gateway should allow the SNVT to be transmitted on "min", "max" and "delta"	
	Rename one of the SNVTs from the	Gateway should allow all variable names to be customized.	
	Check total capacity of Gateway.	Gateway shall have 50% extra capacity to map over additional points.	
Notes:			
4	Press service pin on gateway.	Gateway should broadcast the neuron ID and Program ID over the network.	

Item	Action Item	Expected Results	Approved
Notes:			
5	Remove power source from gateway for two hours. Then return power to gateway.	Gateway should retain all configuration data.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Nineteen
TEST TITLE: Local Display Panel (LDP)

OBJECTIVE:

1. To demonstrate capability of the Local display panel to view and override control points

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
a. O & M Manual for LDP
2. Equipment
   a. Hardware and software to connect and demo LDP configuration tool.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the testing.
4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
1	Connect LDP to LON bus. Push service pin button on LDP.	LDP Controller should broadcast its neuron ID.	
Notes:			

Item	Action Item	Expected Results	Approved
2	Use navigation buttons on LDP to display a status point such as a temperature or fan	LCP should allow user to read all status points	
Notes:			
3	Use navigation buttons to display a control point such as a discharge air temperature setpoint	LCP should allow user to read all control points.	
Notes:			
4	Use LDP to override setpoint.	System accepts new setpoint. Verify system reacts to new setpoint.	
Notes:			
5	Use LDP to release local control override.	Verify system returns to normal control.	
Notes;			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twenty
TEST TITLE: Network Configuration Tool

OBJECTIVE:

1. To validate the performance of the network configuration tool.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
a. Network configuration tool manuals.
2. Equipment
   a. Hardware, network connection, LNS database, and network configuration tool.
3. Reference Documentation
   a. List user manual documentation and sections pertaining to the

testing.

4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Open network configuration tool and verify LNS data for project opens is being used.	The Network Configuration Tool is being used and entire LNS database for project is exposed.	
Notes:			
2	Open a typical LNS plug-in.	Plug-in shall open and enable configuration of the device.	
Notes:			
3	Reconstruct a database by connecting to an existing network and uploading the data.	The database and drawing shall be created.	
Notes:			
4	Verify that a graphical interface is in use.	Note that Network Configuration Tool uses Visio (type) as a graphical interface.	
Notes:			
5	Print the graphical representation	Printing shall be successful.	
Notes:			
6	Merge two LNS databases into a single database.	The merge shall be successful.	
Notes:			

Item	Action Item	Expected Results	Approved
7	Print reports from network configuration tool.	Address table, SNVT I/O table, and SCPT/UCPT table reports shall be successfully printed.	
Notes:			
8	Randomly select a sample of network variable and confirm they are using correct SNVT types.	Correct SNVT types were used	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twenty One
TEST TITLE: Custom Tests

OBJECTIVE:

1. To test custom applications for UMCS and/or DDC for HVAC, that are specific to a project.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals:
a. Documents related to custom application - to be identified.
2. Equipment
   a. Equipment to be provided related to custom application - to be identified.
3. Date of Test: ___________
4. Time of Test: ___________
5. Contractor's Representative: ______________________
6. Government's Representative: ______________________

TEST PROCEDURES:

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			

Item	Action Item	Expected Results	Approved
1	Identify special tests for the UMCS that relate to a custom application for a specific project - to be completed by designer.	To be completed by designer.	
Notes:			
2	Identify special tests for the DDC for HVAC systems that relate to a custom application for a specific project - to be completed by designer.	To be completed by designer.	
Notes:			

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

-- End of Section --

SECTION 25 10 10

UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION
02/19, CHG 1: 05/21

PART 1 GENERAL

1.1 SUMMARY

Provide a Utility Monitoring and Control System (UMCS) which performs supervisory monitoring and supervisory control of base-wide building control systems and utility control systems using one or more of: CEA-709.1-D (LonWorks) with LonWorks Network Services (LNS), ASHRAE 135 (BACnet), MODBUS Protocol, MODBUS TCP/IP, OPC DA, or the Niagara Framework with Fox protocol as indicated and shown. Integrate CEA-709.1-D field control systems installed per Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS into the UMCS as specified and maintain the LNS database(s) for the entire network at the UMCS Front End. Integrate field control systems installed per Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS or Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS to the UMCS via Niagara Framework Supervisory Gateways as specified. Integrate ASHRAE 135 (BACnet) field control systems installed per Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS as specified.

1.1.1 System Requirements

Provide a UMCS as specified and indicated, and in accordance with the following characteristics:

1.1.1.1 General System Requirements

a. The system performs supervisory monitoring and control functions including but not limited to Scheduling, Alarm Handling, Trending, Overrides, Report Generation, and Electrical Demand Limiting as specified.

b. The system includes a Graphical User Interface which allows for graphical navigation between systems, graphical representations of systems, access to real-time data for systems, ability to override points in a system, and access to all supervisory monitoring and control functions.

c. All software used by the UMCS and all software used to install and configure the UMCS is licensed to and delivered to the installation.

d. All necessary documentation, configuration information, configuration tools, programs, drivers, and other software is licensed to and otherwise remains with the Government such that the Government or their agents are able to repair, replace, upgrade, and expand the system without subsequent or future dependence on the Contractor. Software licenses must not require periodic fees and must be valid in perpetuity.

e. Provide sufficient documentation and data, including rights to documentation and data, such that the Government or their agents can execute work to repair, replace, upgrade, and expand the system without subsequent or future dependence on the Contractor.

f. The UMCS interfaces directly to ASHRAE 135, CEA-709.1-D, MODBUS Protocol, MODBUS TCP/IP, OPC DA, and Niagara Framework field control systems as specified and may interface to field control systems using other protocols via an M&C Software protocol driver or a Gateway.

g. For UMCS systems with Monitoring and Control Software functionality implemented in Monitoring and Control (M&C) Controller Hardware, provide sufficient additional controller hardware to support the full capacity requirements as specified.

h. All Niagara Framework components have an unrestricted interoperability license with a Niagara Compatibility Statement (NiCS) following the Tridium Open NiCS Specification and have a value of "ALL" for "Station Compatibility In", "Station Compatibility Out", "Tool Compatibility In" and "Tool Compatibility Out". Note that this will result in the following entries in the license.dat file:

```
accept.station.in="*"
accept.station.out="*"
accept.wb.in="*"
accept.wb.out="*"
```

1.1.1.2 LonWorks Requirements

a. The UMCS must communicate using CEA-709.1-D over the Government furnished IP network in accordance with CEA-852-C as specified and must interface to CEA-709.1-D building control networks using LonWorks/IP Routers as specified.

b. All communication between the UMCS and LonWorks field control networks must be via the CEA-709.1-D protocol over the IP network in accordance with CEA-852-C.

c. Except for communication for device commissioning, configuration, and programming, all communication between the M&C Software and the field control system devices must be via SNVT.

1.1.1.3 BACnet Requirements

a. The UMCS must communicate using ASHRAE 135 Annex J over the Government furnished IP network as specified.

b. All communication between the UMCS and ASHRAE 135 field control networks must be via the ASHRAE 135 protocol over the IP network.

c. All communication between the M&C Software and the field control system devices must be via standard ASHRAE 135 services other than PrivateTransfer and ConfirmedPrivateTransfer except as follows:

(1) PrivateTransfer and ConfirmedPrivateTransfer may be used for device configuration and device programming.

(2) PrivateTransfer and ConfirmedPrivateTransfer may be used for communication between the M&C Software and the field control system if and only if both the M&C Software and the field control system devices automatically (without requiring reconfiguration)

revert to the use of other standard ASHRAE 135 services when one of the components is modified or replaced.

1.1.1.4 Modbus Requirements

The UMCS must communicate using MODBUS Protocol, MODBUS TCP/IP over the Government furnished IP network as specified.

Modbus communications must support all of the following Modbus data types:

a. The four standard data types defined by MODBUS Protocol, MODBUS TCP/IP: Discrete Inputs, Coils, Input Registers, and Holding Registers. (Note that these four data types are included in the MODBUS Protocol, MODBUS TCP/IP standard. The remaining data types indicated in this Section are not included in the MODBUS Protocol, MODBUS TCP/IP standard but are defined by this Section to provide a standard for communication between systems.)

b. Character: Character data using a single Input Register or single Holding Register where that Modbus register is interpreted as two 8 bit ISO 8859-1 characters, with the low order bits representing the right-hand character.

c. Floating Point: Floating point data using two consecutive Input Registers or two consecutive Holding Registers where the resulting 32 bits are interpreted as a Binary32 (Single Precision Floating point) number as specified in IEEE 754. Use the first Register for the higher 16 bits, and the second Register for the lower 16 bits.

d. Integer Date: Date data using three consecutive Input Registers or three consecutive Holding Registers where the resulting 48 bits are interpreted as a 48-bit unsigned big-endian integer. The value is the number of milliseconds, not including leap seconds, from 1970-01-01T00:00:00.000 (12AM, January 1, 1970). Use the first Register for the highest 16 bits and the third Register for the lowest 16 bits.

e. Character Date: Date data using the format specified in ISO 8601 of "YYYY-MM-DDTHH:MM:SS.SSS", where the individual characters are formatted as specified for character data.

1.1.1.5 OPC Requirements

The UMCS must communicate using OPC DA over the Government furnished IP network as shown and specified.

1.1.1.6 Niagara Framework Requirements

The UMCS must use the Niagara Framework and must communicate with Niagara Framework field control systems using the Fox protocol over the Government furnished IP network as indicated and specified.

1.1.2 Symbols, Definition and Abbreviations

Use symbols, definitions, and engineering unit abbreviations indicated in the contract drawings for displays, submittals and reports. For symbols, definitions and abbreviations not in the contract drawings use terms conforming at a minimum to IEEE Stds Dictionary and the ASHRAE FUN IP, as applicable.

1.1.3 System Units and Accuracy

Use English (inch-pound) units for displays, print-outs and calculations. Perform calculations with an accuracy of at least three significant figures. For displays and printouts present values to at least three significant figures.

1.1.4 Data Packages/Submittals Requirements

Technical data packages consisting of computer software and technical data (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications must be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered must be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered shop drawings under the Federal Acquisition Regulation Supplement (FARS) and must contain no proprietary information and must be delivered with unrestricted rights.

1.2 RELATED SECTIONS

Cybersecurity requirements related to this Section are specified in a separate cybersecurity specification derived from UFGS 25 05 11. Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS specifies cybersecurity requirements related to this Section.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI INCITS 154 (1988; R 2004) Office Machines and Supplies - Alphanumeric Machines - Keyboard Arrangement

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135 (2016) BACnet—A Data Communication Protocol for Building Automation and Control Networks

ASHRAE FUN IP (2021) Fundamentals Handbook, I-P Edition

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D (2014) Control Network Protocol Specification

CEA-709.3 (1999; R 2015) Free-Topology Twisted-Pair Channel Specification

CEA-852-C (2014) Tunneling Device Area Network

Protocols Over Internet Protocol Channels

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 754	(2008) Floating-Point Arithmetic - IEEE Computer Society
IEEE 802.11	WARNING: Text in tags exceeds the maximum length of 300 characters
IEEE 1815	(2015; CORR 2016) Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815 Distributed Network Protocol (DNP3)
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 8601	(2004) Data Elements and Interchange Formats - Information Interchange - Representation of Dates and Times
ISO 8859-1	(1998) Information Technology - 8-Bit Single-Byte Coded Graphic Character Sets - Part 1: Latin Alphabet No. 1

INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 4361	(2006) Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)
IETF RFC 7465	(2015) Prohibiting RC4 Cipher Suites
RFC 821	(2001) Simple Mail Transfer Protocol (SMTP)

LONMARK INTERNATIONAL (LonMark)

LonMark Interoperability Guide	(2005) LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4
LonMark SNVT List	(2014) LonMark SNVT Master List; Version 15
LonMark XIF Guide	(2001) LonMark External Interface File Reference Guide; Revision 4.402

MODBUS ORGANIZATION, INC (MODBUS)

MODBUS Protocol	(2012) Modbus Application Protocol Specification; Version 1.1b3
MODBUS TCP/IP	(2006) Modbus Messaging on TCP/IP

Implementation Guide; Version V1.0b

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 262	(2019) Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

OPC FOUNDATION (OPC)

OPC DA	(Ver 3.0; Errata) OPC Data Access (DA)

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

TRIDIUM, INC (TRIDIUM)

Niagara Framework	(2012) NiagaraAX User's Guide
Tridium Open NiCS	(2005) Understanding the NiagaraAX Compatibility Statement (NiCS)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC EMC	(2002) FCC Electromagnetic Compliance Requirements
FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1778	(2014; Reprint Sep 2017) UL Standard for Safety Uninterruptible Power Systems
UL 60950	(2000; Reprint Oct 2007) Safety of Information Technology Equipment

1.4 DEFINITIONS

The following list of definitions may contain terms not found elsewhere in this Section but are included here for completeness. Some terms are followed with a protocol reference in parenthesis indicating to which protocol the term and definition applies. Inclusion of protocol-specific definitions does not create a requirement to support that protocol, nor does it relax any requirements to support specific protocols as indicated elsewhere in this section.

1.4.1 Alarm Generation

The process of comparing a point value (the point being alarmed) with a pre-defined alarm condition (e.g. a High Limit) and performing some action based on the result of the comparison.

1.4.2 Alarm Handling

see Alarm Routing

1.4.3 Alarm Routing

Alarm routing is M&C software functionality that starts with a notification that an alarm exists (typically as the output of an Alarm Generation process) and sends a specific message to a specific alarm recipient or device.

1.4.4 Application Generic Controller (AGC)(LonWorks)

A device that is furnished with a (limited) pre-established application that also has the capability of being programmed. Further, the ProgramID and XIF file of the device are fixed. The programming capability of an AGC may be less flexible than that of a General Purpose Programmable Controller (GPPC).

1.4.5 Application Specific Controller (ASC)(LonWorks)

A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e Program ID) with configurable settings.

1.4.6 BACnet (BACnet)

The term BACnet is used in two ways. First meaning the BACnet Protocol Standard - the communication requirements as defined by ASHRAE 135 including all annexes and addenda. The second to refer to the overall technology related to the ASHRAE 135 protocol.

1.4.7 BACnet Advanced Application Controller (B-AAC)(BACnet)

A hardware device BTL Listed as a B-AAC. A control device which contains BIBBs in support of scheduling and alarming but otherwise has limited resources relative to a B-BC. It may be intended for specific applications and supports some degree of programmability.

1.4.8 BACnet Advanced Operator Workstation (B-AWS)(BACnet)

Monitoring and Control (M&C) Software BTL Listed as an Advanced Operator

Workstation and includes the ability to manage scheduling, alarming and trending in an open manner. The B-AWS is the advanced operator's window into a BACnet system. It is primarily used to monitor the performance of a system and to modify parameters that affect the operation of a system.

1.4.9 BACnet Application Specific Controller (B-ASC)(BACnet)

A hardware device BTL Listed as a B-ASC. A controller with limited resources relative to a B-AAC. It is intended for use in a specific application and supports limited programmability.

1.4.10 BACnet Building Controller (B-BC)(BACnet)

A hardware device BTL Listed as a B-BC. A general-purpose, field-programmable device capable of carrying out a variety of building automation and control tasks including control and monitoring via direct digital control (DDC) of specific systems and data storage for trend information, time schedules, and alarm data. Like the other BTL Listed controller types (B-AAC, B-ASC etc.) a B-BC device is required to support the server ("B") side of the ReadProperty and WriteProperty services, but unlike the other controller types it is also required to support the client ("A") side of these services. Communication between controllers requires that one of them support the client side and the other support the server side, so a B-BC is often used when communication between controllers is needed.

1.4.11 BACnet Internetwork (BACnet)

Two or more BACnet networks connected with BACnet routers. In a BACnet Internetwork, there exists only one message path between devices.

1.4.12 BACnet Interoperability Building Blocks (BIBBs) (BACnet)

A BIBB is a collection of one or more BACnet services intended to define a higher level of interoperability. BIBBs are combined to build the BACnet functional requirements for a device in a specification. Some BIBBs define additional requirements (beyond requiring support for specific services) in order to achieve a level of interoperability. For example, the BIBB DS-V-A (Data Sharing-View-A), which would typically be used by an M&C client, not only requires the client to support the ReadProperty Service, but also provides a list of data types (Object / Properties) which the client must be able to interpret and display for the user.

1.4.13 BACnet Operator Display (B-OD)(BACnet)

A hardware device BTL Listed as a B-OD. A basic operator interface with limited capabilities relative to a B-OWS. It is not intended to perform direct digital control. The B-OD profile could be used for wall-mounted LCD devices, displays affixed to BACnet devices; hand-held terminals or other very simple user interfaces.

1.4.14 BACnet Operator Workstation (B-OWS)(BACnet)

Monitoring and Control (M&C) Software BTL Listed as a B-OWS. An operator interface with limited capabilities relative to a B-AWS. The B-OWS is used for monitoring and basic control of a system, but differs from a B-AWS in that it does not support configuration activities, nor does it provide advanced troubleshooting capabilities.

1.4.15 BACnet Smart Actuator (B-SA)(BACnet)

A hardware device BTL Listed as a B-SA. A simple control output device with limited resources; it is intended for specific applications.

1.4.16 BACnet Smart Sensor (B-SS)(BACnet)

A hardware device BTL Listed as a B-SS. A simple sensing device with very limited resources.

1.4.17 BACnet Testing Laboratories (BTL)(BACnet)

Established by BACnet International to support compliance testing and interoperability testing activities and consists of BTL Manager and the BTL Working Group (BTL-WG). BTL also publishes Implementation Guidelines.

1.4.18 BACnet Testing Laboratories (BTL) Listed (BACnet)

A device that has been certified by BACnet® Testing Laboratory. Devices may be certified to a specific device profile, in which case the certification indicates that the device supports the required capabilities for that profile, or may be certified as "other".

1.4.19 Binary

A two-state system or signal; for example one where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

1.4.20 Binding (LonWorks)

The act of establishing communications between CEA-709.1-D devices by associating the output of a device to the input of another so that information is automatically (and regularly) sent without being requested by the recipient.

1.4.21 Broadcast

Unlike most messages, which are intended for a specific recipient device, a broadcast message is intended for all devices on the network.

1.4.22 Building Control Network (BCN)

The network used by the Building Control System. Typically the BCN is a BACnet ASHRAE 135 or LonWorks CEA-709.1-D network installed by the building control system contractor.

1.4.23 Building Control System (BCS)

One type of Field Control System. A control system for building electrical and mechanical systems, typically HVAC (including central plants) and lighting. A BCS generally uses Direct Digital Control (DDC) Hardware and generally does NOT include its own local front end.

1.4.24 Building Point of Connection (BPOC)

A FPOC for a Building Control System. (This term is being phased out of use in preference for FPOC but is still used in some specifications and criteria. When it was used, it typically referred to a piece of control hardware. The current FPOC definition typically refers instead to IT hardware)

1.4.25 Channel (LonWorks)

A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 128 devices per channel.

1.4.26 Commandable (BACnet)

A point (Object) is commandable if its Present_Value Property is writable and it supports the optional Priority_Array Property. This functionality is useful for Overrides.

1.4.27 Configuration Property (LonWorks)

Controller parameter used by the application which is usually set during installation/testing and seldom changed. For example, the P and I settings of a P-I control loop. Also see 'Standard Configuration Property Type (SCPT)'

1.4.28 Control Logic Diagram

A graphical representation of control logic for multiple processes that make up a system.

1.4.29 Device Object (BACnet)

Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object_Identifier number on the BACnet Internetwork. This number is often referred to as the device instance or device ID.

1.4.30 Explicit Messaging (LonWorks)

A non-standard and often vendor (application) specific method of communication between devices.

1.4.31 External Interface File (XIF) (LonWorks)

A file which documents a device's external interface, specifically the number and types of LonMark objects, the number, types, directions, and connection attributes of network variables, and the number of message tags.

1.4.32 Field Point Of Connection (FPOC)

The FPOC is part of the UMCS IP network and acts as the point of connection between the UMCS IP Network and the field control IP network. The FPOC is an IT device such as a switch, IP router, or firewall, typically managed by the site IT staff. (Note that the field control IP network may consist of a single IP device, or that integration may require installation of a field control network IP device.)

1.4.33 Field Control Network

The network used by a field control system.

1.4.34 Field Control System (FCS)

A building control system or utility control system.

1.4.35 Fox Protocol (Niagara Framework)

The protocol used for communication between components in the Niagara Framework. By default, Fox uses TCP port 1911

1.4.36 Functional Profile (LonWorks)

A standard description, defined by LonMark International, of a LonMark Object used to classify and certify devices.

1.4.37 Gateway

A device that translates from one protocol to another. Devices that change only the transport mechanism of the protocol - "translating" from LonWorks over TP/FT-10 to LonWorks over IP for example - are not gateways as the underlying protocol (data format) does not change. Gateways are also called Communications Bridges or Protocol Translators.

1.4.38 General Purpose Programmable Controller (GPPC) (LonWorks)

Unlike an ASC or AGC, a GPPC is not furnished with a fixed application program and does not have a fixed ProgramID or XIF file. A GPPC can be (re-)programmed, usually using vendor-supplied software. When a change to the program affects the external interface (and the XIF file) the ProgramID will change.

1.4.39 Internetwork (BACnet)

See BACnet Internetwork.

1.4.40 JACE (Niagara Framework)

Java Application Control Engine. See Niagara Framework Supervisory Gateway

1.4.41 LonMark Object (LonWorks)

A collection of network variables, configuration properties, and associated behavior defined by LonMark International and described by a Functional Profile. It defines how information is exchanged between devices on a network (inputs from and outputs to the network).

1.4.42 LNS Plug-in (LonWorks)

Software which runs in an LNS compatible software tool, typically a network configuration tool. Device configuration plug-ins provide a 'user friendly' method to edit a device's configuration properties.

1.4.43 LonMark (LonWorks)

See LonMark International. Also, a certification issued by LonMark International to CEA-709.1-D devices.

1.4.44 LonMark International (LonWorks)

Standards committee consisting of independent product developers, system integrators and end users dedicated to determining and maintaining the interoperability guidelines for LonWorks. Maintains guidelines for the interoperability of CEA-709.1-D devices and issues the LonMark Certification for CEA-709.1-D devices.

1.4.45 LonWorks (LonWorks)

The term used to refer to the overall technology related to the CEA-709.1-D protocol (sometimes called "LonTalk"), including the protocol itself, network management, interoperability guidelines and products.

1.4.46 LonWorks Network Services (LNS) (LonWorks)

A network management and database standard for CEA-709.1-D devices.

1.4.47 LonWorks Network Services (LNS) Database (LonWorks)

The standard database created and used by LonWorks Network Services (LNS) compatible tools, such as LNS Network Configuration tools.

1.4.48 Modbus

A basic protocol for control network communications generally used in utility control systems. The Modbus protocol standard is maintained by The Modbus Organization.

1.4.49 Master-Slave/Token Passing (MS/TP)(BACnet)

Data link protocol as defined by the BACnet standard. Multiple speeds (data rates) are permitted by the BACnet MS/TP standard.

1.4.50 Monitoring and Control (M&C) Software

The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

1.4.51 Network (BACnet)

In BACnet, a portion of the control internetwork consisting of one or more segments of the same media connected by repeaters. Networks are separated by routers.

1.4.52 Network Variable (LonWorks)

See 'Standard Network Variable Type (SNVT)'.

1.4.53 Network Configuration Tool (LonWorks)

The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

1.4.54 Niagara Framework

A set of hardware and software specifications for building and utility control owned by Tridium Inc. and licensed to multiple vendors. The

Framework consists of front end (M&C) software, web based clients, field level control hardware, and engineering tools. While the Niagara Framework is not adopted by a recognized standards body and does not use an open licensing model, it is sufficiently well-supported by multiple HVAC vendors to be considered a de-facto Open Standard.

1.4.55 Niagara Framework Supervisory Gateway (Niagara Framework)

DDC Hardware component of the Niagara Framework. A typical Niagara architecture has Niagara specific supervisory gateways at the IP level and other (non-Niagara specific) controllers on field networks (TP/FT-10, MS/TP, etc.) beneath the Niagara supervisory gateways. The Niagara specific controllers function as a gateway between the Niagara framework protocol (Fox) and the field network beneath. These supervisory gateways may also be used as general purpose controllers and also have the capability to provide a web-browser based user interface.

Note that different vendors refer to this component by different names. The most common name is "JACE"; other names include "EC-BOS", "FX-40", and "UNC".

1.4.56 Node (LonWorks)

A device that communicates using the CEA-709.1-D protocol and is connected to a CEA-709.1-D network.

1.4.57 Node Address (LonWorks)

The logical address of a node on the network, consisting of a Domain number, Subnet number and Node number. Note that the "Node number" portion of the address is the number assigned to the device during installation and is unique within a subnet. This is not the factory-set unique Node ID (see Node ID).

1.4.58 Node ID (LonWorks)

A unique 48-bit identifier assigned (at the factory) to each CEA-709.1-D device. Sometimes called the Neuron ID.

1.4.59 Object (BACnet)

A BACnet Object. The concept of organizing BACnet information into standard components with various associated Properties. Examples include Analog Input objects and Binary Output objects.

1.4.60 Override

To change the value of a point outside of the normal sequence of operation where this change has priority over the sequence. An override can be accomplished in one of two ways: the point itself may be Commandable and written to with a priority or there may be a separate point on the controller for the express purpose of implementing the override.

Typically this override is from the Utility Monitoring and Control System (UMCS) Monitoring and Control (M&C) Software. Note that this definition is not standard throughout industry.

1.4.61 Point, Calculated

A value within the M&C Software that is not a network point but has been calculated by logic within the software based on the value of network points or other calculated points. Calculated points are sometimes called virtual points or internal points.

1.4.62 Point, Network

A value that the M&C Software reads from or writes to a field control network.

1.4.63 Polling

A requested transmission of data between devices, rather than an unrequested transmission such as Change-Of-Value (COV) or Binding where data is automatically transmitted under certain conditions.

1.4.64 Program ID (LonWorks)

An identifier (number) stored in the device (usually EEPROM) that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and intended device usage.

1.4.65 Property (BACnet)

A BACnet Property - a data element associated with an Object. Different Objects have different Properties, for example an Analog Input Object has a Present_Value Property (which provides the value of the underlying hardware analog input), a High_Limit Property (which contains a high limit for alarming), as well as other properties.

1.4.66 Protocol Implementation Conformance Statement (PICS)(BACnet)

A document, created by the manufacturer of a device, which describes which potions of the BACnet standard are implemented by a given device.

1.4.67 Repeater

A device that connects two control network segments and retransmits all information received on one side onto the other.

1.4.68 Router (LonWorks)

A device that connects two channels and controls traffic between the channels by retransmitting signals received from one subnet onto the other based on the signal destination. Routers are used to subdivide a control network and to control bandwidth usage.

1.4.69 Router (BACnet)

A device that connects two or more BACnet networks and controls traffic between the networks by retransmitting signals received from one network onto another based on the signal destination. Routers are used to subdivide an internetwork and to control bandwidth usage.

1.4.70 Segment

A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type. For example, a TP/FT-10 segment with locally powered devices is limited to 64 devices, and a BACnet MS/TP segment is limited to 32 devices.

1.4.71 Service (BACnet)

A BACnet Service. A defined method for sending a specific type of data between devices. Services are always defined in a Client-Server manner, with a Client initiating a Service request and a Server Executing the Service. Some examples are ReadProperty (a client requests a data value from a server), WriteProperty (a client writes a data value to a server), and CreateObject (a client requests that a server create a new object within the server device).

1.4.72 Service Pin (LonWorks)

A hardware push-button on a device which causes the device to broadcast a message containing its Node ID and Program ID. This broadcast can also be initiated via software.

1.4.73 Standard BACnet Object/Property/Service (BACnet)

BACnet Objects, Properties, or Services that are standard Objects, Properties, or Services enumerated and defined in ASHRAE 135. Clause 23 of ASHRAE 135 defines methods to extend ASHRAE 135 to non-standard or proprietary information. Standard BACnet Objects/Properties/Services specifically exclude any vendor specific extensions.

1.4.74 Standard Configuration Property Type (SCPT) (LonWorks)

Pronounced 'skip-it'. A standard format type (maintained by LonMark International) for Configuration Properties.

1.4.75 Standard Network Variable Type (SNVT) (LonWorks)

Pronounced 'snivet'. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

1.4.76 Subnet (LonWorks)

Consists of a logical grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Each subnet is assigned a number which is unique within the Domain. See also Node Address.

1.4.77 Supervisory Controller

A controller implementing a combination of supervisory logic (global control strategies or optimization strategies), scheduling, alarming, event management, trending, web services or network management. Note this is defined by use; many supervisory controllers have the capability to also directly control equipment.

1.4.78 Supervisory Gateway

A device that is both a supervisory controller and a gateway, such as a

Niagara Framework Supervisory Gateway.

1.4.79 TP/FT-10 (LonWorks)

A Free Topology Twisted Pair network (at 78 kbps) defined by CEA-709.3. This is the most common media type for a CEA-709.1-D control network.

1.4.80 TP/XF-1250 (LonWorks)

A high speed (1.25 Mbps) twisted pair, doubly-terminated bus network defined by the LonMark Interoperability Guidelines. This media is typically used only as a backbone media to connect multiple TP/FT-10 networks.

1.4.81 UMCS Network

An IP network connecting multiple field control systems to the Monitoring and Control Software using one or more of: LonWorks (CEA-709.1-D and CEA-852-C), BACnet (ASHRAE 135 Annex J), MODBUS Protocol, MODBUS TCP/IP or OPC DA.

1.4.82 User-defined Configuration Property Type (UCPT) (LonWorks)

Pronounced 'u-keep-it'. A Configuration Property format type that is defined by the device manufacturer.

1.4.83 User-defined Network Variable Type (UNVT) (LonWorks)

A network variable format defined by the device manufacturer. Note that UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.4.84 Utility Control System (UCS)

One type of field control system. Used for control of utility systems such as an electrical substation, sanitary sewer lift station, water pump station, etc. Building controls are excluded from a UCS, however it is possible to have a Utility Control System and a Building Control System in the same facility, and for those systems to share components such as the FPOC. A UCS may include its own local front-end.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES and TABLE 1: PROJECT SEQUENCING:

SD-02 Shop Drawings

UMCS Contractor Design Drawings; G

UMCS Contractor Design Drawings as a single complete package: 4 hard copies and 2 copies on CDROM. Submit hardcopy drawings on ISO A1 34 by 22 inchesorA3 17 by 11 inches sheets, and electronic drawings in both PDF and AutoCAD format.

Draft As-Built Drawings; G

Draft As-Built Drawings as a single complete package: 4 hard copies and 2 copies on CDROM. Submit hardcopy drawings must on ISO A1 34 by 22 inchesorA3 17 by 11 inches sheets, and electronic drawings in both PDF and AutoCAD format.

Final As-Built Drawings; G

Final As-Built Drawings as a single complete package: 4 hard copies and 2 copies on CDROM. Submit hardcopy drawings on ISO A1 34 by 22 inchesorA3 17 by 11 inches sheets, and electronic drawings in both PDF and AutoCAD format.

SD-03 Product Data

Product Data Sheets; G

Computer Software; G

The most recent versions of all computer software provided under this specification delivered as a Technical Data Package. Submit the user manuals for all software delivered for this project with the software.

Enclosure Keys; G

SD-05 Design Data

UMCS IP Network Bandwidth Usage Estimate; G

Four copies of the UMCS IP Network Bandwidth Usage Estimate.

SD-06 Test Reports

Pre-Construction QC Checklist; G

Four copies of the Pre-Construction QC Checklist.

Post-Construction QC Checklist; G

Four copies of the Post-Construction QC Checklist.

Factory Test Procedures; G

Four copies of the Factory Test Procedures. The Factory Test Procedures may be submitted as a Technical Data Package.

Factory Test Report; G

Four copies of the Factory Test Report. The Factory Test Report may be submitted as a Technical Data Package.

Existing Conditions Report; G

Four copies of the Existing Conditions Report.

Start-Up and Start-Up Testing Report; G

Four copies of the Start-Up and Start-Up Testing Report. The

Start-Up and Testing report may be submitted as a Technical Data Package.

PVT Phase I Procedures; G

Four copies of the PVT Phase I Procedures. The PVT Procedures may be submitted as a Technical Data Package.

PVT Phase I Report; G

Four copies of the PVT Phase I Report. The PVT Phase I Report may be submitted as a Technical Data Package.

PVT Phase II Report; G

Four copies of the PVT Phase II Report. The PVT Phase II Report may be submitted as a Technical Data Package.

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G

Four bound O&M Instructions and 1 copies of the Instructions in PDF format on optical disc. Index and tab bound instructions. Submit instructions in PDF form as a single PDF file, or as multiple PDF files with a PDF file table of contents containing links to the other files. O&M Instructions may be submitted as a Technical Data Package.

Preventive Maintenance Work Plan; G

Four copies of the Preventive Maintenance Work Plan. The Preventive Maintenance Work Plan may be submitted as a Technical Data Package.

Basic Training Documentation; G

Training manuals for Basic Training delivered for each trainee on the Course Attendance List with two additional copies delivered for archival at the project site. Submit two copies of the Course Attendance List with the archival copies. The Basic Training Documentation may be submitted as a Technical Data Package.

Advanced Training Documentation; G

One set of training manuals delivered for each trainee on the Course Attendance List with two additional copies delivered for archival at the project site. Submit two copies of the Course Attendance List with the archival copies. The Advanced Training Documentation may be submitted as a Technical Data Package.

Refresher Training Documentation; G

One set of training manuals delivered for each trainee on the Course Attendance List with two additional copies delivered for archival at the project site. Submit two copies of the Course Attendance List with the archival copies. The Refresher Training Documentation may be submitted as a Technical Data Package.

SD-11 Closeout Submittals

Closeout QC Checklist; G

Four copies of the Closeout QC Checklist.

1.6 PROJECT SEQUENCING

TABLE I: PROJECT SEQUENCING specifies the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3 EXECUTION (denoted by an 'E' in the 'TYPE' column).

1.6.1 Sequencing for Submittals

The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within 14 days of notification that the submittal has been rejected. Upon re-submittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

1.6.2 Sequencing for Activities

The sequencing specified for activities indicates the earliest the activity may begin.

1.6.3 Abbreviations

In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE I. PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1		Notice to proceed	
2	S	Existing Conditions Report	7 days after #1
3	S	Design Drawings	28 days after #1
4	S	Product Data Sheets and Certificate of Networthiness Documentation	[_____] days after #1
5	S	UMCS IP Network Bandwidth Usage Estimate	[_____] days after #1

TABLE I. PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
6	S	Pre-construction QC Checklist	[_____] days after #1
7	E	Install UMCS	AAO #2 thru #6
8	E	Start-Up and Start-Up Testing	ACO #7
9	S	Post-Construction QC Checklist	[_____] days ACO #8
10	S	Computer Software	[_____] days ACO #8
11	S	Start-Up and Start-Up Testing Report	[_____] days ACO #8
12	S	Draft As-Built Drawings	[_____] days ACO #8
13	S	PVT Phase I Procedures	[_____] days before scheduled start of #14 and AAO #11
14	E	PVT Phase I	AAO #13 and #12
15	S	PVT Phase I Report	[_____] days ACO #14
16	S	Preventive Maintenance Work Plan	AAO #11
17	S	O&M Instructions	AAO #11
18	S	Basic Training Documentation	AAO #11 and [_____] days before scheduled start of #19
19	E	Basic Training (PVT Phase II)	AAO #16, #17 and #18
20	S	PVT Phase II Report	[_____] days ACO #19
21	S	Final As-Built Drawings	[_____] days AAO #20
22	S	Advanced Training Documentation	[_____] days before schedule start of #23 and AAO #18
23	E	Advanced Training	ACO #19, [_____] days AAO #22, and no later than [60] days ACO #19

TABLE I. PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
24	S	Refresher Training Documentation	[_____] days before #25 and AAO #18 and #22
25	E	Refresher Training	between [_____] and [_____] days ACO #19 and AAO #24
26	S	Closeout QC Checklist	ACO #23

1.7 QUALITY CONTROL (QC) CHECKLISTS

The Contractor's Chief Quality Control (QC) Representative must complete the QC Checklist in APPENDIX A, and must submit the Pre-Construction QC Checklist, Post-Construction QC Checklist and Closeout QC Checklist as specified. The QC Representative must verify each item in the Checklist and initial in the provided area to indicate that the requirement has been met. The QC Representative must sign and date the Checklist prior to submission to the Government.

The APPENDIX A QC Checklist is available as an editable file at http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-10-10.

1.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Provide UMCS Operation and Maintenance Instructions which include:

a. Procedures for the UMCS system start-up, operation and shut-down.

b. Final As-Built drawings.

c. Routine maintenance checklist, arranged in a columnar format: The first column listing all installed devices, the second column stating the maintenance activity or stating that no maintenance required, the third column stating the frequency of the maintenance activity, and the fourth column providing any additional comments or reference.

d. Qualified service organization list including points of contact with phone numbers.

e. Start-Up and Start-Up Testing Report.

f. Performance Verification Test (PVT) Procedures and Reports.

PART 2 PRODUCTS

2.1 EQUIPMENT REQUIREMENTS

2.1.1 Product Certifications

For computing devices, as defined in FCC Part 15, supplied as part of the

UMCS provide devices which are certified to comply with the requirements of Class B computing devices.

2.1.2 Product Sourcing

For units of the same type of equipment, provide products of a single manufacturer. For each major component of equipment provide equipment with the manufacturer's name and the model and serial number in a conspicuous place. For materials and equipment, provide new standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products.

2.1.3 General Requirements

Provide components that meet the following requirements:

a. Portions of the data communications equipment system installed in unconditioned spaces must operate properly in an environment with ambient temperatures between 32 and 120 degrees F and ambient relative humidity between 10 percent and 90 percent noncondensing.

b. Components must accept 100 to 125 volts AC (Vac), 60 Hz, single phase, three wire with a three-pronged, dedicated circuit outlet or be provided with a transformer to meet the component's power requirements.

c. The equipment must meet the requirements of NFPA 70, UL 60950, NFPA 262, FCC EMC, and FCC Part 15.

2.1.4 Nameplates

Provide nameplates of laminated plastic identifying the function, network address, if applicable, and identifier of the device. Laminated plastic must be at least 0.125 inch thick, white with black center core. Nameplates must be a minimum of 1 by 3 inch with minimum 0.25 inch high engraved block lettering.

2.1.5 Product Data Sheets

For all products (equipment) specified in PART 2 and supplied under this contract, submit copies of all manufacturer catalog cuts and specification sheets to indicate conformance to product requirements. For Monitoring and Control (M&C) Software also include the PICS verifying BTL Listing as a B-AWS.

2.2 CONTROL HARDWARE

2.2.1 Control Protocol Routers

2.2.1.1 LonWorks/IP Router

Provide LonWorks/IP Routers which perform layer 3 routing of CEA-709.1-D packets over an IP network in accordance with CEA-852-C. The router must provide the appropriate connection to the IP network and connections to the CEA-709.3 TP/FT-10 or TP/XF-1250 network. LonWorks/IP Routers must support the Dynamic Host Configuration Protocol (DHCP; IETF RFC 4361) for IP configuration and the use of an CEA-852-C Configuration Server (for CEA-852-C configuration), but must not rely on these services for configuration. LonWorks/IP Routers must be capable of manual configuration via a console RS-232 port.

2.2.1.2 BACnet/IP Router

Provide BACnet/IP Routers which perform layer 3 routing of ASHRAE 135 packets over an IP network in accordance with ASHRAE 135 Annex J and Clause 6. The router must provide the appropriate connection to the IP network and connections to a ASHRAE 135 MS/TP, or other ASHRAE 135 network. Devices used as BACnet/IP Routers must be BTL Listed and must support the Network Management-Router Configuration-B (NM-RC-B) BIBB.

2.2.1.3 Modbus/IP Router

Provide Modbus/IP Routers which perform layer 3 routing of MODBUS Protocol/ MODBUS TCP/IP packets over an IP network in accordance with MODBUS Protocol/ MODBUS TCP/IP. The router must provide the appropriate connection to the IP network and connections to a non-IP MODBUS Protocol/MODBUS TCP/IP network. Modbus/IP Routers must support the Dynamic Host Configuration Protocol (DHCP; IETF RFC 4361) for IP configuration but must not rely on this service for configuration. Modbus/IP Routers must be capable of disabling the capability for remote configuration of Modbus routing information from the IP network.

2.2.2 Monitoring and Control (M&C) Controller Hardware

Provide Monitoring and Control (M&C) Controller Hardware which is a Niagara Framework Supervisory Gateway or a microprocessor-based direct digital control hardware and which communicates over the UMCS IP network using one of:

a. CEA-709.1-D in accordance with CEA-852-C and using only Standard Network Variable Types (SNVTs) as defined by the LonMark SNVT List.

b. ASHRAE 135 in accordance with ASHRAE 135 Annex J and using only Standard ASHRAE 135 services.

Monitoring and Control (M&C) Controller Hardware must either meet the requirements of the LonMark Interoperability Guide or be BTL Listed.

2.2.3 BACnet Supervisory Controller Hardware

Provide BACnet Supervisory Controller Hardware which is direct digital control hardware and which:

a. is BTL Listed

b. communicates using ASHRAE 135 over an IP network in accordance with ASHRAE 135 Annex J

c. has a configurable Object_Name Property

d. supports the following BIBBS

(1) DS-RP-B (Data Sharing-Read Property-B) BIBB for Objects requiring read access from the M&C Software

(2) DS-WP-B (Data Sharing-Write Property-B) BIBB for Objects requiring write access from the M&C Software.

(3) SCHED-E-B (Scheduling-External-B)

(4) AE-N-I-B (Alarm and Event-Notification Internal-B)

(5) AE-ACK-B (Alarm and Event-ACK-B)

(6) T-VMT-I-B (Trending-Viewing and Modifying Trends-Internal-B)

(7) T-ATR-B (Trending-Automated Trend Retrieval-B)

e. has a Writable Recipient_List Property of the Notification Class Object

2.2.4 Control Protocol Gateways

Provide Control Protocol Gateways which perform bi-directional protocol translation between two of the following protocols, or between one of the following protocols and another protocol: CEA-709.1-D, ASHRAE 135, MODBUS Protocol, MODBUS TCP/IP, Fox protocol, and OPC DA. Provide Control Protocol Gateways which also meet the following requirements.

a. Gateways must have two or more separate network connections, each appropriate for the protocol and media used. A single network connection must not be used for both protocols.

b. Gateways must be capable of being installed, configured and programmed through the use of instructions in the manual supplied by the Contractor.

c. Provide and license to the Government all software required for gateway configuration.

d. Gateways must retain their configuration after a power loss of an indefinite time, and must automatically return to their pre-power loss state once power is restored.

e. Gateways must provide capacity for mapping all required points as indicated plus an additional 10 percent between the two protocols it uses.

f. Gateways must, in addition, meet all requirements specified (in the following subparagraphs) for each of the two protocols it translates.

2.2.4.1 Gateway for CEA-709.1

For a gateways using CEA-709.1-D provide gateways which meet the following requirements in addition to the requirements for all gateways:

a. It must allow bi-directional mapping of data in the Gateway to Standard Network Variable Types (SNVTs) according to the LonMark SNVT List.

b. Gateways communicating CEA-709.1-D over an IP network must communicate in accordance with CEA-852-C.

c. It must allow of its standard network variables (SNVTs) and support transmitting data using the "min, max, and delta" (throttling and heartbeat) methodology.

d. It must provide the ability to label SNVTs.

e. It must supply a LonMark external interface file (XIF) as defined in the LonMark XIF Guide for use with LNS tools and utilities.

f. It must have a "service pin" which, when pressed, will cause the Gateway to broadcast its 48-bit NodeID and ProgramID over the network.

g. It must provide a configurable self-documenting string.

2.2.4.2 Gateway for ASHRAE 135

For gateways using ASHRAE 135 provide gateways which meets the following requirements in addition to the requirements for all gateways:

a. It must allow bi-directional mapping of data in the Gateway to Standard Objects as defined in ASHRAE 135.

b. All ASHRAE 135 Objects must have a configurable Object_Name Property.

c. It must be BTL Listed.

d. Gateways communicating ASHRAE 135 over an IP network must communicate in accordance with ASHRAE 135 Annex J.

e. Gateways communicating ASHRAE 135 to a field control systems must support the DS-RP-A (Data Sharing-Read Property-A) BIBB and the DS-WP-A (Data Sharing-Write Property-A) BIBB.

f. Gateways communicating ASHRAE 135 to the M&C Software or to a BACnet Supervisory Controller must support the DS-RP-B (Data Sharing-Read Property-B) BIBB for Objects requiring read access from the M&C Software and the DS-WP-B (Data Sharing-Write Property-B) BIBB for Objects requiring write access from the M&C Software

2.2.4.3 Gateway for Modbus

For gateways that use MODBUS Protocol/MODBUS TCP/IP provide gateways that meet the requirements specified for all gateways and which allow bi-directional mapping of data in the Gateway to MODBUS Protocol/ MODBUS TCP/IP registers using the four standard Modbus register types (Discrete Input, Coil, Input Register,and Holding Register). Gateways communicating MODBUS Protocol/MODBUS TCP/IP to the M&C Software must communicate via MODBUS Protocol/MODBUS TCP/IP over TCP/IP and must present floating point values, character values, and date values using the appropriate data type as specified in paragraph MODBUS REQUIREMENTS.

2.2.4.4 Gateway for OPC

For gateways that use OPC DA, provide gateways that meet the requirements specified for all gateways and which allow bi-directional mapping of data in the Gateway using OPC DA tags and which communicate over an IP network in accordance with OPC DA.

2.2.4.5 Gateway for DNP3

For gateways that use DNP3, provide gateways that meet the requirements specified for all gateways and which allow bi-directional mapping of data in the Gateway to DNP3 object groups and variations as defined by IEEE 1815. Gateways communicating DNP3 over an IP network must communicate in accordance with the LAN/WAN Networking volume of IEEE 1815.

2.3 COMPUTER HARDWARE

For computer hardware furnished under this specification provide standard products of a single manufacturer which advertises service in all 48 contiguous states, and provide only model currently in production. Except for PCI-E cards installed into expansion slots provided in a desktop or server computer in order to meet the requirements of this specification, do not modify computer hardware from the manufacturer configuration.

2.3.1 Server Hardware

Computer Server Hardware (server) must be a desktop or server computer meeting the following minimum requirements:

2.3.1.1 Processor

Quad-core processor designed for server applications. Processor speed must be at least 50 percent of the speed of the fastest Intel server processor commercially available.

2.3.1.2 Random Access Memory (RAM)

300 percent of the recommended requirements of the software to be installed on the server.

2.3.1.3 Communications Ports

Four USB ports.

2.3.1.4 Hard Drives

2.3.1.4.1 Internal Hard Drives

Hard drives with SATA-3 Controller providing at least 2TB usable disk space. Hard drives must use RAID (Redundant Array of Inexpensive Disks) at levels 1 or 5 (RAID-1 or RAID-5).

2.3.1.4.2 External Hard Drive

4TB disk space with a USB 3.0 interface.

2.3.1.5 Optical Drive

Blueray burner drive.

2.3.1.6 Video Output

32-bit color at a minimum resolution of 1920 by 1080 at a minimum refresh rate of 70 Hz and a DVI or display port output.

2.3.1.7 Network Interface

Two integrated 1000Base-T Ethernet with RJ45 connector.

2.3.1.8 Monitor

Widescreen flat panel LCD monitor sized as indicated but no less than 24 inch nominal with a minimum resolution of 1600 by 1050 pixels and a minimum refresh rate of 70Hz.

2.3.1.9 Keyboard

101 key wired USB keyboard having a minimum 64 character standard ASCII character set based on ANSI INCITS 154 and an integral smart card reader compatible with a Department of Defense Common Access Card (CAC).

2.3.1.10 Mouse

2-button wired USB optical scroll mouse with a minimum resolution of 400 dots per inch.

2.3.1.11 Power Supplies

Hot-swappable redundant power supplies.

2.3.2 Workstation Hardware (Desktop and Laptop)

Provide a standard desktop computer or a laptop meeting the following minimum requirements for the Computer Workstation Hardware (workstation) as indicated.

2.3.2.1 Processor

2.3.2.1.1 Desktop

Quad-core processor designed for desktop applications. Processor speed must be at least 75 percent of the speed of the fastest Intel desktop processor commercially available.

2.3.2.1.2 Laptop

Quad-core processor designed for laptop applications. Processor speed must be at least 50 percent of the speed of the fastest Intel laptop processor commercially available.

2.3.2.2 Random Access Memory (RAM)

300 percent of the recommended requirements of the software to be installed on the server and no less than 8GB.

2.3.2.3 Communications Ports

2.3.2.3.1 Desktop

Six USB ports.

2.3.2.3.2 Laptop

Two USB ports, plus a PCMCIA card slot or an additional USB port, plus an integral RS-232 serial port or an additional USB port and a USB to RS-232 serial adapter.

2.3.2.4 Hard Drive and Controller

2.3.2.4.1 Desktop

1.5TB or larger with a SATA-3 controller.

2.3.2.4.2 Laptop

250GB or larger solid state drive.

2.3.2.5 Optical Drive

DVD-RW drive

2.3.2.6 Video Output

2.3.2.6.1 Desktop

32-bit color with dual monitor support minimum resolutions of 1920 by 1080 at minimum refresh rates of 70 Hz and dual DVI or display port outputs.

2.3.2.6.2 Laptop

32-bit color with a minimum resolution of 1920 by 1080 at minimum refresh rates of 70 Hz and VGA or HDMI output.

2.3.2.7 Network Interface

2.3.2.7.1 Desktop

Integrated 1000Base-T Ethernet with RJ45 connector.

2.3.2.7.2 Laptop

Integrated 1000Base-T Ethernet with RJ45 connector and an integrated IEEE 802.11b/g/n wireless interface. The Laptop must have a physical switch for activation and deactivation of the wireless interface.

2.3.2.8 Monitor

2.3.2.8.1 Desktop

Dual widescreen flat panel LCD monitors sized as indicated but no less than 24 inch nominal with minimum resolutions of 1920 by 1080 pixels and a minimum refresh rate of 70Hz.

2.3.2.8.2 Laptop

LCD Screen sized as indicated but no less than 325 mm 13 inch nominal with a maximum supported resolution of no less than 1600 by 900 pixels.

2.3.2.9 Keyboard and Smart Card Reader

2.3.2.9.1 Desktop

101 key wired USB keyboard having a minimum 64 character standard ASCII character set based on ANSI INCITS 154 and an integral smart card reader compatible with a Department of Defense Common Access Card (CAC).

2.3.2.9.2 Laptop

Standard laptop keyboard. Internal smart card reader compatible with a Department of Defense Common Access Card (CAC).

2.3.2.10 Mouse

2.3.2.10.1 Desktop

2-button wired USB optical scroll mouse with a minimum resolution of 400 dots per inch.

2.3.2.10.2 Laptop

Integrated touch-pad plus a 2-button wired USB optical scroll mouse with a minimum resolution of 400 dots per inch.

2.3.3 Printers

Provide local or network printers as indicated. Provide local printers which have a USB interface. Provide network printers which have a 100Base-T or faster interface with an RJ45 connection and a firmware print spooler compatible with the Operating System print spooler.

2.3.3.1 Alarm Printer

Provide alarm printers which use sprocket-fed fanfold paper with adjustable sprockets for paper width up to 11 inches. Alrm printers must have programmable control of top-of-form. Provide floor stands with paper racks for alarm printers.

2.3.3.2 Laser Printer

Provide laser printers as indicated meeting the following minimum requirements:

Resolution	600 by 600 dots per inch
Printing Time	10 pages per minute
Data Buffer Size	16 Megabytes
Media Type	Paper and transparency film
Media Size	ANSI A(8.5 by 11 inches) and other sizes as indicated
Paper Cassette	250 sheet capacity

2.4 COMPUTER SOFTWARE

2.4.1 Operating System (OS)

The Operating System media will be furnished by the Government. The Government will provide the Operating System license.

2.4.2 Office Automation Software

Office Automation Software will be furnished by the Government.

2.4.3 Virus Protection Software

Virus Protection Software will be furnished by the Government.

2.4.4 Disk Imaging (Backup) Software

Disk imaging (backup) software will be furnished by the Government.

2.4.5 M&C Controller Hardware Configuration Software

Provide M&C Controller Hardware Configuration Software consisting of the software required to configure, program, or configure and program each Monitoring and Control (M&C) Controller Hardware provided for the functions it performs.

2.4.6 CEA-852-C Configuration Server

Provide CEA-852-C configuration server software meeting the requirements of CEA-852-C.

2.4.7 CEA-709.1-D Network Configuration Tool

Provide a network configuration tool software which:

a. Solely uses LonWorks Network Services (LNS) for all network configuration and management of CEA-709.1-D devices.

b. Is capable of executing LNS plug-ins.

c. Is capable of performing network database reconstruction of an CEA-709.1-D control network, such that if connected to an existing CEA-709.1-D network it has the ability to query the network and create an LNS database for that network.

d. Allows configuration of the network while off-line such that an operator may set up changes to the network while disconnected from the network, and then execute all of them once connected.

e. Includes the standard LNS Report Generator and is capable of generating and printing the following reports:

   (1) A table containing domain/subnet/node address and node identifier for the entire network or any subset thereof, selected by the user.

   (2) A table containing Standard Network Variable (SNVT) input and output details for any CEA-709.1-D device on the network.

   (3) A table containing Standard and User-Defined Configuration Properties (SCPTs and UCPTs) for any CEA-709.1-D device on the network.

f. Is capable of merging two existing standard LNS databases into a single standard LNS database.

2.4.8 BACnet Network Browser

Provide a BACnet Network Browser software that:

a. Can perform full discovery of a ASHRAE 135 system including but not limited to discovery of all ASHRAE 135 devices, the ASHRAE 135 Objects and Properties of each device, and the standard ASHRAE 135 services supported by each device.

b. Can read any ASHRAE 135 Property of any Object in any device. Proprietary Properties may be presented as read without further interpretation.

c. Can write any Standard ASHRAE 135 Property of any Object in any device.

d. Supports segmentation.

e. Supports all of the following BIBBs:

(1) DM-ANM-A (Device Management-Automatic Network Management-A)

(2) DM-ADM-A (Device Management-Automatic Device Management-A)

(3) DM-DDB-A (Device Management-Dynamic Device Binding-A)

(4) DM-DOB-A (Device Management-Dynamic Object Binding-A)

(5) DS-RP-A (Data Sharing-Read Property-A)

(6) DS-RPM-A (Data Sharing-Read Property Multiple-A)

(7) DS-WP-A (Data Sharing-Write Property-A)

2.4.9 Niagara Framework Engineering Tool

Provide Niagara Framework engineering tool software which:

a. has unrestricted interoperability license and a Niagara Compatibility Statement (NiCS) which follows the Tridium Open NiCS Specification.

b. is capable of performing network configuration for Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.

c. is capable of programming and configuring Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.

d. is capable of discovery of Niagara Framework Supervisory Gateways and all points mapped into each Niagara Framework Supervisory Gateway and making these points accessible to Niagara Framework Monitoring and Control Software.

2.4.10 Monitoring and Control (M&C) Software

Provide monitoring and control (M&C) software which is a client-server software package with a graphical user interface (GUI) using web-browser based clients. Provide Niagara Framework monitoring and control software which communicates with Niagara Framework field control systems using the Fox protocol. Provide M&C Software which communicates via CEA-709.1-D, and ASHRAE 135, and MODBUS Protocol/MODBUS TCP/IP, and OPC DA. The M&C Software may support other field control protocols. Provide M&C Software which is BACnet Testing Laboratories Certified ("Listed") as a B-AWS.

Provide a single software package which implements the Scheduling, Alarming, Trending, Graphical System Display, and System Display Editor functionality. Other specified M&C functionality may be implemented in the same software package or in additional software packages. As specified in PART 3 EXECUTION, the M&C Software must operate on Server hardware, except that software for Point Calculations and Demand Limiting may operate on M&C Controller Hardware.

2.4.10.1 M&C Software License

License the M&C Software as specified. Use of multiple copies of M&C Server software working in coordination and sharing data between them such that they function as, and appear to an operator as, a single M&C Server is permitted to meet these requirements.

2.4.10.1.1 Network Points

Provide M&C Software and licensing to support no less than than [_____] network points, and to be capable of expansion to support no less than 50,000 network points.

2.4.10.1.2 Web Clients

Provide M&C Software and licensing to support no less than 10 simultaneous web clients with no limit on the total number of web clients. M&C Software must be capable of expansion to support no less than 30 simultaneous web clients.

2.4.10.1.3 Calculations

Provide M&C Software and licensing to support no less than one calculated point for every ten network points (see "Network Points" above).

2.4.10.1.4 Other Points

For installations using M&C Software installed on M&C Controller Hardware (as opposed to Server hardware), provide additional licensing to support additional network points for the communications between portions of the M&C Software installed on different hardware. For example, if the Calculations requirement is performed by M&C Software installed on Controller hardware, the M&C Software must be licensed for additional network points to cover the network points required for communication between the Controller hardware and the Server hardware.

2.4.10.1.5 Alarming

Provide M&C Software and licensing to support alarm generation and the handling (routing) of alarms for no less than 10,000 points and ASHRAE 135 Alarm Event Notifications.

2.4.10.1.6 Trending

Provide M&C Software and licensing to support a minimum of 8,000 simultaneous trends.

2.4.10.1.7 Scheduling

Provide M&C Software and licensing to support a minimum of 200 user-definable schedules.

2.4.10.1.8 Niagara Framework Open License

Provide M&C Software with an unrestricted interoperability license and a Niagara Compatibility Statement (NiCS) which follows the Tridium Open NiCS

Specification.

2.4.10.2 M&C Software Update Licensing

In addition to all other licensing requirements, provide M&C Software licensing which includes licensing of the following software updates for a period of no less than 5 years:

a. Security and bug-fix patches issued by the M&C Software manufacturer.

b. Security patches to address any vulnerability identified in the National Vulnerability Database at http://nvd.nist.gov with a Common Vulnerability Scoring System (CVSS) severity rating of MEDIUM or higher.

2.4.10.3 Supported Field Control Protocols

Provide M&C Software which supports field control protocols as follows:

a. The M&C Software must include a driver to LNS, or a driver to an OPC interface to LNS, or a driver to CEA-852-C, and must be capable of reading and writing any SNVT on the CEA-852-C network. Software with a driver to LNS or a driver to an OPC interface to LNS must communicate with field control systems via LNS using this driver. Software with a driver to CEA-852-C must obtain all communication information (such as device addresses and network variable indices) from LNS and must automatically update this information whenever the LNS Database changes.

b. The M&C Software must include a driver to ASHRAE 135 over IP in accordance with ASHRAE 135 Annex J.

c. The M&C Software must include a driver to MODBUS Protocol/MODBUS TCP/IP over TCP/IP. The M&C Software must be capable of reading and writing the Modbus data types as defined in paragraph MODBUS REQUIREMENTS and must, in addition, be capable of manipulating and presenting arbitrary data formats derived from the four standard Modbus data types.

d. The M&C Software must be an OPC DA client.

e. The Software must use the Niagara Framework and must communicate with Niagara Framework Supervisory Gateways using the Fox protocol.

f. The M&C Software may, in addition, include drivers to other protocols.

Provide M&C Software capable of reading values from and writing values to points via any supported field protocol, and capable of reading values from one field protocol and writing them to another. All points obtained from any field protocol must be available to all M&C Software functionality.

2.4.10.4 Supported Enterprise Protocols

Provide M&C Software which supports oBIX, BACnet Web Services or OPC as an enterprise protocol and which meets the following requirements:

a. It is able to read values from any point or collection of points (network point, internal point, trend log or schedule) and transmit these values via the enterprise protocol.

b. It is able to receive data via the enterprise protocol and use this data to change the value of any point.

c. License the enterprise protocol interface to the project site and document he interface such that any system capable of communicating with that protocol can be used to read and write data from the M&C Software.

2.4.10.5 Point Information

Every point, both network and internal, in the M&C Software must contain the following fields:

2.4.10.5.1 Name

A configurable name used for identification of the point within the M&C Software.

2.4.10.5.2 Description

A configurable description of no less than 80 alpha-numeric characters.

2.4.10.5.3 Value

A field containing the current point value.

2.4.10.5.4 Units

A field containing the engineering units.

2.4.10.5.5 Source

A field identifying the source of the point. For network points, this is generally the address or identification of the field device (for example, the Domain-Subnet-Node address for LonWorks field control devices or the DeviceID for BACnet devices).

2.4.10.6 Point Calculations

Provide M&C software capable of performing calculations and computing the value of a calculated point based on the values of two or more network points and calculated points. Mathematical operators must include: addition, subtraction, multiplication, division, exponentiation (y^x, power), square root, reciprocal, natural logarithm, sin, cos, tan, arcsin, arccos, arctan, and parenthesis. Pi and e must be available as constants for use in calculations.

2.4.10.7 Browser-Based Graphical User Interface (GUI)

Provide M&C Software which includes a web-browser based (client-server) graphical user interface through which all M&C Software functionality, except for the Graphics Editor, System Display Editor, report configuration, point calculation configuration, and enterprise protocol configuration, is accessible.

Provide graphical user interface web server and web clients meeting the following requirements:

a. The web server must use HTTPS based on the Transport Layer Security (TLS) Protocol in accordance with IETF RFC 7465 using a Government-furnished certificate.

b. The graphical user interface must be Common Access Card (CAC) enabled: It must support web client authentication using certificates obtained from a Department of Defense Common Access Card (CAC) Smart Card.

c. The web client must operate on any version of Windows currently supported by Microsoft.

d. The web client must function in the most recent three version of Internet Explorer .

e. The web client must not require a connection to any server other than the M&C Server.

f. The web client must function in a browser with Java, Shockwave, Silverlight, and Flash installed. The client may require a download of mobile code from the M&C Server, but must not require the download of additional browser plug-ins or add-ins and there must be no limit on the number of downloads. The client must not require ActiveX.

2.4.10.8 Passwords

Provide M&C software with user-based access control to M&C functionality. The M&C Software must recognize at least 100 separate users and have at least 4 levels of user permissions. User permission levels (from most restrictive to most permissive) must include:

a. Permission Level 1: View-only access to the graphical user interface.

b. Permission Level 2: Permission Level 1 plus acknowledge alarms and set up (configure) trends and reports.

c. Permission Level 3: Permission Level 2 plus override points and set up (configure) alarms, schedules and demand limiting.

d. Permission Level 4: Permission Level 3 plus create and modify Graphical System Displays using the System Display Editor.____

Passwords must not be displayed and must not be logged. The system must maintain a disk file on the server hardware logging all activity of the system. This file must maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. If the file format is not plain ASCII text, provide a means to export or convert the file to plain ASCII text. Provide a mechanism for archiving the log files for long term record storage.

2.4.10.9 Graphical System Displays

Provide graphical displays consisting of building system (air handler units, VAV boxes, chillers, cooling towers, boilers, etc.) graphic displays. Data associated with an active display must be updated at least once every 5 seconds.

2.4.10.9.1 Navigation Scheme

System graphic displays of building systems and points must be hierarchical displays using a building-to-equipment point-and-click navigation scheme which allows navigation from a garrison-wide display, through a building-wide display to the individual units. Each display must show the building name and number. Each display must show system wide data such as outside air temperature and humidity in the case of an HVAC system application.

a. For each Building or Building Sub-Area display, show the building foot print and basic floor plan, and clearly show and distinguish between the individual zones and the equipment serving each zone and space. Show all space sensor and status readings, as applicable, for the individual zones such as space temperature, humidity, occupancy status, etc. Show the locations of individual pieces of monitored and controlled equipment.

b. For each equipment display show a one-line diagram control schematic and 3-dimensional representation of the individual pieces of equipment using the symbols and M&C point data types as specified. Use different colors and textures to indicate various components and real time data. Use consistent color and texture meanings across all displays.

c. Provide displays which clearly distinguish between the following point data types and information:

   (1) Real-time data.

   (2) Other user-entered data.

   (3) Devices in alarm (unacknowledged).

   (4) Out-of-range, bad, or missing data.

   (5) Points which are overridden.

2.4.10.9.2 Navigation Commands

Provide system displays which support English language operator commands via point-and-click mouse or keyboard entry for defining and selecting points, parameters, graphics, report generation, and all other functions associated with operation. The operator commands must be usable from any operator workstation with individual operator passwords as specified.

2.4.10.10 Graphic Editor

Provide a fully featured graphics editor and capable of creating custom graphics and graphic symbols for use by the System Display Editor.

2.4.10.11 System Display Editor

Provide a system display editor which allows the user to create, modify, and delete graphic displays. The display editor may have a separate user interface and is not required to be accessible via the web browser interface. Provide a display editor which includes the following functions:

a. Create and save displays. Save an existing or modified display as a new display (i.e. "save as")

b. Group and ungroup graphics, where graphics include both alphanumeric and graphic symbols, and where a grouped graphic is manipulated as a single graphic.

c. Place, locate, resize, move, remove, reposition, rotate and mirror a graphic on a display.

d. Overlay graphics over other graphics and assign depths such that when there are coincident graphics the one on top is visible.

e. Modify graphic properties based on the value of network points and create conditions governing the display of a graphics such that different graphics are visible based on the value of network points or calculated points

f. Integrate real-time data with the display.

g. Establish connecting lines.

h. Establish sources of latest data and location of readouts.

i. Display analog values as specified.

j. Assign conditions which automatically initiate a system display.

k. Include library of display symbols which include: Pump, Motor, Two- and Three-way Valves, Flow Sensing Element, Point and Averaging Temperature Sensors, Pressure Sensor, Humidity Sensor, Single and Double Deck Air Handling Unit, Fan, Chiller, Boiler, Air Compressor, Chilled Water Piping, Steam Piping, Hot Water Piping, Ductwork, Unit Heater, Pressure Reducing Valve, Damper, Electric Meter, Limit Switch, Flow Switch, High- and Low- Point and Averaging Temperature Switches, High- and Low-Pressure Switches, Coil, Solenoid Valve, Filter, Condensing Unit, Cooling Tower, Variable Frequency Drive (VFD), Heat Exchanger, Current Sensing Relays, Generator, Circuit Breaker, Transformer, Tank. Symbols must at a minimum conform to ASHRAE FUN IP where applicable.

2.4.10.12 Scheduling

a. Provide M&C software capable of changing the value of any network point according to a schedule. The M&C Software must be capable of scheduling points to any value, including a "null" or invalid value if one is defined for the data type of the point.

b. The specified scheduling functions must be operator accessible and adjustable via the graphical user interface. Each schedule must be able to change the value of multiple points. The M&C software must reinforce all schedules by transmitting the scheduled value no less than once every 30 minutes.

c. The M&C software must be capable of performing time synchronization and configuring Schedule Objects in ASHRAE 135 field devices in accordance with the DM-MTS-A (Device Management-Manual Time Synchronization-A).

d. The M&C software must be capable of performing time synchronization and configuring Niagara Framework Schedule Objects in Niagara Framework Supervisory Gateways.

e. The M&C Software must include a scheduling graphic display, accessible via the graphical user interface, with the following fields and functions:

(1) Current date and time.

(2) System identifier(s) and name(s), including location information such as Building name(s) and number(s).

(3) System group. Systems grouped by the user to perform according to a common schedule.

(4) Weekly schedules. For each system, a weekly schedule based on a seven day per week schedule with independent schedules for each day of the week including no less than 6 value changes per day.

(5) Holiday and special event schedules. Support for holiday and special event calendar schedules independent of the daily schedule. Special event schedules include one-time events and recurring events. Scheduling of one-time events include the beginning and ending dates and times of the event. Holiday and special event schedules must have precedence over device weekly schedules.

2.4.10.13 Alarms

Provide M&C Software meeting the following minimum requirements for alarms:

a. The M&C software must be capable of generating alarms by comparing the value of any point from any connected system to user-configurable limits, and configuring alarms in ASHRAE 135 field devices in accordance with the B-AWS BIBBs, and configuring alarms in Niagara Framework Supervisory Gateways using the Niagara Alarm Service.

b. The M&C software must be capable of handling (routing) alarms generated by the M&C Software, and alarms received as an ASHRAE 135 Alarm Event Notifications, and alarms received from a Niagara Framework Supervisory Gateway.

c. The M&C software must support Niagara Framework Alarm Classes.

d. The M&C software must support at least two alarm priority levels: critical and informational. Critical alarms must remain in alarm until acknowledged by an operator and the alarm condition no longer exists; informational alarms must remain in alarm until the alarm condition no longer exists or until the alarm is acknowledged.

e. The creation, modification, and handling (routing) of alarms must be fully accessible and fully adjustable from the graphical user interface.

f. Alarm Data. Alarm data to be displayed and stored must include:

(1) Identification of alarm including building, system (or sub-system), and device name.

(2) Date and time to the nearest second of occurrence.

(3) Alarm type:

(a) Unreliable: Indicates that the source device has failed due to the sensing device or alarm parameter being out-of-range or bad data.

(b) High Alarm.

(c) Low Alarm.

(4) Current value or status of the alarm point, including engineering units

(5) Alarm limits, including engineering units.

(6) Alarm priority.

(7) Alarm Message: A unique message with a field of at least 60 characters. Assignment of messages to an alarm must be an operator editable function.

(8) Acknowledgement status of the alarm including the time, date and user of acknowledgement.

g. Alarm Notification and Routing: The M&C software must be capable of performing alarm notification and routing functions. Upon receipt of ASHRAE 135 event notification, network variable of type SNVT_alarm or SNVT_alarm_2, OPC alarm, or upon generation of an alarm the M&C software must immediately perform alarm notification and routing according to an assigned routing for that alarm. The M&C software must support at least 100 alarm routes, where an alarm route is a unique combination of any of the following activities:

(1) Generate a pop-up up active clients. The pop-up display must include the Alarm Data. Alarms must be capable of being acknowledged from the pop-up display by operators with sufficient permissions. Pop-up must be displayed until acknowledged.

(2) Send an e-mail message via simple mail transfer protocol (SMTP; RFC 821). The e-mail must contain a configurable message and all alarm data. The e-mail recipient and scripted message must be user configurable for each alarm route.

(3) Print alarms to designated alarm printers. The printed message must be the same as the pop-up message.

h. Alarm Display and Acknowledgement. The M&C software must include an alarm display. Alarms must be available for display at each workstation as shown, along with all associated alarm data. Alarms must be capable of being acknowledged from this display. Multiple alarms must be capable of being acknowledged using a single command. Operator acknowledgment of one alarm must not automatically be considered as acknowledgment of any other alarm nor may it inhibit reporting of subsequent alarms.

i. Alarm Storage and Reports: The M&C software must store each alarm and its associated alarm data to hard disk and retain this information after the alarm no longer exists. The stored data must be sortable, searchable, and printable.

2.4.10.14 Trending

Provide M&C software capable of creating, modifying, uploading and archiving ASHRAE 135 Trend Objects in field devices in accordance with the B-AWS BIBBs and of performing real-time trending with a minimum trending rate of 100 points per second and of using the Niagara history service to create, modify, upload and archive trend log objects in Niagara Framework Supervisory Gateways.

a. The M&C Software must include a graphical display for trend configuration, creation and deletion accessible through the graphical user interface. Each trend must be user-configurable for:

   (1) Point to trend.

   (2) Sampling interval: adjustable between 1 second and 1 hour.

   (3) Start and Stop Time of Trend: Start and stop times determined by one or more of the following methods:

      (a) Start time and stop time

      (b) Start time and duration

      (c) Start time and number of samples

b. The M&C software must be capable of displaying and printing a graphical representation of each trend, and of multiple trended points on the same graph. The software must be capable of saving trend logs to a file. If the file format is not plain ASCII text in a Comma-Separated-Value (CSV) format, provide a means to export or convert the file to plain ASCII text in a CSV format.

2.4.10.15 Electrical Power Demand Limiting

Provide M&C software which includes demand limiting functionality capable of performing electrical demand limiting such that it can change the occupancy mode or setpoint of field control system hardware via a network point based on a projected demand in order to maintain demand below a configured target. The demand target must incorporate real-time pricing data. The demand limiting algorithm must incorporate priority levels such that low priority equipment is adjusted before high-priority equipment. The demand limiting algorithm must generate a critical alarm when it begins to impact the system and a critical alarm if the demand target is exceeded.

2.4.10.16 Report Generation

Provide M&C Software capable of generating, saving and printing reports. Dynamic operation of the system must not be interrupted to generate a report. The report must contain the time and date when the samples were taken, and the time and date when the report was generated. The software must be capable of saving reports to a PDF file and to a file compatible with the provided Office Automation Software.

The software must allow for automatic and manual generation of reports. For automatic reports an operator must be able to specify the time the initial report is to be generated, the time interval between reports, end of period, and the output format for the report. Manual report generation must allow for the operator to request at any time the output of any report.

2.4.10.17 Custom Report Generation

Provide M&C software capable of generating custom reports, including but not limited to the following standard reports:

2.4.10.17.1 Electrical Power Usage Report

An electrical power Usage summary, operator selectable for substations, meters, or transducers, individual meters and transducers, any group of meters and transducers, and all meters for an operator selected time period. The report must include the voltage, current, power factor, electrical demand, electrical power consumption, reactive power (Kvar) for each substation, facility, system or equipment as selected by the operator. The report must be automatically printed at the end of each summary period and include:

a. Total period consumption.

b. Demand interval peak for the period, with time of occurrence.

c. Energy consumption (kWh) over each demand interval.

d. Time-of-use peak, semi-peak, off-peak, or baseline total kWh consumption.

e. Reactive power during each demand interval.

f. Power factor during each demand interval.

g. Outside air (OA) temperature and relative humidity (RH) taken at the maximum and minimum of OA temperature of the report period with the time and dates of occurrence. At the installation's peak demand interval, the OA temperature and RH must also be recorded.

h. Calculated heating and cooling degree days based on a 65 degrees F balance point.

2.4.10.17.2 Electrical Peak Demand Prediction Report

A report based on the demand limiting program, which includes:

a. Electrical Demand Target (EDT).

b. Actual peak and predicted peak for each demand interval for that day.

c. Predicted demand for the next demand interval.

2.4.10.17.3 Energy usage Report

An energy usage summary, operator selectable, for a unit, building, area, installation, and the entire UMCS. The report must be divided by utility, and must be capable of reporting on at least four separate utilities. The report must include the following information:

a. Beginning and ending dates and times.

b. Total energy usage for each utility for the current and previous day.

c. Total energy usage for each utility for the current and previous month.

d. Maximum 15-minute interval average rate of consumption for each utility for the current and previous day and current and previous month.

e. Outside air (OA) temperature and OA humidity for current and previous month and current and previous day:

(1) Average temperature and humidity.

(2) Temperature and humidity at maximum and minimum OA temperature with time and date of occurrence.

(3) Temperature and humidity at maximum and minimum humidity with time and date of occurrence.

(4) Temperature and humidity at the installation's peak demand interval with the time and date of occurrence

f. Calculated degree days. Reports which include humidity must be configurable to report either dewpoint or relative humidity.

2.4.10.17.4 Water Usage Report

A water usage summary, operator selectable, for a unit, building, area, installation, and the entire UMCS. The report must include the following information:

a. Beginning and ending dates and times.

b. Total energy water usage for the current and previous day.

c. Total water usage for the current and previous month.

2.4.10.17.5 Alarm Report

Outstanding alarms by building or unit, including time of occurrence.

2.4.10.17.6 M&C Software Override Report

Points overridden by the M&C Software, including time overridden, and identification of operator overriding the point.

2.4.10.17.7 Run Time Reports

A report totalizing the accumulated run time of individual pieces of equipment. The operator must be able to define equipment groupings and to generate reports based on these groupings.

2.4.10.17.8 Cooling Tower Profiles

A cooling tower profile for each cooling tower as indicated, including:

a. Total daily and monthly on-time (each fan).

b. Number of on and off transitions (each fan).

c. Maximum and minimum daily condenser water temperature and the time of occurrence for the current and previous months.

d. Total daily and monthly makeup water consumption.

2.4.10.17.9 Chiller usage Report

A report of the operation of each chiller as shown on a daily and monthly basis, for each of at least 10 discrete loading levels. The report must include:

a. Average power for the month at each level in kW

b. Total monthly energy use in kWh at each level

c. Total monthly energy use in kWh for the chiller (all levels)

d. Total daily run hours at each level

e. Total Monthly run hours at each level

2.4.10.17.10 Device Offline Report

A report listing all offline devices in all CEA-709.1-D or ASHRAE 135 building control systems integrated to the M&C Software and all offline Niagara Framework Supervisory Gateways.

2.5 UNINTERRUPTIBLE POWER SUPPLY (UPS)

Provide uninterruptible power supplies (UPS) as self contained devices suitable for installation and operation at the location of Server and Workstation hardware and sized to provide a minimum of 20 minutes of operation of the connected hardware. Equipment connected to the UPS must not be affected in any manner by a power outage of a duration less than the rated capacity of the UPS. Provide the UPS complete with all necessary power supplies, transformers, batteries, and accessories. Provide UPS which include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of AC input loss and low battery power. Provide UL 1778 approved UPS. UPS powering Server Hardware must notify the server via USB interface of impending battery failure.

2.6 RACKS AND ENCLOSURES

2.6.1 Enclosures

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable. Provide two Enclosure Keys for each lockable enclosure on a single ring per enclosure with a tag identifying the enclosure the keys operate. Provide enclosures meeting the following minimum requirements:

2.6.1.1 Outdoors

For enclosures located outdoors, provide enclosures meeting NEMA 250 Type 3 or Type 4 requirements.

2.6.1.2 Mechanical and Electrical Rooms

For enclosures located in mechanical or electrical rooms, provide enclosures meeting NEMA 250 Type 2 or Type 4 requirements.

2.6.1.3 Other Locations

For enclosures in other locations including but not limited to occupied spaces, above ceilings, and in plenum returns, provide enclosures meeting NEMA 250 Type 1 requirements.

2.6.2 Equipment Racks

Provide standard 19 inch equipment racks compatible with the electronic equipment provided. Racks must be either aluminum or steel with bolted or welded construction. Steel equipment racks must be painted with a flame-retardant paint. Guard rails must be included with each equipment rack and have a copper grounding bar installed and grounded to the earth.

PART 3 EXECUTION

3.1 FACTORY TEST

Perform factory testing of the UMCS as specified. The Contractor is responsible for providing personnel, equipment, instrumentation, and supplies necessary to perform required testing. Provide written notification of planned testing to the Government at least 21 days prior to testing, and do not give this notice until after receiving written Government approval of the specific Factory Test Procedures. Provide Factory Test Procedures which define the tests required to ensure that the system meets technical, operational, and performance specifications. Within the Procedures define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required. Provide procedures which test all capabilities and functions specified and indicated. Develop Procedures from the design documentation and in accordance with Section 25 08 10 UTILITY MONITORING AND CONTROL SYSTEM TESTING. Perform the Factory Test using equipment and software of the same manufacturer, model and revision as will be used for the specified project. Include detailed instructions for test setup, execution, and evaluation of test results in the Procedures. Upon completion of the test, prepare a Factory Test Report, documenting the results of the Test, and submit it as specified.

Perform the Factory Test and provide Factory Test Submittals as shown in TABLE II. FACTORY TEST SEQUENCING.

TABLE II. FACTORY TEST SEQUENCING

ITEM #	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1	Submit Factory Test Procedures	10 days after notice to proceed
2	Perform Factory Test	After Approval Of #1
3	Submit Factory Test Report	10 days After Completion Of #2

3.2 EXISTING CONDITIONS SURVEY

Perform a field survey, including but not limited to testing and inspection of equipment to be part of the UMCS, and submit an Existing Conditions Report documenting the current status and its impact on the Contractor's ability to meet this specification. For field control systems to be integrated to the UMCS which are not already connected to the UMCS IP network, verify the availability of the building network backbone at the FPOC location, and verify that FPOCs shown as existing are installed at the FPOC location.

3.3 DRAWINGS AND CALCULATIONS

3.3.1 UMCS IP Network Bandwidth Usage Estimate

Provide a UMCS IP Network Bandwidth Usage Estimate for a small, medium or large systems. In this estimate account for field control systems using all M&C required protocols and the integration of field control system via gateways. Define all assumptions used to create the estimate, including but not limited to: trending, fast trends for commissioning, schedules, alarms, display of system graphics and load shedding.

3.3.2 UMCS Contractor Design Drawings

Revise and update the Contract Drawings to include details of the system design and all hardware components, including contractor provided and Government furnished components. Details to be shown on the Design Drawing include:

a. The logical structure of the network, including but not limited to the location of all Control Hardware (including but not limited to each BACnet Supervisory Controller, Control Protocol Gateway, Control Protocol Router, Niagara Framework Supervisory Gateway and Monitoring and Control (M&C) Controller).

b. Manufacturer and model number for each piece of Computer Hardware and Control Hardware.

c. Physical location for each piece of Computer Hardware and Control Hardware.

d. Version and service pack number for all software and for all Control Hardware firmware.

3.3.3 As-Built Drawings

Prepare draft as-built drawings consisting of Points Schedule drawings for the entire UMCS, including Points Schedules for each Gateway, and an updated Design Drawing including details of the actual installed system as it is at the conclusion of Start-Up and Start-Up Testing. Provide As-Built Drawings which include details of all hardware components, including contractor provided and Government furnished components. In addition to the details shown in the design drawings, the as-built drawing must include:

a. IP address(es) and Ethernet MAC address(es) as applicable for each piece of Control Hardware (including but not limited to each BACnet Supervisory Controller, Niagara Framework Supervisory Gateway, Control Protocol Gateway, Control Protocol Router, and Monitoring and Control (M&C) Controller).

b. IP address and Ethernet MAC address for each computer server, workstation, and networked printer.

c. Network identifier (name) for each printer, computer server and computer workstation.

d. List of ports, protocols and network services for each device connected to an IP network.

e. Network Addresses: CEA-709.1-D address (domain, subnet, node address) for all Control Hardware using CEA-709.1-D.ASHRAE 135 address and

Object_ID of the Device Object for all Control Hardware using ASHRAE 135. MODBUS Protocol/MODBUS TCP/IP address for all Control Hardware using MODBUS Protocol/MODBUS TCP/IP. Niagara Framework Station ID for all Niagara Framework components including but not limited to Niagara Framework Supervisory Gateways and the Niagara Framework M&C Software.

Prepare Draft As-Built Drawings upon the completion of Start-Up and Start-Up Testing and Final As-Built Drawings upon completion of PVT Phase II.

3.4 INSTALLATION REQUIREMENTS

3.4.1 General

Install system components as shown and specified and in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Install communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation. Install Fiber Optic cables and wiring in exposed areas, including low voltage wiring but not including network cable in telecommunication closets, in metallic raceways or EMT conduit as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Do not install equipment in any space which experiences temperatures or humidity outside of the rated operating range of the equipment.

3.4.2 Isolation, Building Penetrations and Equipment Clearance

Provide dielectric isolation where dissimilar metals are used for connection and support. Make all penetrations through and mounting holes in the building exteriors watertight. Drill or core drill holes in concrete, brick, steel and wood walls with proper equipment. Seal conduits installed through openings with materials which are compatible with existing materials. Seal openings with materials which meet the requirements of NFPA 70 and SECTION 07 84 00 FIRESTOPPING.

3.4.3 Nameplates

Provide Nameplates for all Control Hardware and all Computer Hardware. Attach Nameplates to the device in a conspicuous location.

3.5 INSTALLATION OF EQUIPMENT

3.5.1 Wire and Cable Installation

Install system components and appurtenances in accordance with NFPA 70, manufacturer's instructions and as indicated. Provide necessary interconnections, services, and adjustments required for a complete and operable signal distribution system. Label components in accordance with TIA-606. Firestop Penetrations in fire-rated construction in accordance with Section 07 84 00 FIRESTOPPING. Install conduits, outlets and raceways in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Install wiring in accordance with TIA-568.1 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Mark wiring terminal blocks and outlets in accordance with TIA-606. Do not install non-fiber-optic cables in the same cable tray, utility pole compartment, or floor trench compartment with power cables. Properly secure and install neat in appearance cables not installed in conduit or raceways.

3.5.2 Grounding

Install signal distribution system ground in accordance with TIA-607 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Connect equipment racks to the electrical safety ground.

3.5.3 Power-Line Surge Protection

Protect equipment connected to ac circuits must be protected against or withstand power-line surges. Provide equipment protection which meets the requirements of IEEE C62.41. Do not use fuses for surge protection.

3.5.4 IP Addresses

For all Control Hardware requiring an IP address on the UMCS IP Network, obtain static IP addresses from a DHCP server.

3.5.5 Computer Hardware and Software

3.5.5.1 Hardware Installation

Install Computer Hardware as specified and indicated. Power Computer Servers through a UPS, and install and configure them such that the server automatically undergoes a clean shutdown upon low battery signal from the UPS.

3.5.5.2 Software Installation

Install software as follows:

a. CEA-852-C Configuration Server: Install and configure one CEA-852-C Configuration Server. Install the he CEA-852-C Configuration Server on Server Hardware or on an CEA-709.1-D TP/FT-10 to IP Router.

b. CEA-709.1-D Network Configuration Tool: Install the CEA-709.1-D Network Configuration Tool software as shown. Install the CEA-709.1-D Network Configuration Tool on workstation or server hardware.

c. BACnet Network Browser: Install the BACnet Network Browser software as indicated. Install the BACnet Network Browser on workstation hardware.

e. Monitoring and Control Software: Install the monitoring and control (M&C)software as shown. Except for M&C Software performing Point Calculations or Electrical Peak Demand Limiting, install M&C Software on server hardware. Install M&C Software performing Point Calculations or Electrical Peak Demand Limiting on either server hardware or Monitoring and Control (M&C) Controller Hardware. Install M&C Software in a manner consistent with its B-AWS listing such that it provides all functionality of a B-AWS.

   Provide sufficient computer hardware and M&C Controller Hardware and install M&C Software to support the number of points required in PART 2 (PRODUCTS), regardless of the number of points integrated under this project specification. Note that meeting this requirement may entail the installation of unused hardware or spare point licenses to accommodate the full number of required points in order to allow for integration of future field control systems.

f. M&C Controller Hardware Configuration Software: Install the M&C Controller Hardware Configuration Software on server hardware.

g. Operating system: Install the OS on each Server and Workstation and configure user names and passwords..

h. Office Automation Software: Install the office automation software on each server and workstation.

i. Virus Protection software: Install the virus protection software on each server and workstation and configure weekly virus scans.

j. Disk Imaging (Backup) Software: Install the disk imaging (backup) software on each server and configure for imaging the internal hard drive to external hard drive.

Where software requires connection to an IP device outside of the UMCS, coordinate with the project site NEC to obtain access to a Government-furnished server to provide the needed functionality. Do not connect to any device outside of the UMCS without explicit permission from the project site NEC.

3.5.5.3 Monitoring and Control (M&C) Software Configuration

Configure the Monitoring and Control (M&C) Software as specified, as indicated and as follows:

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a. Set up M&C Software user accounts and passwords. Coordinate user accounts, passwords and permissions with the Controls shop supervisor.

b. Change the default password on all accounts. Remove or disable any accounts which do not require authentication (such as guest accounts).

c. Configure e-mail capability to use the government furnished SMTP server using the following server information.

d. Disable all ports, protocols, and network services other than those required or specifically permitted by this Section. Services to be disabled include but are not limited to: FTP, Telnet and SSH.

e. Install web server certificate. Obtain certificate from the project site NEC.

3.5.5.4 Control Hardware Installation

Install Control Hardware in a lockable enclosure and as specified. Configure Control Hardware as specified, as required to meet the functions for which the hardware is used and as follows:

a. Disable all ports, protocols, and network services other than those required or specifically permitted by this Section. Services to be disabled include but are not limited to: FTP, Telnet, SSH, and HTTP. When disabling of ports, protocols and services is not supported by a product, obtain an exception from this requirement prior to using the product and document non-compliance on the Product Data Sheets and As-Built drawings.

b. Change the default passwords in all Control Hardware which have passwords. Coordinate new passwords with the Controls shop supervisor ____.

3.6 INTEGRATION OF FIELD CONTROL SYSTEMS

Fully integrate the field control systems in accordance with the following three step sequence and as specified and shown.

STEP 1: Install and configure Control Hardware as necessary to connect the field control system to the FPOC, which is part of the UMCS IP network, and to provide control protocol translation and supervisory functionality.

STEP 2: Add Field Control System to M&C Software: Perform system discovery, system database merges, or any other actions necessary to allow M&C Software access to the field control system.

STEP 3: Configure M&C Software to provide monitoring and control of the field control system, including but not limited to the creation of system displays and the configuration of scheduling, alarming, and trending.

3.6.1 Integration Step 1: Install Control Hardware

Install Control Hardware as specified at the FPOC location to connect the field control system to the UMCS IP network via the FPOC and, if necessary, to provide control protocol translation and supervisory functionality. Coordinate all connections and other activities related to an FPOC with Contracting Officer. Depending on the field control system media and protocol this must be accomplished through one of the following:

a. Connect the existing field control network hardware at the FPOC location to the FPOC.

b. Install either a Control Protocol Gateway or Niagara Framework Supervisory Gateway connected to both the field control network and the FPOC.c. Install a Control Protocol Router connected to both the field control network and the FPOC.

d. Install a Control Protocol Gateway connected to the field control network. Then install a Control Protocol Router connected to both the Control Protocol Gateway and the FPOC.

In addition, for integration of field control systems via ASHRAE 135, also install a BACnet Supervisory Controller as needed to implement scheduling, alarming and trending in the field control system. The BACnet supervisory controller may be the same device as the control protocol gateway or router.

3.6.1.1 Installation of Control Protocol Gateway

If the field control system uses a protocol which is not supported by the M&C Software, install a gateway to convert the field control system protocol to ASHRAE 135, or to CEA-709.1-D, or to MODBUS Protocol/ MODBUS TCP/IP, or to OPC DA. Install additional field control system network media and hardware as needed to connect the Gateway to the field control system. Connect the Gateway according to one of the two following methods:

a. Connect the Gateway to the field control network and to the FPOC. .

b. Connect the Gateway to the field control network and to a BACnet/IP Router, or to a LonWorks/IP Router, or to a Modbus/IP Router installed as specified.

Create and configure points and establish network communication between the Control Protocol Gateway and the field control system to provide points from the field control system to the M&C software.

3.6.1.2 Installation of Niagara Framework Supervisory Gateway

Install Niagara Framework Supervisory Gateway hardware to connect the field control network to the FPOC. Install additional field control system network media and hardware as needed to connect the Niagara Framework Supervisory Gateway to the field control system.

3.6.1.3 Installation of Control Protocol Router

If there is not an existing connection between the FPOC and the field control network, install a BACnet/IP Router, or a LonWorks/IP Router, or a Modbus/IP Router to connect the field control network to the FPOC. Install additional field control system network media as needed to connect the Router to the field control system.

3.6.1.4 Installation of BACnet Supervisory Controller

If required for implementation of scheduling, alarming and trending, install a BACnet Supervisory Controller connected to the building control system IP network and configure it to provide scheduling, alarming and trending functions for the field control system. When the BACnet Supervisory Controller is the same device as a control protocol router or gateway, install it in accordance with the installation requirements for a router or gateway.

3.6.2 Integration Step 2: Add Field Control System to M&C Software

Perform system discovery, system database merges, or any other actions necessary to allow M&C Software access to points and data in the field control system.

3.6.2.1 Integration of Field Control Systems Via ANSI-709.1-C

a. When a LNS Database of the field control system is not available, use the Network Configuration Tool software to discover the field control system and create an LNS Database for the field control system.

b. When the UMCS does not already contain an LNS Server, provide an LNS Server to support the UMCS LNS Database.

c. When there is no existing UMCS LNS Database, use the field control system database as the UMCS Database.

d. When there is an existing UMCS LNS Database, merge the field control system with the UMCS LNS database.

3.6.2.2 Integration of Field Control Systems Via ASHRAE 135

Use the M&C Software to fully discover the field control system. Full discovery of a field control system includes but is not limited to discovery of all ASHRAE 135 devices, all standard ASHRAE 135 Objects and Properties of each device, and all standard ASHRAE 135 services supported by each device.

3.6.2.3 Integration of Field Control Systems Via Niagara Framework

For each Niagara Framework Supervisory Gateway installed in integration step 1 for this project do both of the following:

a. Use the Niagara Framework Engineering Tool to fully discover the field control system and make all field control system information available to the Niagara Framework Supervisory Gateway.

b. Create and configure points and establish network communication between the Niagara Framework Supervisory Gateway and the field control system to provide points from the field control system to the M&C software and to provide support for supervisory functions, including but not limited to schedule objects, trend logs and alarming.

For each Niagara Framework Supervisory Gateway to be integrated as part of this project, make all information in the Niagara Framework Supervisory Gateway available to the M&C Software.

3.6.2.4 Integration of Field Control Systems Via Modbus

Survey the field control system to create Points Schedules. Using these Points Schedules make all points from the field control system available in the M&C Software.

3.6.2.5 Integration of Field Control Systems Via OPC DA

Establish a connection between the M&C Software OPC DA client and the field control system OPC DA server and make all points from the field control system available in the M&C Software.

3.6.3 Integration Step 3: Configure M&C Software

Configure M&C Software to provide monitoring and control of the field control system, including but not limited to the creation of system displays and the configuration of scheduling, alarming, and trending.

3.6.3.1 Configure M&C Software Communication

Create and configure points and establish network communication between M&C Software and Field Control Systems as specified to support M&C Software functionality:

a. Update points on currently active displays via polling as necessary to meet M&C Software display refresh requirements.

b. Send points used for overrides to the device receiving the override as shown on the Points Schedule. For LonWorks systems, for points used for overrides use the network variable and SNVT type indicated on the Points Schedule. For SNVTs for overriding schedules (via the Simple Scheduler) use SNVT type SNVT_occupancy and support the following values: OC_OCCUPIED, OC_UNOCCUPIED, OC_STANDBY and OC_NUL. For SNVTs used to override schedules or setpoints for Demand Limiting functions use the acknowledged service. For BACnet systems write operator overrides with a priority of 8 and demand limiting overrides with a priority of 10.

c. For Notification Class Objects used for Alarms, configure the Recipient_List Property to point to the appropriate M&C Software process. Use the ConfirmedEventNotification service for events from ASHRAE 135 field control systems used for alarms. Bind points from CEA-709.1-D field control systems used using acknowledged service or poll the point at 5 minute intervals. Poll points from MODBUS Protocol/ MODBUS TCP/IP field control systems used for alarms at 5 minute intervals. For points from OPC DA field control systems used for alarms use a subscription or poll the point at 5 minute intervals.

d. Update points used for currently active trends via polling as necessary to meet trend interval requirements.

e. Send points used for scheduling to the field control system with a maximum time between subsequent transmissions of the point of 30 minutes. For LonWorks field control systems, send points used for scheduling to the appropriate System Scheduler using SNVTs of type SNVT_occupancy which support the following values: OC_OCCUPIED, OC_UNOCCUPIED and OC_STANDBY.

Edit the Description field of each point to include the Real Property Unique IDs (RPUID) associated with that point as shown on the Points Schedule

3.6.3.2 Configure M&C Software Functionality

Fully configure M&C Software functionality using the M&C Software capabilities specified in PART 2 of this Section.

a. Create System Displays including overrides, as shown on the Points Schedule and as specified. Label all points on displays with full English language descriptions. Configure user permissions for access to and executions of action using graphic pages. Coordinate user permissions with the Controls shop supervisor____

b. Configure alarm generation and alarm handling as shown on the Points Schedule, as shown on the Alarm Routing Schedule, and as specified. Create and configure Objects in BACnet Supervisory Controllers and in the field control system to support alarming as shown on the Points Schedule and as specified. Alarm events with priority 112 are critical and events with priority 224 are non-critical. For alarm events with other priorities, treat events with priorities of 200 or above as non-critical, and all others as critical. For alarms requiring notification via text message or e-mail, configure the alarm notification to use the specified Government furnished SMTP server to send the alarm notification.

c. Configure scheduling as indicated and as shown on the points schedule. Configure M&C Software scheduling functionality to schedule Modbus systems andOPC systems. Configure M&C Software scheduling functionality for LonWorks field control systems which do not use the Simple Scheduler Object. For LonWorks field control systems which do use the Simple Scheduler Object, configure the Simple Scheduler Objects in the field control system. Create and configure Schedule Objects in BACnet Supervisory Controllers or in the field control system.

Create and configure displays for configuration of M&C Software schedules and Simple Scheduler Objects in the field control system and Schedule Objects in the field control system. Label schedules and scheduled points with full English-language descriptors. Provide a separate configuration capability for each schedule. A single configuration display may be used to configured multiple schedules, provided that each schedule is separately configurable from the display.

d. Create M&C Software trends for required points as shown on the Points Schedule and as specified. Create and configure Trend Objects in BACnet Supervisory Controllers and in the field control system as shown on the Points Schedule and as specified. Trend points at 15 minute intervals.

   Create and configure displays for creation and configuration of trends and for display of all trended points.

e. Configure Demand Limiting as shown on the Demand Limit Schedule and Points Schedule and as specified.

f. Configure M&C Software standard reports.

3.7 START-UP AND START-UP TESTING

Test all equipment and perform all other tests necessary to ensure the system is installed and functioning as specified. Prepare a Start-Up and Start-Up Testing Report documenting all tests performed and their results and certifying that the system meets the requirements specified in the contract documents.

3.8 PERFORMANCE VERIFICATION TEST (PVT)

3.8.1 PVT Phase I Procedures

Provide PVT Procedures which include:.

a. Network bandwidth usage and available bandwidth (throughput) measurements. Network bandwidth usage must reference the normal usage network Bandwidth Calculations.

b. Test System Reaction during PVT: The total system response time from initiation of a control action command from the workstation, to display of the resulting status change on the workstation must not exceed 20 seconds under system normal heavy load conditions assuming a zero response time for operation of the node's control device.

c. Verification of IP Connectivity.

d. Verification of configuration of M&C Software functionality.

3.8.2 PVT Phase I

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures previously approved by the Government, demonstrate all physical and functional requirements of the project. Upon completion of PVT Phase I and as specified, prepare and submit the PVT Phase I Report documenting all tests performed during the PVT and their results. In the PVT report, include all tests in the PVT Procedures and any other testing performed during the PVT. Document failures and repairs with test results.

3.8.3 PVT Phase II

Include Basic Training as part of PVT Phase II. Failures or deficiencies of the UMCS during Basic Training are considered PVT failures. Upon completion of PVT Phase II, and as specified, prepare and submit the PVT Phase II Report documenting any failures which occurred and repairs performed during PVT Phase II.

3.9 MAINTENANCE AND SERVICE

Perform inspection, testing, cleaning, and part or component replacement as specified and as required to maintain the warranty. Work includes providing necessary preventive and unscheduled maintenance and repairs to keep the UMCS operating as specified, and accepted by the Government, and other services as specified. Perform work in compliance with manufacturer's recommendations and industry standards. Provide technical support via telephone during regular working hours.

3.9.1 Work Coordination

Schedule and arrange work to cause the least interference with the normal Government business and mission. In those cases where some interference may be essentially unavoidable, coordinate with the Government to minimize the impact of the interference, inconvenience, equipment downtime, interrupted service and personnel discomfort.

3.9.2 Work Control

Upon completion of work on a system or piece of equipment, that system or piece of equipment must be free of missing components or defects which would prevent it from functioning as originally intended and designed. Replacements must conform to the same specifications as the original equipment. During and at completion of work, do not allow debris to spread unnecessarily into adjacent areas nor accumulate in the work area itself.

3.9.3 Working Hours

Working hours are from 7:30 A.M. to 4:00 P.M. local time Mondays through Fridays except Federal holidays.

[3.9.4 Equipment Repairs

Initiate and complete equipment repairs within the following time periods, where time periods are measured as actual elapsed time from first notification, including working and non-working hours:

a. for non-redundant computer server hardware, initiate within 4 hours and complete within 8 hours.

b. for non-redundant computer workstation hardware, initiate within 4 hours and complete within 8 hours.

c. for redundant computer server hardware, initiate within 36 hours and complete within 5 days.

d. for redundant computer workstation hardware, initiate within 2 days and complete within 5 days.

e. for active (powered) control hardware, initiate within 4 hours and complete within 6 hours.

f. for cabling and other passive network hardware, initiate within 16 hours and complete within 5 days.

Repair is the restoration of a piece of equipment, a system, or a facility to such condition that it may be effectively used for its designated purposes. Repair may be overhaul, reprocessing, or replacement of nonfunctional parts or materials or replacement of the entire unit or system.

]3.9.5 Replacement, Modernization, Renovation

The Government may replace, renovate, or install new equipment as part of the UMCS at Government expense and by means not associated with this contract without voiding the system warranty. Replaced, improved, updated, modernized, or renovated systems and equipment interfaced to the system may be added to the Contractor's maintenance and service effort as a modification.

3.9.6 Access To UMCS Equipment

Access to UMCS equipment must be in accordance with the following:

a. Coordinate access to facilities and arrange that they be opened and closed during and after the accomplishment of the work effort. For access to a controlled facility contact the Government for assistance.

b. The Government may provide keys for access to UMCS equipment where the Government determines such key issuance is appropriate. Establish and implement methods of ensuring that keys issued by the Government are not lost or misplaced, are not used by unauthorized persons, and are not duplicated.

c. The Government may provide passwords or issue Common Access Cards (CAC) for access to UMCS computer equipment where the Government determines such issuance is appropriate. Establish and implement methods of ensuring that passwords and Common Access Cards issued by the Government are not used by unauthorized persons.

3.9.7 Records, Logs, and Progress Reports

Keep records and logs of each task, and organize cumulative chronological records for each major component, and for the complete system. Maintain a continuous log for the UMCS. Keep complete logs and be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the UMCS.

3.9.8 Preventive Maintenance Requirements

Perform maintenance procedures as described below, or more often if required by the equipment manufacturer. Prepare a Preventive Maintenance Work Plan as specified.

3.9.8.1 Preventive Maintenance Work Plan

Prepare a Preventive Maintenance Work Plan detailing all required preventive maintenance. Obtain Government approval of the Work Plan as specified in paragraph PROJECT SEQUENCING. Strictly adhere to the approved work plan to facilitate Government verification of work. If it is necessary to reschedule maintenance, make a written request to the Government detailing the reasons for the proposed change at least five days prior to the originally scheduled date. Scheduled dates will be changed only with the prior written approval of the Government.

3.9.8.2 Semiannual Maintenance

Perform the following Semiannual Maintenance as specified:

a. Perform data backups on all Server Hardware.

b. Run system diagnostics and correct diagnosed problems.

c. Perform fan checks and filter changes for UMCS hardware.

d. Perform all necessary adjustments on printers.

e. Resolve all outstanding problems.

f. Install new ribbons, ink cartridges and toner cartridges into printers, and ensure that there is at least one spare ribbon or cartridge located at each printer.

3.9.8.3 Maintenance Procedures

3.9.8.3.1 Maintenance Coordination

Coordinate any scheduled maintenance event that may result in component downtime with the Government as follows, where time periods are measured as actual elapsed time from beginning of equipment off-line period, including working and non-working hours:

a. For non-redundant computer server hardware, provide 14 days notice, components must be off-line for no more than 8 hours.

b. For non-redundant computer workstation hardware, provide 7 days notice, components must be off-line for no more than 8 hours.

c. for redundant computer server hardware, provide 7 days notice, components must be off-line for no more than 36 hours.

d. For redundant computer workstation hardware, provide 4 days notice, components must be off-line for no more than 48 hours.

e. For active (powered) control hardware, provide 14 days notice, components must be off-line for no more than 6 hours.

f. For cabling and other passive network hardware, provide 21 days notice, components must be off-line for no more than 12 hours.

3.9.8.3.2 Software/Firmware

Software/firmware maintenance includes operating systems, application programs, and files required for the proper operation of the UMCS regardless of storage medium. User (project site) developed software is not covered by this contract, except that the UMCS software/firmware must be maintained to allow user creation, modification, deletion, and proper execution of such user-developed software as specified. Perform diagnostics and corrective reprogramming as required to maintain total UMCS operations as specified. Back up software before performing any computer hardware and software maintenance. Do not modify any parameters without approval from the Government. Properly document any approved changes and additions, and update the appropriate manuals.

3.9.8.3.3 Network

Network maintenance includes testing transmission media and equipment to verify signal levels, system data rates, errors and overall system performance.

3.9.9 Service Call Reception

a. A Government representative will advise the Contractor by phone or in person of all maintenance and service requests, as well as the classification of each based on the definitions specified. A description of the problem or requested work, date and time notified, location, classification, and other appropriate information will be placed on a Service Call Work Authorization Form by the Government.

b. Submit procedures for receiving and responding to service calls 24 hours per day, seven days a week, including weekends and holidays . Provide a single telephone number for receipt of service calls during regular working hours; service calls are to be considered received at the time and date the telephone call is placed by the authorized Government representative.

c. Separately record each service call request, as received on the Service Call Work Authorization form and complete the Service Call Work Authorization form for each service call. Include the following information in the completed form: the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion.

d. Respond to each service call request within two working hours. Provide the status of any item of work within four hours of the inquiry during regular working hours, and within 16 hours after regular working hours or as needed to meet the Equipment Repair requirements as specified.

3.9.10 Service Call Work Warranty

Provide a 1 year unconditional warranty on service call work which includes labor and material necessary to restore the equipment involved in the initial service call to a fully operable condition. In the event that service call work causes damage to additional equipment, restore the system to full operation without cost to the Government. Provide response times for service call warranty work equivalent to the response times required by the initial service call.

3.9.11 System Modifications

Make recommendations for system modification in writing to the Government. Do not make system modifications without prior approval of the Government.

Incorporate any modifications made to the system into the Operations and Maintenance Instructions, and any other documentation affected. Make available to the Government software updates for all software furnished under this specification during the life of this contract. Schedule at least one update near the end of the contract period, at which time make available the latest released version of all software provided under this specification, and install and validate it upon approval by the Government.

3.10 TRAINING

Conduct training courses for designated personnel in the maintenance, service, and operation of the system as specified, including specified hardware and software. The training must be oriented to the specific system provided under this contract. Provide audiovisual equipment and other training material and supplies required for the training. When training is conducted at Government facilities, the Government reserves the right to record the training sessions for later use. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, the Contractor should assume that attendees will be tradesmen such as electricians or boiler operators. Obtain approval of the training schedule from the Government at least 30 days prior to the first day of training.

3.10.1 Training Documentation

Prepare and submit one set of Training manuals for each of Basic Training Documentation, Advanced Training Documentation, and Refresher Training Documentation, where each set of documentation consists of:

3.10.1.1 Course Attendance List

Course Attendance List developed in coordination with and signed by the Controls shop supervisor.

3.10.1.2 Training Manuals

Include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson in the training manuals. Where portions of the course material are presented by audiovisuals, include copies of those audiovisuals as a part of the printed training manuals.

3.10.2 Basic Training

Conduct a Basic Training course at the project site on the installed system for a period of no less than 5 training days during Phase 2 of the PVT. A maximum of ten personnel will attend this course. Design training targeted towards training personnel in the day-to-day operation and basic maintenance of the system. Upon completion of this course, each student, using appropriate documentation, should be able to start the system, operate the system, recover the system after a failure, perform routine maintenance and describe the specific hardware architecture and operation of the system. Include the following topics at a minimum:

a. General system architecture.

b. Functional operation of the system, including workstations and system navigation.

c. System start-up procedures.

d. Failure recovery procedures.

e. Schedule configuration.

f. Trend configuration.

g. Perform point overrides and override release.

h. Reports generation.

i. Alarm reporting and acknowledgements.

j. Diagnostics.

k. Historical files.

l. Maintenance procedures:

(1) Physical layout of each piece of hardware.

(2) Troubleshooting and diagnostic procedures.

(3) Preventive maintenance procedures and schedules.

3.10.3 Advanced Training

Conduct an Advanced Operator Training course at the project site for a period of not less then five days. A maximum of ten personnel will attend this course. Structure the course to consist of "hands-on" training under the constant monitoring of the instructor. Include training on the M&C Software, and the CEA-709.1-D Network Configuration Tool , and the BACnet Network Browser, and the Niagara Framework Engineering Tool. Upon completion of this course, the students should be fully proficient in the operation and management of all system operations and must be able to perform all tasks required to integrate a field control system into the UMCS. Report the skill level of each student at the end of this course. Include the following topics at a minimum:

a. A review of all topics in Basic Training

b. Using the CEA-709.1-D Network Configuration Tool for Network Management and using the BACnet Network Browser for network discovery

c. M&C Software configuration, including but not limited to: creating and editing system displays, alarms, schedules, trends, demand limiting and calculations.

3.10.4 Refresher Training

Conduct a Refresher Training course at the project site for a period of two training days when approved by the Government and as specified in paragraph PROJECT SEQUENCING. A maximum of ten personnel will attend the course. Structure the course to address specific topics that the students need to discuss and to answer questions concerning the operation of the system. Upon completion of the course, the students should be fully proficient in system operation and have no unanswered questions regarding operation of the installed UMCS. Correct any system failures discovered during the Refresher Training at no cost to the Government.

APPENDIX A

QC CHECKLIST			
This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.			
This checklist is for (check one:)			
	Pre-Construction QC Checklist Submittal (Items 1-2)		( )
	Post-Construction QC Checklist Submittal (Items 1-6)		( )
	Close-out QC Checklist Submittal (Items 1-14)		( )
Instructions: Initial each item in the space provided (|____|) verifying that the requirement has been met.			
Verify the following items for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:			
1	Contractor Design Drawing Riser Diagram includes location and types of all Control Hardware and Computer Hardware.		|____|
2	M&C Software supports the Niagara Framework, and ASHRAE 135, and CEA-709.1-D, and MODBUS Protocol/MODBUS TCP/IP, and OPC DA. M&C Software is BTL Listed as a B-AWS. M&C Software is LonWorks Network Services (LNS) based.		|____|
Verify the following items for Post-Construction and Closeout QC Checklist Submittal:			
3	Communication between the M&C Software and Niagara Framework field control systems uses only Fox protocol. Communication between the M&C Software and ASHRAE 135 field control systems uses only ASHRAE 135. Communication between the M&C Software and CEA-709.1-D field control systems uses only CEA-709.1-D. Communication between the M&C Software and MODBUS Protocol/MODBUS TCP/IP field control systems uses only MODBUS Protocol/MODBUS TCP/IP. Communication between the M&C Software and OPC DA field control systems uses only OPC DA.		|____|

QC CHECKLIST			
4	Connections to field control systems are via Niagara Framework Supervisory Gateways.		|____|
5	Computer workstations and servers are installed as shown on the UMCS Riser Diagram.		|____|
6	Training schedule and course attendee lists have been developed and coordinated with shops and submitted.		|____|
Verify the following items for Closeout QC Checklists Submittal:			
7	LNS Database is up-to-date and accurately represents the final installed system. All points in field control systems have been discovered using the Niagara Framework Engineering Tool and are available at the M&C Software.		|____|
8	All software has been licensed to the Government.		|____|
9	M&C software monitoring displays have been created for all building systems, including all override and display points indicated on Points Schedule drawings.		|____|
10	Final As-built Drawings accurately represent the final installed system.		|____|
11	Default trends have been set up (per Points Schedule drawings).		|____|
12	Scheduling has been configured at the M&C Software (per Occupancy Schedule drawing).		|____|
13	O&M Instructions have been completed and submitted.		|____|

QC CHECKLIST			
14	Basic Operator and Advanced Training courses have been completed.		|____|
______________________________		____________	
	(QC Representative Signature)	(Date)	

-- End of Section --

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SECTION 26 05 00.00 40

COMMON WORK RESULTS FOR ELECTRICAL
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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480 (1981) Toggle Switches

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.12.29 (2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

IEEE Stds Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL CODE COUNCIL (ICC)

ICC/ANSI A117.1 (2009) Accessible and Usable Buildings and Facilities

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7 (2014) Requirements for Watthour Meter Sockets

ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
ANSI Z535.1	(2017) Safety Colors
ANSI/NEMA OS 1	(2013; R 2020) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA PB 1	(2011) Panelboards
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA

	20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2020) UL Standard for Safety Flexible Metal Conduit
UL 5	(2016; Reprint Aug 2020) UL Standard for Safety Surface Metal Raceways and Fittings
UL 5A	(2015; Reprint Aug 2020) Nonmetallic Surface Raceways and Fittings
UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 20	(2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Jul 2020) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Aug 2021) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Sep 2021) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers

UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Mar 2021) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 4248-1	(2022) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. Vertical assembly: A vertical assembly is a pole, tower or other such support, mounting hardware, arms, brackets and the load. Load can be a luminaire, siren, loudspeaker or other device. All components of a vertical assembly will be rated by the manufacturer to withstand 150 mph wind loading in accordance with ASCE 7-16.

]1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval.Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Marking Strips; G

SD-03 Product Data

Conduits and Raceways; G,

Wire and Cable; G

Splices and Connectors; G

Switches; G

Receptacles; G

Outlet Boxes, Pull Boxes and Junction Boxes; G

Circuit Breakers; G

Panelboards; G

Dry-Type Distribution Transformers; G

Device Plates; G

SD-06 Test Reports

Continuity Test; G

Phase-Rotation Tests; G

Insulation Resistance Test; G

600-Volt Wiring Test; G

Transformer Tests; G

Ground-Fault Receptacle Test; G

Insulation-Resistance Test; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

PART 2 PRODUCTS

2.1 EQUIPMENT

Provide the standard cataloged materials and equipment of manufacturers regularly engaged in the manufacture of the products. For material, equipment, and fixture lists submittals, show manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI Light Gray.

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.1.1 Conduits and Raceways

2.1.1.1 Rigid Steel Conduit

Provide hot dipped galvanized rigid steel conduit complying with NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable. Except where installed underground, or in corrosive areas, provide polyvinylchloride (PVC), or protect from corrosion by painting with bitumastic coating or wrapping with corrosion inhibiting tape..

Use threaded fittings for rigid steel conduit.

Use solid gaskets. Ensure conduit fittings with blank covers have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Provide covers with captive screws and are accessible after the work has been completed.

2.1.1.2 Electrical Metallic Tubing (EMT)

Ensure EMT is in accordance with UL 797, UL 5, and ANSI C80.3 and is zinc coated steel. Provide zinc-coated couplings and connectors that are raintight, compression type with insulated throat. Crimp, spring, or setscrew type fittings are not acceptable.

2.1.1.3 Flexible Metallic Conduit

Ensure flexible metallic conduit is galvanized steel and complies with UL 1 and UL 360.

Ensure fittings for flexible metallic conduit are specifically designed for such conduit.

Provide liquidtight flexible metallic conduit with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Ensure fittings for liquidtight flexible metallic conduit are specifically designed for such conduit.

2.1.1.4 Intermediate Metal Conduit

Ensure intermediate metal conduit is galvanized steel and complies with UL 1242, NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable.

2.1.1.5 Rigid Nonmetallic Conduit

Ensure rigid nonmetallic conduit complies with NEMA TC 2, NEMA TC 3, and UL 651 as applicable with a wall thickness not less than Schedule 40.

2.1.1.6 Surface Metal Raceway

Ensure surface metal raceways and multi-outlet assemblies conform to NFPA 70, and have receptacles conforming to NEMA WD 1, Type 5-15R.

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every 18inches. Wire alternate receptacles on different circuits.

2.1.1.7 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every 18 inches. Wire alternate receptacles on different circuits.

2.1.2 Wireways

Ensure wireways and auxiliary gutters are a minimum 4 by 4-inch trade size conforming to UL 870.

UL 870. Material: steel[epoxy painted][galvanized] 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with hinged cover NEMA[1][3R][12] enclosure per NEMA ICS 6.

2.1.3 Outlet Boxes, Pull Boxes and Junction Boxes

Ensure outlet boxes for use with conduit systems are in accordance with NEMA FB 1 UL 514A, UL 514B, UL 514C and ANSI/NEMA OS 1 and are not less than 1-1/2 inches deep. Furnish all pull and junction boxes with screw-fastened covers.

2.1.4 Panelboards

Provide panelboards in accordance with NEMA PB 1, UL 67, and UL 50. Ensure panelboards for use as service equipment are also in accordance with UL 869A. Ensure panelboards have current rating, number of phases, and number of wires as indicated or specified herein. Ensure panelboards are rated for 240-volt (maximum), single-phase 120/208-volt, three-phase 277/480-volt, three-phase, 60-hertz. Ensure each panelboard, as a complete unit, has a short-circuit current rating equal to or greater than the integrated equipment rating indicated, but in no case less than 10,000 amperes symmetrical.

Provide panelboards with bolt-on circuit breakers only. Use of plug-in style breaker is not permitted. Ensure panelboards are designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining required clearance. Provide main lugs or main circuit breakers mounted "above" or "below" branch breakers with current ratings as indicated. Use of sub-feed breakers is not acceptable unless specifically indicated otherwise. Where "space only" is indicated, make provisions for future installation of breakers.

Submit detail drawings and manufacturer's standard product data for panelboards. Detail drawings consist of fabrication and assembly drawings for all parts of the work in sufficient detail to verify conformity with all requirements. Ensure drawings for panelboards indicate details of bus layout, overall physical features, dimensions, ratings, service requirements, and weights of equipment.

Provide copper buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems with a separate grounding bus in accordance with UL 67 bonded to the panelboard enclosure. Ensure grounding bus is a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment grounding conductors.

Provide bus bar connections to the branch circuit breakers that are the "distributed phase" or "phase sequence" type. Ensure single-phase, three-wire panelboard busing is such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Ensure that three-phase, four-wire panelboard busing is such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Ensure current-carrying parts of the bus assembly are plated.

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping.

2.1.4.1 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 and as specified in Section 26 05 71.00 40 LOW VOLTAGE OVERCORRECT PROTECTIVE DEVICES with frame a trip ratings as indicated.

Provide bolt-on type, molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering. Plug-in type, tandem, and half-size circuit breakers are not permitted.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers or overcurrent protective devices to achieve indicated interrupt rating is not permitted.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

2.1.5 Dry-Type Distribution Transformers

2.1.5.1 General Requirements

Ensure that general purpose dry-type transformers with windings 600 volts or less are two-winding, 60 hertz, and self-cooled in accordance with UL 506 and UL 1561. Ensure windings have a minimum of two 2-1/2-percent taps above and below nominal voltage.

Provide transformers in NEMA 1 or 3R enclosure as per application requirements.

Transformer insulation system:

a. 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C.

b. 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C.

2.1.5.2 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

2.2 MATERIALS

2.2.1 Wire And Cable

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

Ensure connectors used in wire systems comply with UL 486A-486B and UL 486C as applicable.

Ensure conductors installed in plenums are marked plenum rated.

2.2.1.1 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.2.2 Device Plates

Provide the following:

a. UL listed, one-piece device plates for outlets to suit the devices installed.

b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.

c. For nonmetallic boxes and fittings, other suitable plates may be provided.

[d. Plates on finished walls: nylon or lexan, minimum 0.03 inch wall thickness and same color as receptacle or toggle switch with which they are mounted.

][e. Plates on finished walls: satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.

] f. Screws: machine-type with countersunk heads in color to match finish of plate.

g. Sectional type device plates are not be permitted.

h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

]2.2.3 Switches

2.2.3.1 Safety Switches

Ensure safety switches comply with NEMA KS 1, and are the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated on the drawings. Ensure fused switch fuse holders comply with UL 4248-1. Ensure switch construction is such that, when the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device is coinproof and so constructed that an external tool is used to open the cover. Make provisions to lock the handle in the "OFF" position. Ensure the switch is not capable of being locked in the "ON" position.

Provide switches of the quick-make, quick-break type and terminal lugs for use with copper conductors.

Ensure safety color coding for identification of safety switches conforms to ANSI Z535.1.

2.2.3.2 Toggle Switches

Ensure toggle switches comply with EIA 480, NEMA WD 1, and UL 20 control Light Emitting Diode (LED), and fluorescent lighting fixtures and are the heavy duty, general purpose, noninterchangeable flush-type.

Provide commercial grade toggle switches, single, double-pole, three or four -way two-position devices rated 20 amperes at 120/277 volts, 60 hertz alternating current (ac) only.

Ensure all toggle switches are products of the same manufacturer.

2.2.4 Fuses

NEMA FU 1. Provide complete set of fuses for each fusible switch. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers or other circuit protective devices for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.2.4.1 Fuseholders

Provide in accordance with UL 4248-1.

2.2.4.2 Cartridge, Current Limiting Type (Class R)

UL 198M, Class[RK-1][RK-5][time-delay type]. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.2.4.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.2.4.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.2.5 Receptacles

Provide the following:

a. UL 498, hard use (also designated heavy-duty), grounding-type.

b. Ratings and configurations: as indicated.

c. Bodies: ivory as per NEMA WD 1.

d. Face and body: thermoplastic supported on a metal mounting strap.

e. Dimensional requirements: per NEMA WD 6.

f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.

g. Grounding pole connected to mounting strap.

h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

2.2.5.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle: switched when installed.

2.2.5.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations." Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, polycarbonate, UV resistant/stabilized cover plate.

2.2.5.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.2.5.4 Plugs

Provide heavy-duty, rubber-covered three-, four-, or five-wire cord of required size, install plugs thereon, and attach to equipment. Provide UL listed plugs with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.2.5.5 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.2.6 Manufacturer's Nameplate

Ensure each item of equipment has a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable.

2.2.7 Warning Signs

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. Enclosure integrity to conform with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers and pad-mounted SF6 switches. Provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Provide decal signs with nominal dimensions of 7 by 10 inches. Print the legend "DANGER HIGH VOLTAGE" in two lines of nominal 2 inch high letters. Show the word "DANGER" in white letters on a red background and the words "HIGH VOLTAGE" in black letters on a white background. Use Panduit decal No. PPSO710D72 or approved equal.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3-inch high white letters on a red and black field.

2.2.8 Firestopping Materials

Provide firestopping around electrical penetrations in accordance with Section 07 84 00, FIRESTOPPING.

2.2.9 Metering

ANSI C12.1. Provide a self-contained, socket-mounted, electronic programmable outdoor watthour meter. Meter: either programmed at the factory or programmed in the field. Turn field programming device over to the Contracting Officer at completion of project. Coordinate meter to system requirements.

a. Design: Provide watthour meter designed for use on a single-phase, three-wire,[240/120][480/240] volt system. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Class: 200; Form: [2S][_____], accuracy: plus or minus 1.0 percent; Finish: Class II.

c. Cover: Polycarbonate and lockable to prevent tampering and unauthorized removal.

d. Kilowatt-hour Register: five digit electronic programmable type.

e. Demand Register:

(1) Provide solid state.

(2) Meter reading multiplier: Indicate multiplier on the meter face.

(3) Demand interval length: programmed for[15][30][60] minutes with rolling demand up to six subintervals per interval.

f. Socket: ANSI C12.7. Provide NEMA Type 3R, box-mounted socket, ringless, having [manual circuit-closing bypass and having]jaws compatible with requirements of the meter. Provide manufacturers standard enclosure color unless otherwise indicated.

2.2.10 Surge Protective Devices

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance[, load centers] [, panelboards] [, MCC] [and] [_____]. Provide surge protectors in a NEMA[1][_____] enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N)
[Neutral to ground (N-G)]
[Phase to ground (L-G)]

[FOR DELTA CONNECTIONS-
Phase to phase (L-L)
Phase to ground (L-G)

] SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G)[and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G)].

[Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, L-G, and N-G Voltage Protection Rating:

[600V for 120V, single phase system]
[600V for 120/240V, single phase system]
[600V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-L Voltage Protection Rating:

[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]
[1,200V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

][Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:

[700V for 120V, single phase system]
[700V for 120/240V, single phase system]
[700V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-L Voltage Protection Rating:

[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]
[1,200V for 208Y/120V, three phase system]
[2,000V for 480Y/277V, three phase system]

] The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120% of nominal voltage for 240 volts and below; 115% of nominal voltage above 240 volts to 480 volts.

[Provide EMI/RFI filtering per UL 1283 for each mode with the capability to attenuate high frequency noise. Minimum attenuation: 20db.

]PART 3 EXECUTION

3.1 PREPARATION

Submit manufacturer's instructions including special provisions required to install equipment components and system packages. Special provisions include impedances, hazards and safety precautions.

Clean and paint conduit, supports, fittings, cabinets, pull boxes, and racks as specified in Section 09 90 00 PAINTS AND COATINGS.

Protect metallic materials against corrosion. Provide equipment enclosures with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and abrasive action), and all outdoor installations, refer to Section 09 96 00 HIGH-PERFORMANCE COATINGS. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect by using approved fittings and treatment. Except where other equivalent protective treatment is specifically approved in writing, provide hot-dip galvanized ferrous metals for items such as, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous items not made of corrosion-resistant steel.

3.2 INSTALLATION

3.2.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.2.2 Overhead Service

Overhead service conductors into buildings: terminate at service entrance fittings or weatherhead outside building. Overhead service conductors and support bracket for overhead conductors are included in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.2.3 Hazardous Locations

Perform work in hazardous locations, as defined by NFPA 70, in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Provide conduit with tapered threads.

3.2.4 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.2.5 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.2.6 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00, FIRESTOPPING.

3.2.6.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.2.7 Conduits, Raceways and Fittings

Ensure that conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting does not contain more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Do not install crushed or deformed conduit. Avoid trapped conduit runs where possible. Take care to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clear any clogged conduit of obstructions or replace conduit.

Conduit and raceway runs concealed in or behind walls, above ceilings, or exposed on walls and ceilings 5 feet or more above finished floors and not subject to mechanical damage may be electrical metallic tubing (EMT).

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.2.7.1 Rigid Steel Conduit

Make field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use long radius conduit for elbows larger than 2-1/2 inches.

Provide a flush coupling for all conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, when the floor slab is of sufficient thickness. Otherwise, provide a floor box set flush with the finished floor. For conduits installed for future use, terminate with a coupling and plug; set flush with the floor.

3.2.7.2 Electrical Metallic Tubing (EMT)

Ground EMT in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

3.2.7.3 Flexible Metallic Conduit

Use flexible metallic conduit to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

Use bonding wires in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit is not considered a ground conductor.

Make electrical connections to vibration-isolated equipment with flexible metallic conduit.

Use liquidtight flexible metallic conduit in wet and oily locations and to complete the connection to motor-driven equipment.

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquidtight flexible nonmetallic conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.2.7.4 Intermediate Conduit

Make all field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use intermediate metal conduit only for indoor installations.

3.2.7.5 Rigid Nonmetallic Conduit

Install a green insulated copper grounding conductor in conduit with conductors and solidly connect to ground at each end. Size grounding wires in accordance with NFPA 70.

3.2.7.6 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab. Plastic coating: extend minimum 6 inches above floor.

3.2.7.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.2.7.8 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.2.7.9 Conduit Installed Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab.

3.2.7.10 Conduit Installed in Concrete Floor Slabs

Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab.

3.2.7.11 Stub Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.2.7.12 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.2.7.13 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.2.7.14 Wireway and Auxiliary Gutter

Bolt together straight sections and fittings to provide a rigid, mechanical connection and electrical continuity. Close dead ends of wireways and auxiliary gutters. Plug all unused conduit openings.

Support wireways for overhead distribution and control circuits at maximum 5-foot intervals.

Ensure auxiliary gutters used to supplement wiring spaces for equipment not contained in a single enclosure contains no switches, overcurrent devices, appliances, or apparatus and is not more than 30 feet long.

3.2.7.15 Surface Raceways and Assemblies

Mount surface raceways plumb and level, with the base and cover secured.

Minimum circuit run is three-wire, with one wire designated as ground.

3.2.7.16 Cable Trays

Support cable trays from ceiling hangers, equipment bays, or floor or wall supports. Cable trays may be mounted on equipment racks. Provide support when the free end extends beyond 3 feet. Maximum support spacing is 6 feet. Support trays 10-inches wide or less by one hanger. Support trays greater than 10 inches wide by two hangers. Bond cable trays at splices.

3.2.8 Wiring

Color code feeder and branch circuit conductors as follows:

CONDUCTOR	COLOR AC
Phase A	Black (208VAC); Brown (480VAC)
Phase B	Red (208VAC); Orange (480VAC)
Phase C	Blue (208VAC); Yellow (480VAC)
Neutral	White (208VAC); Natural Gray (480VAC)
Equipment Grounds	Green

Use conductors up to and including AWG No. 2 that are manufactured with colored insulating materials. For conductors larger than AWG No. 2, have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splice in accordance with the NFPA 70. Provide conductor identification within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Match terminal and conductor identification as indicated.

Where several feeders pass through a common pullbox, tag the feeders to clearly indicate the electrical characteristics, circuit number, and panel designation.

3.2.9 Wiring Devices

3.2.9.1 Wall Switches and Receptacles

Install wall switches and receptacles so that when device plates are applied, the plates are aligned vertically to within 1/16 inch.

Bond ground terminal of each flush-mounted receptacle to the outlet box with an approved green bonding jumper when used with dry wall type construction.

3.2.9.2 Device Plates

Ensure device plates for switches are suitably engraved with a description of the loads when not within sight of the loads controlled.

Mark device plates and receptacle cover plates for receptacles other than 125-volt, single-phase, duplex, convenience outlets. Show the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Use self-adhesive labels having _____ 1/4 inch embossed letters.

Similarly mark device plates for convenience outlets indicating the supply panel and circuit number.

3.2.10 Splices and Connectors

Make all splices in AWG No. 8 and smaller with approved insulated electrical type.

Make all splices in AWG No. 6 and larger with indentor crimp-type connectors and compression tools. Wrap joints with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

3.2.11 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.2.11.1 Marking Strips

Provide marking strips in accordance with the following:

a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.

b. Use permanent ink for the wire numbers

c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.

d. Size marking strips to accommodate the two sets of wire numbers.

e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.

f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.

g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.2.12 Safety Switches

Securely fasten switches to the supporting structure or wall, utilizing a minimum of four 1/4 inch bolts. Do not use sheet metal screws and small machine screws for mounting. Do not mount switches in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height 5 feet above floor level, when possible.

3.2.13 Boxes and Fittings

Provide pullboxes where necessary in the conduit system to facilitate conductor installation. For conduit runs longer than 100 feet or with more than three right-angle bends, install a pullbox at a convenient intermediate location.

Securely mount boxes and enclosures to the building structure using supports that are independent of the conduit entering or leaving the boxes.

Select the mounting height of wall-mounted outlet and switch boxes, as measured between the bottom of the box and the finished floor, in accordance with ICC/ANSI A117.1 and as follows, unless otherwise indicated:

LOCATION	MOUNTING HEIGHT (inches)
Receptacles in offices	18
Receptacles in corridors	18
Receptacles in shops and laboratories	48
Receptacles in rest rooms	48
Switches for light control	48

3.2.14 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.2.15 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.2.16 Panelboards

Securely mount panelboards so that the top operating handle does not exceed 72-inches above the finished floor. Do not mount equipment within 36-inches of the front of the panel. Ensure directory card information is complete and legible.

3.2.17 Dry-Type Distribution Transformers

Connect dry-type transformers with flexible metallic conduit.

Mount all dry-type transformers on vibration isolators in accordance with Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

3.2.18 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet.

3.2.19 Field Fabricated Nameplates

Ensure nameplates conform to ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device, as specified or as indicated on the drawings. Each nameplate inscription identifies the function and, when applicable, the position. Provide nameplates that are melamine plastic, 0.125-inch thick, white with black center core and a matte finish surface with square corners. Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 by 2.5 inches. Lettering is a minimum of 0.25-inch high normal block style.

3.2.20 Identification Plates and Warnings

Provide identification plates for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, door bells, pilot lights, disconnect switches, manual starting switches, and magnetic starters. Attach identification plates to process control devices and pilot lights.

Install identification plates for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. For circuits 480 volts and above, install conspicuously located warning signs in accordance with OSHA requirements.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.5 FIELD APPLIED MOUNTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting: as specified in Section 09 90 00 PAINTS AND COATINGS.Where field painting of enclosures for panelboards, load centers or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.

3.6 FIELD QUALITY CONTROL

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

After completion of the installation and splicing, and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified before the conductors are energized.

Provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified.

Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Use substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices to isolate the circuits under test.

Perform insulation-resistance test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential is 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values is not less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes AWG No. 8 and smaller insulation resistance testing is not required.

Perform continuity test to insure correct cable connection end-to-end (i.e correct phase conductor, grounded conductor, and grounding conductor wiring). Repair and verify any damages to existing or new electrical equipment resulting from mis-wiring. Receive approval for all repairs prior to commencement of the repair.

Conduct phase-rotation tests on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment in a clockwise direction, facing the source.

Perform 600-volt wiring test on wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

Perform the standard, not optional, transformer tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

Perform ground-fault receptacle test for ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

Submit test reports in accordance with referenced standards in this section.

Final acceptance requires the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved.

-- End of Section --

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SECTION 26 05 13.00 40

MEDIUM-VOLTAGE CABLES
05/20

PART 1 GENERAL

[Section 33 71 01.00 40 OVERHEAD TRANSMISSION AND DISTRIBUTION] [33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION]applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS1 (2012) Impregnated-Paper-Insulated, Metallic Sheathed Cable, Solid Type

AEIC CS8 (2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B3 (2013) Standard Specification for Soft or Annealed Copper Wire

ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D746 (2014) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48 (2020) Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV

IEEE 386 (2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV

IEEE 400.2 (2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)

IEEE 404 (2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated

2500 V to 500,000 V

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA WC 70	(2021) Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
NEMA WC 27500	(2020) Standard for Aerospace and Industrial Electrical Cable

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 70B	(2019) Recommended Practice for Electrical Equipment Maintenance
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace

1.2 DEFINITIONS

Medium-voltage power cables include all cables rated above 600 volts up to 35,000 volts.

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Pre-Installation Meetings

No later than 30 days of Contract Award, coordinate with the Contracting Officer to schedule a pre-installation meeting. Submit the following for review and approval prior to the meeting:

a. Pulling Plan including calculations of pulling tension and side wall pressure anticipated, and the maximum allowable pulling tension for each pull. Do not perform any pull until Government reviews and approves the pulling plan.

b. Splicer/Terminator Certifications

c. List of Splices and Terminations to be Installed by Splicer/Terminator

d. Manufacturer's catalog data for all cables, cable supports and fittings, cable tags, fireproof tape, splice kits, terminations, and any other product data required to complete the work.

e. Certificates showing that the cable manufacturer has made factory-conducted tests on each shipping length (reel) of cable. Include certified copies of test data showing conformance with the referenced standards and approval prior to delivery of cable.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

List of Splices and Terminations to be Installed by Splicer/Terminator; G

SD-02 Shop Drawings

Pulling Plan; G

SD-03 Product Data

Multiple-Conductor Shielded Cables; G

Multiple-Conductor Nonshielded Cables; G

Single-Conductor Shielded Cables; G

Single-Conductor Nonshielded Cables; G

Portable Cables; G

Cable Supports and Fittings; G

Polyethylene Cable Tags; G

Fireproof Tape; G

Splices; G

Terminations; G

Polyethylene Cable Tags; G

SD-06 Test Reports

Field Testing; G

Qualification Test Reports; G

Radiographic Tests; G

SD-07 Certificates

Splicer/Terminator Certifications; G

SD-08 Manufacturer's Instructions

Medium-Voltage Power Cables; G

Terminations; G

Splices; G

1.5 QUALITY CONTROL

1.5.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.5.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

Qualifications`

Verify personnel performing Medium Voltage (MV) splicing or terminations have 5 years minimum experience in cable splicing and terminations of the type used in this project. Submit splicer/terminator certifications issued by the cable splice and termination manufacturer who has examined and tested a test splice or termination of each type required by this contract for each cable splicer. Ensure the certification identifies which splices and terminations it applies to.

Once a splice or termination has been started by a splicer, ensure the same splicer completes that particular splice, and that each termination and splice is started and completed in one continuous work period.

Maintain and submit a list of splices and terminations to be installed by splicer/terminator. Ensure the list includes the following for each splice or termination completed.

a. Name of splicer/terminator.

b. Date splice or termination was performed.

c. Location of splice or termination. For terminations at equipment indicate equipment number as required to completely define the location.

d. Feeder number.

1.5.3 Predictive Testing and Inspection Technology Requirements

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure that building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

1.6 DELIVERY, STORAGE, AND HANDLING

Ship cables on reels in a way that protects the cable from mechanical injury. Hermetically seal end of each cable length using heat-shrinkable molded cable end caps to exclude moisture and securely attached to the reel..

Make the minimum reel drum diameter 14 times the overall diameter of the cable. Ensure that each cable length is installed with a pulling eye installed by the manufacturer, for installation in ducts, manholes, and utility tunnels.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide medium-voltage power cables including multiple- and single-conductor cables rated 15,000 volts, ungrounded neutral, on [2,400/4,160][13,200/13,800][12,470][   ]-volt three-phase, 60-hertz, phase-to-phase, for grounded and ungrounded neutral systems.

Provide conductor cable assemblies consisting of:

a. Conductor core with an extruded semiconductor shield over the conductors

b. Insulation

c. A polyethylene (PE) jacket.

d. An extruded semiconductor insulation shield, a concentric neutral

2.2 EQUIPMENT

Ensure that ethylene-propylene rubber and cross-linked polyethylene-insulated conductors are lead-free.

2.2.1 Multiple-Conductor Shielded Cables

2.2.1.1 [Natural] [Synthetic] Rubber with Interlocked Armor

Provide multiple-conductor, [natural] [synthetic]-rubber-insulated, interlocked-armor-covered, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639.

Apply close-fitting, interlocked-armor tape of galvanized steel over the jacket.

2.2.1.2 Cross-Linked Polyethylene

Provide multiple-conductor, cross-linked polyethylene-insulated, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC CS8. Provide taped shielding that consists of 5-mil thick copper shielding lap applied over 12-mil thick semiconducting tape. Wrap both helically with [10] [_____]-percent overlap, providing 100-percent coverage.

[Shield cross-linked polyethylene (XLP) single- and multiple-conductor cables for grounded and ungrounded neutral voltage ratings of 2,000 volts or more.

]2.2.1.3 Ethylene Propylene Rubber (EPR) with Jacketed Interlocked Armor

Provide multiple-conductor ethylene propylene rubber insulated interlocked armor covered shielded cables that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC CS8.

[Shield ethylene propylene (EP) or ethylene propylene rubber (EPR), single- and multiple-conductor cables for grounded or ungrounded neutral voltage ratings of more than 8,000 volts.

]2.2.2 Multiple-Conductor, Nonshielded Cables

2.2.2.1 [Natural] [Synthetic] Rubber with Neoprene Jacket

Provide multiple-conductor, [natural] [synthetic]-rubber-insulated, neoprene-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639.

2.2.2.2 Cross-Linked Polyethylene with PVC Jacket

Provide multiple-conductor, polyethylene-insulated, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC CS8.

2.2.2.3 Ethylene-Propylene with PVC Jacket

Provide multiple-conductor, ethylene-propylene-insulated, PVC-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC CS8.

2.2.3 Single-Conductor Shielded Cables

2.2.3.1 Cross-Linked Polyethylene with PVC Jacket

Provide single-conductor, polyethylene-insulated, PVC-jacketed, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC CS8.

2.2.3.2 Cross-Linked Polyethylene with Interlocked Armor

Provide single-conductor, polyethylene-insulated, PVC-jacketed, shielded cable with interlocked armor that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC CS8.

Apply a close-fitting, interlocked-armor tape of [galvanized steel] [aluminum] over the jacket.

2.2.3.3 Ethylene-Propylene-Rubber-Insulated with PVC Jacket

Provide single-conductor 15 kV rated cable assemblies that consist of the following: Class B stranded copper conductors, an extruded semiconducting shield over the conductors, 220 mils of ethylene propylene rubber insulation, an extruded or other approved semiconducting shield, a 5-mil minimum copper tape shield wrapped helically with a minimum [12.5] percent overlap and a PVC jacket.

Provide single-conductor, ethylene-propylene-insulated, PVC-jacketed, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC CS8.

2.2.4 Single-Conductor Nonshielded Cables

2.2.4.1 Cross-Linked Polyethylene

Provide single-conductor, cross-linked polyethylene-insulated, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, and NEMA WC 74/ICEA S-93-639.

2.2.4.2 Ethylene-Propylene-Rubber-Insulated with PVC Jacket

Provide single-conductor, ethylene-propylene-rubber-insulated, PVC-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, and NEMA WC 74/ICEA S-93-639.

2.2.5 Portable Cables

Provide SHD multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded portable cable conforming to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639.

2.2.6 Insulated Medium Voltage Connectors

Provide connector with a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material per IEEE 386. Ensure connections are compatible with equipment bushings. Provide connectors as follows:

a. 200 Ampere loadbreak connector ratings: Voltage: 15kV, 95kV BIL. Short time rating: 10,000 amperes rms, symmetrical for a time duration of 0.17 seconds.

b. 600 Ampere deadbreak connector ratings: Voltage: 15kV, 95kV BIL. Short time rating: 27,000 ampere rms, symmetrical for a time duration of 4.0 seconds.

c. Provide connectors with a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material per IEEE 386. Provide hot line voltage indicators on all connectors.

Ensure connections are compatible with equipment bushings.

2.2.7 Splices

Provide heat shrink splice kits which are the product of a single manufacturer. Ensure the power cable splice meets the requirements of IEEE 404 for a 15 kV rating, and must be rated by the manufacturer for use on 15 kV class cable systems. Ensure splices are rated for continuous operation at 221 degrees F, with an emergency overload temperature rating of 284 degrees F. Ensure the kit is capable of splicing cables with copper conductors sized as indicated in the contract drawings or accommodate a conductor size transitionProvide splices specifically designed for the cable and grounding provisions.

Provide heat shrink splices which include but are not limited to the following:

a. Inner heat shrink stress control tube with external end sealant, additional heat shrink tube over inner tube and inner tube end sealant.

b. Heat shrink outer wraparound sleeve with heat sensitive indications on both the tube and rail/channel area to indicate proper torch heating, stress relief material, mastic, sealant, shielding mesh, and silicone grease.

2.2.8 Terminations

Provide Class 1 terminations per IEEE 48.

2.2.9 Cable Supports and Fittings

Provide cable supports, related fittings, and accessories for use in corrosive underground locations, such as manholes and utility tunnels, with a factory-applied coating of PVC of at least 20 mils thick. Provide PVC coated items that have a uniform thickness and are free of blisters, breaks, and holidays. Provide PVC compound that conforms to ASTM D746.

Provide cable racks, cable tray supports and related fittings that are UL-listed heavy-duty nonmetallic .

2.2.10 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 4500 pounds per square inch, and are 0.035-inch thick, non-corrosive non-conductive. Ensure tags are resistive to acids, alkalis, organic solvents, salt water, and are distortion resistant to 300 degrees F. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ensure ties have a minimum loop tensile strength of 175 pounds. Provide cable tags with block letters, numbers, and symbols 1 inch high on a yellow background. Ensure letters, numbers, and symbols do not fall off or change positions regardless of the cable tags orientation.

2.2.11 Fireproof Tape

Provide fireproof tape approximately 30 mils thick by 3 inches wide, consisting of a flexible, unsupported elastomer that expands in fire to provide a thick char buildup between the flame and the cable. Ensure the tape does not give off a smoke when subjected to flames or support combustion. Also, ensure tape does not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.

2.3 MATERIALS

2.3.1 Conductors

Ensure that conductors conform to the applicable requirements of NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639.

Ensure that conductors are solid copper core conforming to ASTM B3 and ASTM B8 and that they are bare, or tin-alloy-coated, according to the type of insulation used.

Provide Class B stranded conductors.

2.3.2 Insulation

Ensure the provided cables are rated for minimum 221 degrees F continuous conductor temperature and 266 degrees F emergency overload.

Provide cables with [100][133][173] percent insulation. Ensure insulation thickness is in accordance with the following:

Voltage Rating (kV)	Insulation Level (%)	Typical Insulation Thickness	
		mm	mils
5	100	2.29	90
	137	2.92	115
	173	3.56	140
8	100	2.92	115
	133	3.56	140
	173	4.45	175

Voltage Rating (kV)	Insulation Level (%)	Typical Insulation Thickness	
		mm	mils
15	100	4.45	175
	133	5.59	220
	173	6.6	260
25	100	6.6	260
	133	8.13	320
	173	10.67	420
35	100	8.76	345
	133	10.67	420
	173	14.73	580

2.3.3 Cable Identification

Provide cables with printing on the outer jacket showing the cable type, name of the manufacturer, the year in which the cable was manufactured, sequential cable reel length markings and a unique number for identification purposes. Closely group the information on the tape at 6 foot maximum intervals to permit complete identification.

2.3.4 Non-metallic Insulation Shield

Provide extruded insulation shield made of an extruded thermoset material compatible with the insulation and jacket. Ensure insulation shield is applied directly over and bonded to the insulation, and complies with AEIC CS8.

[2.3.5 Concentric Neutral Shield

Provide [copper][aluminum] wires helically applied over the insulation shield, where the minimum total cross sectional area (of the shield wires) is [1/3 of the core][full core] conductor for the cable. Minimum size of an individual shield wire is No. 14 AWG.

]2.3.6 Jacket

Provide polyvinyl-chloride (PVC) jacketed cable extruded over the cable to a minimum thickness of 80 mils.

2.3.7 Interlock Armored Cable

Provide a nonmetallic, corrosion-resistant jacket over interlock-armored cable that is PVC conforming to NEMA WC 27500 and NEMA WC 74/ICEA S-93-639.

2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

2.4.1 FACTORY TESTING

Submit certified evidence that the cable manufacturer has made factory-conducted tests on each shipping length (reel) of cable. Submit certified copies of test data in accordance with applicable provisions of the referenced standard. Include in tests on each length of cable to include:

(1) Conductor Resistance

(2) Accelerated Water Absorption Test

(3) Water Immersion Test

(4) Ionization

(5) High-Voltage

(6) Partial Discharge Test

Contracting Officer or designee has the option of witnessing required factory testing at no additional cost. Provide a schedule of manufacturing and testing in advance to permit such witnessing, if requested.

Submit certified qualification test reports in accordance with AEIC CS8 made in accordance with the applicable referenced standards. Ensure certified copies of test data show conformance to the requirements of referenced standards and submit for approval prior to shipment of the cable.

Prior to manufacturing, provide data regarding degradation of proposed insulating material and cable performance due to water immersion test as specified in this specification to the Contracting Officer or designee. Indicate in information AC breakdown stress in kV/mm or V/mil versus immersion time. Ensure a complete description and condition under which cable was tested accompanies the test information. Submit an accelerated water absorption test.

PART 3 EXECUTION

3.1 DEMOLITION OR CABLE CUTTING

Notify the Contracting Officer 14 working days prior to an outage for demolition or cable cutting of medium voltage electrical system.

The Government has established a mandatory inspection point prior to Contractor performing any medium voltage cable cuts or demolition. Notify the Contracting Officer 48 hours in advance of this mandatory inspection point.

As part of the mandatory inspection point, positively identify and label the medium voltage cable to be worked utilizing an electronic cable identifier. Ensure the process of identifying and labeling the cable to be worked is witnessed by the Government. Cable cutting and demolition of any medium voltage cable can occur only after approval by the Contracting Officer.

Cut medium voltage cables and conductors by indirect means using cable cutters specifically designed to be operated remotely only. Cutting of medium voltage cables and conductors by direct means is not permitted.

3.2 INSTALLATION

Install medium-voltage cables in accordance with NFPA 70, NFPA 70E; and IEEE C2.

Refer to contract provisions for safety submittals and requirements associated with working in the vicinity of energized cables and equipment. The use of arc-flash and shock prevention equipment and personal protective equipment is mandatory.

Notify the Contracting Officer 14 working days prior to an outage that requires testing for phasing and phase rotation of medium voltage electrical systems. The Government will identify and tag the phasing of equipment and provide to the Contractor, in writing, the results of phasing and phase rotation tests. The Contractor is responsible for maintaining the phasing and phase rotation tests, and is responsible for maintaining the phasing, and matching the existing phase rotation and phasing when installing conductors in existing electrical systems.

Install the cables in the following locations:

Exterior:

a. In underground duct banks

b. In conduit above and below grade

c. In manholes

d. And by direct burial

Inside Buildings:

a. By open wire method

b. On insulator hooks

c. On racks

d. In wall and ceiling mounted cable trays

Secure cables with heavy-duty cable ties in existing or new trays mounted horizontally, where the cable rests on the tray bottom. Install cable ties at a minimum of 10 foot intervals.

Secure cables with non-metallic cable clamps, straps, hangers, or other approved supporting devices to tunnel walls, ceilings, and in new or existing cable trays mounted vertically, where the tray bottom is in a vertical plane.

When field cuts or other damage occurs to the PVC coating, apply a liquid PVC patch to maintain the integrity of the coating. After the installation is complete, perform an inspection to ensure that the coating has no voids, pinholes, or cuts.

Before installing new armored cable, ensure that cable trays are properly secured and supported. Add new permanent or temporary tray support devices as required to preclude cable tray failure during cable pulling or after cable is installed.

Installed cable or conductors of a primary distribution system will be rejected by the Government when placed:

a. Openly in cable trays or openly racked along interior walls

b. In the same raceway or conduit with AC/DC control circuits or AC power circuits operating at less than 600 volts

c. In a manner allowing the cable to support its own weight

3.2.1 Protection During Splicing Operations

Provide a blower to force fresh air into manholes or confined areas where free movement or circulation of air is obstructed. Have waterproof protective coverings available on the work site to protect against moisture while a splice is being made. Use pumps to keep manholes dry during splicing operations. Never make a splice or termination with the interior of a cable exposed to moisture. Moisture-test the conductor insulation paper before the splice is made. Use a manhole ring at least 6 inches above ground around the manhole entrance to keep surface water from entering the manhole. Before starting the splice, plug unused ducts and stop water seepage through ducts in use.

3.2.2 Duct Cleaning

Thoroughly clean ducts before installation of power cables. Pull a standard flexible mandrel through each duct to loosen particles of earth, sand, or foreign material in the line. Use a mandrel that is not less than 12 inches long with a diameter 1/2 inch less than the inside diameter of the duct. Then pull a brush with stiff bristles through each duct to remove the loosened particles. Use a brush with a diameter that is the same as or slightly larger than the diameter of the duct.

3.2.3 Pulling Cables in Ducts, Manholes and Utility Tunnels

Submit a Pulling Plan including calculations of pulling tension and side wall pressure anticipated, and the maximum allowable pulling tension for each pull. Do not perform any pull until Government reviews and approves the pulling plan.

Pull medium-voltage cables into ducts and utility tunnels with equipment designed for this purpose, including a power-driven winch, cable-feeding flexible tube guide, cable grips, and lubricants. Employ a sufficient number of trained personnel and equipment to ensure correct installation of the cable.

Set up the cable reel at the side of the manhole or tunnel hatch opening and above the duct or hatch level, allowing the cable to enter through the opening without reverse bending. Install a flexible tube guide through the opening in a manner that prevents the cable from rubbing against the edges of structural members.

Ensure that the pulling force for a cable grip on lead-sheathed cable does not exceed the force calculated in the pulling plan for the sheath cross-sectional area. Use a dynamometer in the pulling line to ensure that the pulling force is not exceeded. Ensure that the pulling force for a nonmetallic-sheathed cable does not exceed the smaller of 1,000 pounds or a value computed from the following equation:

TM = 0.036 X N X CM

Where: TM = maximum allowable pulling tension in pounds

N = number of conductors in the cable

CM = cross-sectional area of each conductor in circular mils

3.2.3.1 Allowable Sidewall Pressure

The allowable sidewall pressure is the smaller of 500 pounds per foot of bend radius or the cable manufacturer's recommended maximum value. Show in the pulling plan submittal the calculations for allowable tension and sidewall pressure as well as the anticipated tension and sidewall pressure for each pull in the project.

Unreel cable from the top of the reel, carefully controlling payout. Attach cable to be pulled through a swivel to the main pulling wire by means of a pulling eye installed by the factory or approved cable splicer .

Attach pulling eyes to the cable conductors of the 3-1/C circuit to prevent damage to the cable structure. Pull the entire 3-1/C circuit simultaneously.

3.2.3.2 Minimum Bending Radius

Minimum bending radius during cable pulling operations is 30 inches. For permanent cable bending/racking the minimum bending radius is 12 times cable diameter.

3.2.3.3 Coating of Cables

Liberally coat cables with a suitable cable-pulling lubricant as it enters the tube guide or duct. Do not use greaser and oil lubricants. Cover nonmetallic sheathed cables with wire-pulling compounds, when required, which have no deleterious effects on the cable. Use rollers, sheaves or tube guides, around which the cable is pulled, conforming to the 30 inches minimum bending radius of the cable during the pulling operations.

3.2.3.4 Pulling Speed

Pull cables into ducts at a speed not to exceed 50 feet per minute and not in excess of maximum permissible pulling tension specified by the cable manufacturer. Cable pulling using a vehicle is not be permitted. Stop pulling operations immediately with any indication of binding or obstruction and do not resume until such difficulty is corrected. Provide sufficient slack for free movement of cable due to expansion or contraction.

3.2.3.5 Cable Splice Support And Sealing

Firmly support cable splices made up in manholes on cable racks as indicated. Do not pull cable splices in ducts. Overlap cable ends at the ends of a section to provide sufficient undamaged cable for splicing. Overlap cables to be spliced in manholes to the centerline of the proposed joint by not less than 2 feet.

Immediately seal cut ends of cables cut in the field to prevent entrance of moisture with heat-shrinkable molded cable end caps.

3.2.4 Splices and Terminations

Make splices in manholes or tunnels except where cable terminations are specifically indicated. Expedite splicing and terminating of cables in order to minimize exposure and cable deterioration.

Use only equipment and materials recommended by the splice manufacturer including calibrated cutting equipment to ensure consistent cut depths when preparing cable ends for the application of the splice kit. Connect the cable concentric neutral/shield wires across one side of the splice by split bundling the splice neutral wiring and connecting each bundle set to a continuous No. 4 AWG solid bare copper conductor via two compression conductors. Ensure the No. 4 AWG conductor extrudes from the cable splice jacket and connects to the manholes grounding system. Make all connections within the splice utilizing long barrel-type compression connectors and appropriate compression tools with proper size dies to ensure a satisfactory mechanical and electrical joint. Ensure bare connections of concentric neutral/shield wires are either contained within the splice kit or sealed via an additional outer covering,consisting of a heavy wall, heat-shrinkable tubing containing adhesive material (mastic) that melts as heat is applied and the outer tubing shrinks to form a moisture proof environmental seal. Provide outer tubing conforming to ANSI C119.1. Ensure splice meets the requirements of IEEE 404 for a 15 kV rating and is rated by the manufacturer for use on 15 kV class feeder cable systems. Take extra precautions to seal around the exit area of the bare copper jumpers with an additional mastic per the splice manufacturer's recommendations.

Terminate cables in approved cable terminations, rated Class 1 per IEEE 48. Dry terminations with medium voltage pennants, preformed, and hand wrapped stress cones can be used for terminating cables. Provide terminations with adequate means for making external connections to the cable conductors of single-conductor cables (phase and concentric neutral), protecting the cable insulation against moisture, oil, or other contaminants. Take extra precautions in physically protecting and supporting cables, and maintaining the insulation level of the cable.

Ensure that installation includes built-up or prefabricated heat or cold shrink stress-relief cones at the terminals of all shielded cables and at the terminals of single-conductor lead-covered cables rated 15 kV and above, ungrounded.

Field-fabricate cable splices from splicing kits supplied by and in accordance with the cable manufacturer's recommendations for the type, size, and electrical characteristics of the cable specified. Locate cable splices in manholes midway between the cable racks on the walls of the manholes and supported with cable arms at approximately the same elevation as the enclosing duct.

If cable splices in the tunnel are not installed in cable trays, install the cable splices on cable racks or by other approved methods that minimize physical stress on the splice connections. Support splices at approximately the same elevation as the installed cable except where space limitations or existing cable length limitations make this method impractical or impossible.

Support all universal demountable splices in a manner that minimizes physical stress on the splice connections. Support each cable end termination using a pair of saddle supports under the cable end termination or cable with a minimum 12 inches and a maximum 30 inches separation between the supports. Secure the cable end termination and cable to the supports in a manner that prevents movement of termination or cable at the support. Install saddle supports on a galvanized steel framing channel that is anchored to the wall, securely fastened to the cable tray, or installed by other approved methods.

3.2.5 Fireproofing

Provide fireproofing (Arc Proofing) for individual cable conductor in manholes, handholes and vaults which carry current at 2200 volts or more.

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Extend the tape 1 inch into the ducts. To prevent unraveling, random wrap the fireproofing tape the entire length of the fireproofing with pressure-sensitive glass cloth tape.

3.2.6 Cable Tag Installation

Install cable tags in each manhole and at each termination as specified. Install cable tags over the fireproofing and position the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes and equipment.

3.3 FIELD QUALITY CONTROL

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

After the installation of power cables has been completed, including splices, joints, and terminations, and before the cable is energized, subject each medium voltage cable to field testing in accordance with the following requirements:

a. Provide test equipment, labor, and trained technical personnel as necessary to perform the electrical acceptance tests.

b. Record all tests on an approved medium voltage cable test form and submit completed forms to the Contracting Officer.

c. Make arrangements to have tests witnessed and approved by the Contracting Officer.

d. Isolate each power-cable installation completely from extraneous electrical connections at cable splices/terminations and joints. Observe all safety precautions.

e. Ensure each power cable is first given an insulation resistance test using a meg-ohmmeter with a voltage output of at least 2,500-volts. Apply test for a long enough time to fully charge the cable (no less than one minute). Record readings as indicated on forms provided. The minimum reading is 5000 megohms at an ambient temperature of 68 degrees F. Correct readings taken at other than 68 degrees F ambient temperatures accordingly.

f. Conform testing to NETA ATS, and NFPA 70B.

Upon successful completion of the insulation resistance tests, subject the cable to a direct-current high-potential test for 5 minutes applying test voltages in accordance with AEIC CS1 and IEEE 400.2 for paper-impregnated, lead-covered cable; AEIC CS8 and IEEE 400.2 for cross-linked, polyethylene-insulated cable; and AEIC CS8 and IEEE 400.2 for ethylene propylene rubber-insulated cable.

Record leakage current readings every 30 seconds during the first 2 minutes and every minute thereafter for the remainder of the test. When the leakage current continues to increase after the first minute, immediately terminate the test and take steps to find and correct the fault. When a second test becomes necessary, repeat this test procedure.

Upon satisfactory completion of the high-potential test, give the cable a second insulation resistance test as before.

Provide results of the second insulation resistance test that agree with the first test and that indicate no evidence that the cable has been permanently injured by the high-potential test.

Record test data identifying the cable and location, megohm readings versus time, leakage current readings versus time, and cable temperature versus time.

Final acceptance depends upon the satisfactory performance of the cable under test. Do not energize cable until recorded test data has been approved by the Contracting Officer.

Perform radiographic tests on all potheads at the discretion of the Contracting Officer to determine if voids exist in the pothead. Rework unacceptable terminations at no additional expense to the Government.

3.4 CLOSEOUT ACTIVITIES

Provide manufacturer's instructions showing the recommended sequence and method of installation for medium-voltage power cables.

-- End of Section --

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SECTION 26 05 19.10 10

INSULATED WIRE AND CABLE
05/16

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1202	(2006; R 2012; CORR 1 2012) Flame-Propagation Testing of Wire and Cable

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-58-679	(2014) Control, Instrumentation and Thermocouple Extension Conductor Identification
ICEA T-30-520	(1986) Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 70,000 B.T.U./Hour

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA WC 26	(2008) Binational Wire and Cable Packaging Standard
NEMA WC 57	(2014) Standard for Control, Thermocouple Extension, and Instrumentation Cables
NEMA WC 70	(2021) Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 1685	(2015) UL Standard for Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables
UL 2556	(2015) UL Standard for Safety Wire and Cable Test Methods

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wire and Cable; G[, [____]]

Conductors; G[, [____]]

Cable Manufacturing Data

SD-06 Test Reports

Test Report(s), Inspection Report(s), and Verification Report(s); G [, [_____]]

1.3 DELIVERY, STORAGE, AND HANDLING

Furnish cables on reels or coils. Each cable and the outside of each reel or coil, must be plainly marked or tagged to indicate the cable length, voltage rating, conductor size, and manufacturer's lot number and reel number. Each coil or reel of cable must contain only one continuous cable without splices. Cables for exclusively dc applications, as specified in paragraph "High-Voltage Test Source," must be identified as such. Shielded cables rated 2,001 volts and above must be reeled and marked in accordance with NEMA WC 26, as applicable. Reels must remain the property of the [Contractor] [Government].

1.4 PROJECT/SITE CONDITIONS

[_____]

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Wire Table

Furnish wire and cable in accordance with the requirements of the [wire table below] [wire table appended to these specifications], conforming to the detailed requirements specified herein.

2.1.2 Rated Circuit Voltages

All power wire and cable must have minimum rated circuit voltages in accordance with NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Power wire and cable for circuit voltages rated 0-600 volts must be rated not less than 600 volts. Control wire and cable must have minimum rated circuit voltages in accordance with NEMA WC 57, but must be rated 600 volts if routed in raceway with other conductors that are rated 600 volts.

2.1.3 Conductors

2.1.3.1 Material for Conductors

Conductors must conform to all the applicable requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Copper conductors must be annealed copper material and they may be bare, or tin- or lead-alloy-coated, if required by the type of insulation used. Aluminum conductors must be Type AA-8000 aluminum conductors. Type 1350 is not acceptable. Intermixing of copper and aluminum conductors in the same raceway is not permitted."

2.1.3.2 Size

Minimum wire size must be No. 12 AWG for power and lighting circuits; No. 10 AWG for current transformer secondary circuits; No. 14 AWG for potential transformer, relaying, and control circuits; No. 16 AWG for annunciator circuits; and No. 19 AWG for alarm circuits. Minimum wire sizes for rated circuit voltages of 2,001 volts and above must not be less than those listed for the applicable voltage in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable.

2.1.3.3 Stranding

Conductor stranding classes cited herein must be as defined for control conductors in NEMA WC 57 or as defined for 0-2,000 volts power conductors in NEMA WC 70, as applicable. Lighting conductors No. 10 AWG and smaller must be solid or have Class B stranding. Any conductors used between stationary and moving devices, such as hinged doors or panels, must have Class H or K stranding. All other conductors must have Class B or C stranding, except that conductors as shown, or in the schedule, as No. 12 AWG may be 19 strands of No. 25 AWG, and conductors shown as No. 10 AWG may be 19 strands of No. 22 AWG. Conductor stranding classes for circuit voltages 2,001 volts and above must be as defined in ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639, as applicable.

2.1.3.4 Conductor Shielding

Use conductor shielding conforming to NEMA WC 57 for control wire and cable as applicable. Use conductor shielding conforming to ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable, on power cables having a rated circuit voltage above 2,000 volts.

2.1.3.5 Separator Tape

Where conductor shielding, strand filling, or other special conductor treatment is not required, a separator tape between conductor and insulation is permitted.

2.1.4 Insulation

2.1.4.1 Insulation Material

Unless specified otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44. Insulation for control wire and cable must meet the requirements of NEMA WC 57. Insulation requirements for wire and cable rated less than 2,000 volts must meet the requirements of NEMA WC 70. Insulation requirements for wire and cable rated 2,001-5,000 volts must meet the requirements of ANSI/NEMA WC 71/ICEA S-96-659. Insulation requirements for wire and cable rated 5,001 volts and greater must meet the requirements of NEMA WC 74/ICEA S-93-639.

For shielded cables of rated circuit voltages above 2,000 volts, the following provisions must also apply:

a. XLPE, if used, must be tree-retardant.

b. Insulation must be chemically bonded to conductor shielding.

c. The insulation material and its manufacturing, handling, extrusion and vulcanizing processes must all be subject to strict procedures to prevent the inclusion of voids, contamination, or other irregularities on or in the insulation. Insulation material must be inspected for voids and contaminants.

d. Cables with repaired insulation defects discovered during factory testing, or with splices or insulation joints, are prohibited .

2.1.4.2 Insulation Thickness

The insulation thickness for each conductor must be based on its rated circuit voltage.

2.1.4.2.1 Power Cables, 2,000 Volts and Below

The insulation thickness for single-conductor and multiple-conductor power cables rated 2,000 volts and below must be as required by NEMA WC 70, as applicable. Some thicknesses of NEMA WC 70 will be permitted only for single-conductor cross-linked thermosetting polyethylene insulated cables without a jacket. NEMA WC 70 ethylene-propylene rubber-insulated conductors must have a jacket.

2.1.4.2.2 Power Cables, Rated 2,001 Volts and Above

Thickness of insulation for power cables rated 2,001 volts and above must be in accordance with the following

a. Non-shielded cables, 2,001 to 5,000 volts, must comply with ANSI/NEMA WC 71/ICEA S-96-659, as applicable.

b. Shielded cables rated 5,000 volts to 46,000 volts must comply with NEMA WC 74/ICEA S-93-639, as applicable.

2.1.4.2.3 Single-Conductor and Multiple-Conductor Control Cables

The insulation thickness of control conductor sizes 22 AWG to 10 AWG used for control and related purposes must be as required by NEMA WC 57, as applicable. Control conductors larger than 10 AWG must be as required by NEMA WC 70.

2.1.4.3 Insulation Shielding

Unless otherwise specified, provide insulation shielding for conductors having rated circuit voltages of 2,001 volts and above. The voltage limits above which insulation shielding is required, and the material requirements, are given in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The material, if thermosetting, must meet the wafer boil test requirements as described in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The method of shielding must be in accordance with the current practice of the industry; however, the application process must include strict precautions to prevent voids or contamination between the insulation and the nonmetallic component. Voids, protrusions, and indentations of the shield must not exceed the maximum allowances specified in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The cable must be capable of operating without damage or excessive temperature when the shield is grounded at both ends of each conductor. All components of the shielding system must remain tightly applied to the components they enclose after handling and installation in accordance with the manufacturer's recommendations. Shielding systems which require heat to remove are prohibited unless specifically approved.

2.1.5 Jackets

All cables must have jackets meeting the requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, and NEMA WC 74/ICEA S-93-639, as applicable, and as specified herein. Individual conductors of multiple-conductor cables must be required to have jackets only if they are necessary for the conductor to meet other specifications herein. Jackets of single-conductor cables and of individual conductors of multiple-conductor cables, except for shielded cables, must be in direct contact and adhere or be vulcanized to the conductor insulation. Multiple-conductor cables and shielded single-conductor cables must be provided with a common overall jacket, which must be tightly and concentrically formed around the core. Repaired jacket defects found and corrected during manufacturing are permitted if the cable, including jacket, afterward fully meets these specifications and the requirements of the applicable standards.

2.1.5.1 Jacket Material

The jacket must be one of the materials listed below. Polyvinyl chloride compounds will not be permitted. Variations from the materials required below will be permitted only if approved for each specific use, upon submittal of sufficient data to prove that they exceed all specified requirements for the particular application.

2.1.5.1.1 General Use

Heavy-duty black neoprene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Heavy-duty chlorosulfonated polyethylene	NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Heavy-duty cross-linked (thermoset) chlorinated polyethylene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639

2.1.5.1.2 Accessible Use Only, 2,000 Volts or Less

Cables installed where they are entirely accessible, such as cable trays and raceways with removable covers, or where they pass through less than 10 feet of exposed conduit only, must have jackets of one of the materials in item "a. General Use" or one of the following:

General-purpose neoprene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Black polyethylene (MDPE)	NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Thermoplastic chlorinated polyethylene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639

2.1.5.2 Jacket Thickness

The minimum thickness of the jackets must be not less than 80 percent of the respective nominal thicknesses specified below.

2.1.5.2.1 Multiple-Conductor Cables

Thickness of the jackets of the individual conductors of multiple-conductor cables must be as required by NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable and must be in addition to the conductor insulation thickness required by the applicable respective NEMA publication for the insulation used. Thickness of the outer jackets and associated coverings of the assembled multiple-conductor cables must be as required by NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable.

2.1.5.2.2 Single-Conductor Cables

Single-conductor cables must have a jacket thickness as specified in NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable.

2.1.6 Metal-Clad Cable

2.1.6.1 General

The metallic covering or sheath must be continuous corrugated metal, conforming to the applicable requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639. The type of metal for the metallic covering must be galvanized steel . If the covering is of ferrous metal, it must be galvanized. Grounding conductor(s) conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable must be furnished for each multiple-conductor metal-clad cable. Assembly and cabling must be as specified in paragraph "Cabling." The metallic covering must be applied over an inner jacket or filler tape. The cable must be assembled so that the metallic covering will be tightly bound over a firm core.

2.1.6.2 Jackets

Metal-clad cables may have a jacket under the armor, and must have a jacket over the armor. Jackets must comply with the requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. The outer jacket for the metal-clad cable may be of polyvinyl chloride (PVC) only if specifically approved.

2.1.7 Multiple-Conductor Cables

Grounding conductor(s) conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable must be furnished for each multiple-conductor cable. Assembly and cabling must be as specified in paragraph CABLING.

2.2 CABLE IDENTIFICATION

2.2.1 Color-Coding

Insulation of individual conductors of multiple-conductor cables must be color-coded in accordance with ICEA S-58-679, except that colored braids will not be permitted. Only one color-code method must be used for each cable construction type. Control cable color-coding must be as indicated . Power cable color-coding must be black for Phase A, red for Phase B, blue for Phase C, white for grounded neutral, and green for an insulated grounding conductor, if included. Other individual conductors must be color-coded as indicated, but such color-coding may be accomplished by applying colored plastic tapes or colored sleeves at terminations.

2.2.2 Shielded Cables Rated 2,001 Volts and Above

Marking must be in accordance with ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable.

2.2.3 Cabling

Individual conductors of multiple-conductor cables must be assembled with flame-and moisture-resistant fillers, binders, and a lay conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639. Flat twin cables are prohibited. Fillers must be used in the interstices of multiple-conductor round cables with a common covering where necessary to give the completed cable a substantially circular cross section. Fillers must be non-hygroscopic material, compatible with the cable insulation, jacket, and other components of the cable. The rubber-filled or other approved type of binding tape must consist of a material that is compatible with the other components of the cable and must be lapped at least 10 percent of its width.

2.2.4 Dimensional Tolerance

The outside diameters of single-conductor cables and of multiple-conductor cables must not vary more than 5 percent and 10 percent, respectively, from the manufacturer's published catalog data.

PART 3 EXECUTION

3.1 INSTALLATION INSTRUCTIONS

Submit cable manufacturing data . The following information must be provided by the cable manufacturer for each size, conductor quantity, and type of cable furnished:

a. Minimum bending radius, in inches - For multiple-conductor cables, this information must be provided for both the individual conductors and the multiple-conductor cable.

b. Pulling tension and sidewall pressure limits, in pounds.

c. Instructions for stripping semiconducting insulation shields, if furnished, with minimum effort without damaging the insulation.

d. Upon request, compatibility of cable materials and construction with specific materials and hardware manufactured by others must be stated. Also, if requested, recommendations must be provided for various cable operations, including installing, splicing, terminating, etc.

3.2 TEST REPORT(S), INSPECTION REPORT(S), AND VERIFICATION REPORT(S)

3.2.1 Cable Data

Do not begin any wire and cable fabrication until materials are submitted and approved by the Contracting Officer. Submit cable data for approval including, but not limited to, dimensioned sketches showing cable construction and sufficient additional data to show that wire and cable meet the requirements of this Section.

3.2.2 Inspection and Tests

Inspection and tests of wire and cable furnished under these specifications must be made by and at the plant of the manufacturer, and the manufacturer must provide certification and certification reports of completed inspections and completed tests. The Government may require or perform further tests before or after installation. Testing in general must comply with NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Specific tests required for particular materials, components, and completed cables must be as specified in the sections of the above standards applicable to those materials, components, and cable types. Tests must also be performed in accordance with the additional requirements specified below. Submit 4 certified copies of test reports.

3.2.2.1 High-Voltage Test Source

Where the applicable standards allow a choice, high-voltage tests for cables to be used exclusively on dc circuits must be made with dc test voltages. Cables to be used exclusively on ac circuits must be tested with ac test voltages. If both ac and dc will be present, on either the same or separate conductors of the cable, ac test voltages must be used.

3.2.2.2 Shielded Cables Rated 2,001 Volts or Greater

The following test(s) must be performed in addition to those specified above:

a. If high-voltage testing is done with an AC test voltage as specified in paragraph "High-Voltage Test Source," an additional test must be made using a DC test voltage rated at 75 percent of the specified full DC test voltage, for 5 consecutive minutes.

b. If voltage tests after installation are required for 5-65kV shielded power cables then testing must be done in accordance with NEMA WC 74/ICEA S-93-639, Appendix F.

3.2.2.3 Flame Tests

All multiple-conductor and single-conductor cable assemblies must pass either the vertical cable tray flame tests required by ICEA T-30-520 (stated in, but not required by NEMA WC 70), the vertical tray flame propagation test requirements of UL 1685 and IEEE 1202, the wire and cable burning characteristics test of the UL 2556 VW-1 Test, or (for control cables only) the flame test as required by NEMA WC 57. If such tests, however, have previously been made on identical cables, these tests need not be repeated. Instead, certified reports of the original qualifying tests must be submitted. In this case the reports furnished under paragraph "Reports," must include information, identify critical information, and verify that all of each cable's materials, construction, and dimensions are the same as those in the qualifying tests.

3.2.2.4 Independent Tests

The Government may make visual inspections, continuity or resistance checks, insulation resistance readings, power factor tests, or dc high potential tests at field test values. A cable's failure to pass these tests and inspections, or failure to produce readings consistent with acceptable values for the application, will be grounds for rejection of the cable.

3.2.2.5 Reports

Furnish results of tests. No wire or cable must be shipped until authorized. Lot number and reel or coil number of wire and cable tested must be indicated on the test reports.

WIRE TABLE						
Item No.	Size, AWG or kcmil	No. of Conds.	Rated Circuit Voltage	Stranding	Comments	Quantity, lin ft
Class [_____] stranding may be substituted for [______] where indicated by "*".						

-- End of Section --

SECTION 26 05 26.00 40

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
08/19

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

Section 26 41 00 LIGHTNING PROTECTION SYSTEMS applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS A3.0M/A3.0	(2020) Standard Welding Terms and Definitions
AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.1/B2.1M	(2021) Specification for Welding Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA GR 1	(2007) Grounding Rod Electrodes and Grounding Rod Electorode Couplings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-889	(2021; Rev D) Galvanic Compatibility of Electrically Conductive Materials

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 546	(2008) UL Outline of Investigation for Conductor Termination Compounds

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Ground Rods; G

Ground Wires; G

Connectors and Fasteners; G

Test Wells; G

Conductive Corrosion Inhibiting Compounds; G

Ground Buses; G

SD-06 Test Reports

Bond Resistance Test; G

Ground Resistance Tests; G

Ground Isolation Test; G

Equipment Continuity Test; G

SD-07 Certificates

Ground Resistance Test Equipment; G

Micro-Ohmmeter Test Equipment; G

SD-11 Closeout Submittals

Record Drawings

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

1.3.3 Ground Resistance Test Equipment

Provide combination 3-point and 4-point type ground resistance test equipment specifically designed for grounding electrode resistance and soil resistivity tests. Submit proof of current equipment calibration with test equipment product data.

1.3.4 Micro-Ohmmeter Test Equipment

Perform circuit and bond resistance tests using a micro-ohmmeter with the following characteristics:

a. Resistance range selectable and capable of measuring to 10 micro-Ohms using a minimum of 1 ampere of test current.

b. Positive and negative test leads of the 2-wire balanced type. Provide both clamp and probe type connections to allow measurements across all bonded surfaces. Provide long length balanced test lead to allow measurements from a bonding location to the nearest test well.

Submit proof of current equipment calibration with test equipment product data.

1.4 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

PART 2 PRODUCTS

Submit material, equipment, and fixture lists for grounding systems, including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

2.1 MATERIALS

2.1.1 Ground Rods

Provide ground rods of copper-clad steel conforming to UL 467 and ANSI/NEMA GR 1. Ensure ground rods are not less than 3/4 inch in diameter and 10 feet in length.

Where ground rod length is greater than 10 feet, provide sectional type ground rods with each section 10 feet in length. Join sectional type ground rods using exothermic welding completely around both rod/coupling joints. Ensure ground rods have cone-shaped point on the end of the first section driven into the ground.

Provide ground rods and ground rod sections die-stamped near the top with the name or trademark of the manufacturer and the length of the segment in feet.

2.1.2 Ground Wires

2.1.2.1 Bare

Provide annealed bare copper, Class "B" stranded ground and bond wires in accordance with ASTM B8 for wires #4 AWG and larger and solid in accordance with ASTM B3 for wires #6 AWG and smaller. Provide conductors with 98 percent conductivity and sized wires in accordance with the requirements of NFPA 70 and NFPA 780.

2.1.2.2 Insulated

Ensure insulated conductors conform to the requirements of Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

Where installed in conduit as part of a complete circuit provide conductors with green insulation for sizes #8 AWG and smaller and with green phase tape at each end and in each junction box for sizes #6 AWG and larger.

2.1.2.3 Straps/Jumpers

Provide copper bonding straps and jumpers with a cross-sectional area of not less than No. 6 AWG. Ensure bonding straps and jumpers for shock-mounted devices with hinged joints are made of woven-wire braid wire.

2.1.3 Connectors and Fasteners

2.1.3.1 Exothermic Welds

Ensure the molds, materials and powder charges used to make exothermic welds are the standard product of a single manufacturer and listed by the manufacturer for use on the specific type, size, quantity and configuration of conductors to which the weld is applied.

2.1.3.2 Irreversible Compression Lugs

Provide irreversible compression lug type connectors manufactured from tin-plated copper and installed using a hydraulic compression tool and die to apply correct, uniformly distributed, circumferential pressure. Ensure tools and dies are as recommended by the irreversible compression lug type connector manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed onto the conductor. Apply irreversible compression lug type connectors in strict accordance with the manufacturer's written instructions and published installation instructions. Use 2-hole lug type connectors for connections to NEMA cable pads and bus bars, and single-hole connectors otherwise.

2.1.3.3 Mechanical

Provide split bolt and clamp style mechanical type connectors manufactured from copper, copper alloy, or bronze, listed by the manufacturer as suitable for direct burial use. Ensure mechanical type connectors are applied in strict accordance with the manufacturer's published installation instructions.

2.1.3.4 Fasteners

Provide bolts, nuts, washers, lock washers, and associated fasteners used for grounding and bonding connections manufactured of copper. Where fasteners contact dissimilar metals, apply conductive oxide-inhibiting compound.

2.1.4 Test Wells

Provide test wells that are H2O rated, precast reinforced concrete, rectangular, with open bottom and concrete or cast iron lid/frame. Ensure test wells have inside dimensions of not less than 15 inches wide by 22 inches long by 24 inches deep. Provide test well lid with cast "GROUND" legend.

2.1.5 Conductive Corrosion Inhibiting Compounds

Provide conductive corrosion inhibiting compounds UL Listed in accordance with UL 546, listed by the manufacturer as suitable for the application, and suitable for all aluminum and copper conductor/connector applications. Ensure conductive corrosion inhibiting compounds inhibit oxidation at the conductor/connector interface and have no deleterious effect on the conductor/connector metal or EPDM, natural rubber, or polyethylene insulating materials.

2.1.6 Ground Buses

Provide electro-tin plated, solid copper ground buses conforming to ASTM B187/B187M with minimum dimensions of 0.25 inches thick, 4 inches wide, and 12 inches in length or as indicated. Ensure ground buses are equipped with two UL Recognized red 1000V rated insulated standoffs and stainless steel mounting brackets.

Provide Telecommunications Main Ground Buses and Telecommunications Ground Buses in meeting the standards of TIA-607.

Provide grounding buses with predrilled NEMA hole configuration as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Install grounding systems in accordance with NFPA 70, NFPA 780 and IEEE C2, and as indicated.

Bond exposed non-current-carrying metallic parts of electrical equipment and metallic raceway systems to ground.

Bond grounding conductors in metallic and non-metallic raceways to ground. Make ground connections at equipment and to ground rods as indicated. Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems.

Bond wiring system neutrals to ground in accordance with the requirements of NFPA 70. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

Counterpoise ground systems consist of a series of ground rods with a direct buried grounding conductor loop, configured to minimize the number of dead-ends, interconnecting the individual ground rods. Provide ground rods in the locations indicated.

3.1.1 Ground Rods

Install ground rods so that the top of the rod is not less than inches below finished grade.

3.1.2 Conductors

Install bare or insulated conductors as indicated. Install bare conductors where not specifically identified as bare or insulated except where installed in conduit with associated phase conductors. Install insulated conductors in conduit with insulation of the same material as the associated phase conductors with which it is installed.

Provide straps/jumpers across joints subject to vibration. Install strap/jumper such that vibration will not change its electrical characteristics. Apply strap/jumper to the metallic structure on each side of the joint; do not penetrate any adjacent parts. Install straps/jumpers in areas that are accessible for maintenance. Install strap/jumper such that it does not restrict the movement of the metallic structures to which it is connected. Install strap/jumper such that it does not weaken the metallic structures to which it is attached. Do not connect two or more straps/jumpers in series.

3.1.3 Counterpoise

Install No. 4/0 AWG bare copper counterpoise grounding conductor direct buried outside of the structure drip line, within 24 to 72 inches of the structure foundation, with a minimum of 18 inches of earth cover. Install counterpoise grounding conductor in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the conductor.

Install ground rods vertically into the earth not less 10 feet with top of ground rod not less than 18 inches below finished grade. Bond ground rods to counterpoise grounding conductor at intervals no less than 20 linear feet nor greater than 40 linear feet of ground counterpoise cable.

3.1.4 Ground Buses

Install ground busses in accordance with manufacturer's instructions.

3.1.5 Building Grounds

Install No. 4/0 AWG bare copper ground conductor from concrete encased foundation rebar and every corner column and intermediate exterior column to counterpoise. Connect conductors to rebar using exothermic welds. Install one conductor a minimum of every 60 feet of concrete foundation perimeter. Connect ground conductors to columns and counterpoise using exothermic welds.

3.1.6 Equipment Grounding

Install ground systems for power, telecommunications, and instrumentation. Independently connect each system to the building counterpoise.

3.1.6.1 Equipment and Enclosure Bonding

Bond each metallic enclosure and all electrical equipment to ground. Make at least one copper connection from the system ground point to one or more enclosures in the area such that all enclosures and equipment provide a low-impedance path to ground when properly bonded together.

In addition to the green colored equipment grounding conductor required in each raceway and sized in accordance with Table 250.122 of NFPA 70, bond each panelboard, switchboard enclosure, transformer housing, motor housing, disconnect, starter, and other electrical equipment, to the grounding system with a stranded copper conductor, routed external to the feeder raceway.

Individually and directly connect indoor substations, transformers, switchboard frames, switchgear assemblies, motors, motor control centers, air compressors, air handlers, refrigerated air dryers, generators, frames and tracks of cranes, and to the building ground. Ensure the current-carrying capacity of the grounding conductor is the same as the current-carrying capacity of the power conductors for circuits utilizing power lines size No. 2 AWG and smaller. For circuits with power wiring larger than No. 2 AWG, ensure the grounding conductor is in accordance with NFPA 70.

3.1.6.2 Bonding of Conduit and Raceway Systems

Bond all metal conduit, fittings, junction boxes, outlet boxes, armored and metal sheathed cable, and other raceways. Ensure adequate electrical contact at the joints and terminations. Ensure metallic raceway systems have electrical continuity with equipment. Individually and directly connect equipment to the building ground, independent of the raceway system.

For rigid metal conduit and terminations, ensure threaded connections are wrench-tight with no exposed threads. Ream all ends of the conduit to remove burrs and rough edges. Bond conduits entering boxes and enclosures to the box with locknuts and grounding-type bushings. Locknuts that gouge into the metal box when tightened are not acceptable.

Conduit systems that are interrupted by PVC dielectric links are bonded separately on either side of the link. Do not jumper the dielectric link.

Install flexible metal conduit with an integral grounding conductor.

3.1.6.3 Cable Tray Bonding

Bond cable tray sections together. Cable tray sections in tandem assembly are considered as having electrical continuity when these sections are bonded with the appropriate bolts. Install bond straps across expansion joints. Bond cable trays to the building ground system.

3.1.7 Bonding Materials And Methods

Accomplish bonding of metal surfaces by brazing, welding, clamping or structural joining methods.

3.1.7.1 Brazing

Ensure brazing solder conforms to AWS A5.8/A5.8M .

3.1.7.2 Welding

Weld using the exothermic process with procedures conforming to AWS A3.0M/A3.0, AWS B2.1/B2.1M, and manufacturer's recommendation. Where dissimilar metals are to be joined via exothermic weld, follow the weld kit manufacturer's recommendations and published instructions. Ensure connections between dissimilar metals do not produce galvanic action in accordance with MIL-STD-889.

Use welding processes of the exothermic fusion type that makes a connection without corroding or loosening. Ensure process joins all strands and does not cause the parts to be damaged or weakened. Completed connection or joint is equal or larger in size than the conductors joined and has the same current-carrying capacity as the largest conductor. Paint the buried ground connections with a bitumastic paint.

3.1.7.3 Clamping

In external locations, use clamping only where a disconnect type of connection is required. Connection device may utilize threaded fasteners. Construct device such that positive contact pressure is maintained at all times. Use machine bolts with tooth-type lockwashers.

3.1.7.4 Cleaning of Bonding Surfaces

Thoroughly clean surfaces that comprise the bond before joining. Apply an appropriate abrasive with gentle and uniform pressure to ensure a smooth and uniform surface. Do not remove excessive metal from the surface. Clean clad metals in such a manner that the cladding material is not penetrated by the cleaning process. Then clean bare metal with an appropriate solvent to remove any grease, oil, dirt, corrosion preventives, and other contaminants. Bond to the cleaned area within one hour after cleaning. Seal joint and refinish the exposed surfaces within two hours of exposure to prevent oxidation. When additional time is required, apply a corrosion preventive compound until the area can be refinished.

3.1.7.5 Protection of Finished Bonds

Protect finished bonds by painting to match the original finish after the bond is made.

3.2 FIELD QUALITY CONTROL

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

The requirements of Section 26 08 00 APPARATUS COORDINATION, INSPECTION AND TESTING apply to this section.

Perform the following tests in the presence of the Contracting Officer. Furnish test equipment and personnel and submit written results of each test. Notify the Contracting Officer at least 14 calendar working days prior to each test.

Submit written results of each test to Contracting Officer for review and approval. Document each location where test is performed, the field conditions at the time of the test, the measured results of the test, and whether the measured results "PASSED" or "FAILED" relative to specified pass/fail performance criteria.

Perform rework to correct FAILED conditions at no additional cost to the Government.

3.2.1 Bond Resistance Test

Resistance of any bond connection cannot exceed 0.5 milliohm. Rework bonds that exceed this resistance at no additional cost to the Government.

3.2.2 Ground Resistance Tests

Test grounding systems for ground resistance. Total resistance from any point on the ground network to the building counterpoise cannot exceed 50 milliohms.

Make ground resistance and counterpoise tests during dry weather, and no sooner than 48 hours after rainfall. Conduct tests using the ratio method that measures the ratio of the resistance to earth of an auxiliary test electrode to the series resistance of the electrode under test and a second auxiliary electrode. Perform measurements in accordance with IEEE 81.

3.2.3 Ground Isolation Test

Test ground systems for isolation from other ground systems.

3.2.4 Equipment Continuity Test

Test connection from electrical distribution equipment including panelboards, switchboards, transformers, substations, and motor control centers to counterpoise. Measure and record the circuit resistance between electrical equipment ground connections and the counterpoise. The circuit resistance shall not exceed 5 Ohms.

3.3 CLOSEOUT ACTIVITIES

Submit record drawings indicating the location of ground rods, mats, grids, building ground bus, supplementary grounding electrodes, steel building columns, and other metal structures connected to the grounding system.

-- End of Section --

SECTION 26 05 48.00 10

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325 (2017) Steel Construction Manual

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01 (2019, with Change 1, 2022) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 1598 (2021; Reprint Jun 2021) Luminaires

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Apply the requirements for seismic protection measures described in this section to the electrical equipment and systems listed below. Structural requirements are in accordance with Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

1.2.2 Electrical Equipment

Include the following items to the extent required on the drawings or in other sections of these specifications:

Control Panels	Air Handling Units
Pumps with Motors	Switchgear
Light Fixtures	Unit Substations
Motor Control Centers	Transformers
Switchboards (Floor Mounted)	Storage Racks
Solar Heating Units	

1.2.3 Electrical Systems

Install the following electrical systems as required on the drawings and other sections of these specifications and seismically protect in accordance with this specification.

1.2.4 Contractor Designed Bracing

Submit copies of the Design Calculations with the Drawings. Calculations must be approved, certified, stamped and signed by a Registered Professional Engineer. Verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design the bracing in accordance with UFC 3-301-01 and additional data furnished by the Contracting Officer. Accomplish resistance to lateral forces induced by earthquakes without consideration of friction resulting from gravity loads. UFC 3-301-01 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas are required. Loadings determined using UFC 3-301-01 are based on strength design; therefore, use AISC 325 for the design.

1.2.5 Conduits Requiring No Special Seismic Restraints

Seismic restraints may be omitted from electrical conduit less than 2-1/2 inches trade size. Seismically protect all other interior conduit as specified.

1.3 EQUIPMENT REQUIREMENTS

Submit detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals must be complete in detail, indicating thickness, type, grade, class of metal, and dimensions; and must show construction details, reinforcement, anchorage, and installation with relation to the building construction. Submit copies of the design calculations with the detail drawings. Calculations must be stamped by a registered engineer and must verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment: are to be furnished under this contract must be constructed and assembled to withstand the seismic forces specified in UFC 3-301-01. Entirely locate each item of rigid electrical equipment and rigidly attach on one side only of a building expansion joint. Provide items such as piping, electrical conduit, which cross the expansion joint with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

Engine-Generators
Substations
Transformers
Switch Boards and Switch Gears
Motor Control Centers
Free Standing Electric Motors

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting Fixtures in Buildings

Equipment Requirements

SD-03 Product Data

Lighting Fixtures in Buildings; G

Equipment Requirements; G

Contractor Designed Bracing; G

PART 2 PRODUCTS

2.1 LIGHTING FIXTURE SUPPORTS

Provide lighting fixtures and supports conforming to UL 1598.

2.2 SWAY BRACING MATERIALS

Provide sway bracing materials (e.g. rods, plates, rope, angles, etc.) as specified in Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

PART 3 EXECUTION

3.1 SWAY BRACES FOR CONDUIT

Brace conduit as for an equivalent weight pipe in accordance with Section 23 05 48.19 SEISMIC BRACING FOR HVAC.

3.2 LIGHTING FIXTURES IN BUILDINGS

Provide lighting fixtures and supports conforming to the following:

3.2.1 Pendant Fixtures

Provide pendant fixtures conforming to the requirements of UFC 3-301-01.

3.2.2 Ceiling Attached Fixtures

3.2.2.1 Recessed Fluorescent Fixtures

Support recessed fluorescent individual or continuous-row mounted fixtures by a seismic-resistant suspended ceiling support system built in accordance with Section 09 51 00 ACOUSTICAL CEILINGS. Provide seismic protection for the fixtures conforming to the requirements of UFC 3-301-01. Recessed lighting fixtures not over 56 pounds in weight may be supported by and attached directly to the ceiling system runners using screws or bolts, number and size as required by the seismic design. Provide lock or screw attachments for fixture accessories, including louvers, diffusers, and lenses.

3.2.2.2 Surface-Mounted Fluorescent Fixtures

Attach surface-mounted fluorescent individual or continuous-row fixtures to a seismic-resistant ceiling support system built in accordance with Section

09 51 00 ACOUSTICAL CEILINGS. Provide seismic protection for the fixtures conforming to the requirements of UFC 3-301-01.

3.2.3 Assembly Mounted on Outlet Box

Design a supporting assembly, that is intended to be mounted on an outlet box, to accommodate mounting features on 4 inch boxes, plaster rings, and fixture studs.

3.2.4 Wall-Mounted Emergency Light Unit

Design and secure attachments for wall-mounted emergency light units for the worst expected seismic disturbance at the site.

3.2.5 Lateral Force

Provide structural requirements for light fixture bracing in accordance with Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

-- End of Section --

SECTION 26 05 71.00 40

LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES
02/17

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 443	(1979) NARM Standard for Solid State Relays Service

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.17	(2012) Standard for Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers
IEEE C37.90	(2005; R 2011) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C63.2	(2009) Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz - Specifications
IEEE C63.4	(2014) American National Standard for

	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

IPC - ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES (IPC)

IPC D330	(1992) Design Guide Manual

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C78.23	(1995; R 2003) American National Standard for Incandescent Lamps - Miscellaneous Types
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 20	(2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Connection Diagrams; G

Fabrication Drawings; G

Control Devices; G

Protective Devices; G

SD-03 Product Data

Fuses; G

Motor Controllers; G

Instrument Transformers; G

Enclosures; G

Circuit Breakers; G

Control Devices; G

Time Switches; G

Protective Relays; G

Indicating Instruments; G

Indicating Lights; G

SD-06 Test Reports

Dielectric Tests; G

Final Test Reports; G

SD-07 Certificates

Insulating Oil; G

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PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit connection diagrams showing the relations and connections of control devices and protective devices by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit fabrication drawings for control devices and protective devices consisting of fabrication and assembly details performed in the factory.

2.2 EQUIPMENT

2.2.1 Motor Controllers

Conform to NEMA ICS 1, NEMA ICS 2, and UL 508 for motor controllers. Ensure controllers have thermal overload protection in each phase.

2.2.1.1 Manual Motor Controllers

Provide full-voltage, manually operated manual motor controllers for the control and protection of single-phase 60-Hz ac fractional-horsepower squirrel-cage induction motors.

Provide single-throw, single- or double-pole, three-position controllers rated at not more than 1 horsepower at 115 V and 230 V single-phase. Include a supporting base or body of electrical insulating material with enclosed switching mechanism, yoke, thermal-overload relay, and terminal connectors. Provide controllers that clearly indicate operating condition: on, off, or tripped.

Provide toggle- or key-operated-type manual motor controllers as indicated and arrange them so that they are lockable with a padlock in the "OFF" position.

Provide recessed manual motor controllers for single-speed, fractional-horsepower, squirrel-cage induction motors. Include a single controller and indicating light in a 4-inch-square wall outlet box; for flush-wiring devices, include matching corrosion-resistant steel flush cover plates. Provide surface-mounted manual motor controllers for single-speed, fractional-horsepower squirrel-cage induction motors that include a single controller and indicating light in a NEMA 250, Type 1 , general-purpose enclosure.

Provide recessed and surface-mounted manual motor controllers for two-speed, fractional-horsepower, squirrel-cage induction motors; include two controllers, two indicating lights, and a selector switch in a multiple-gang wall outlet box for flush-wiring devices, with matching corrosion-resistant steel flush cover plates. Provide surface-mounted manual motor controllers for two-speed, fractional-horsepower, squirrel-cage induction motors; include two controllers, two indicating lights, and a selector switch in a NEMA 250, Type 1 , general-purpose enclosure.

2.2.1.2 Magnetic Motor Controllers

a. Full-Voltage Controllers

Provide full-voltage, full-magnetic devices for the control and protection of single- and three-phase, 60 Hz, squirrel-cage induction motors in accordance with NEMA ICS 1, NEMA ICS 2, and UL 508 for magnetic motor controllers.

Ensure that the operating coil assembly operates satisfactorily between 85 percent and 110 percent of rated coil voltage. Provide 120 V, 60 Hz motor control circuits.

Provide the controllers with two normally open and two normally closed auxiliary contacts rated according to NEMA ICS 1 and NEMA ICS 2, in addition to the sealing-in contact for the control circuits.

Provide solderless pressure wire terminal connectors for line and load connections to the controllers.

Include three manual-reset thermal-overload devices for overcurrent protection, one in each pole of the controller. Provide thermal-overload relays of the bimetallic nonadjustable type with continuous-current ratings and service-limit current ratings. Ensure that ratings have a plus or minus 15 percent adjustment to compensate for ambient operating conditions.

Provide an externally operable manual-reset button to reestablish control power to the holding coil of the electromagnet. After the controller has tripped from overload, ensure that resetting the motor-overload device does not restart the motor.

Provide an enclosure in accordance with NEMA 250, Type as suitable for the environment.

b. Reduced-Voltage Starters

Conform to the requirements for full-voltage controllers for reduced-voltage starters, except for voltage, and to the following additional requirements:

(1) Fully protect the motor during all phases of motor starting with an overload device in each motor leg. Rate the starter contacts to withstand the switching surges during selector to full voltage. Provide a starter that contains the sensing and timing devices necessary to monitor motor operation and select the correct time for selector to full voltage.

(2) Ensure adequate ventilation of resistors and autotransformers used for starting. Ventilate solid-state starters for starting cycles as well as any follow-on restart-run cycles. Operate external control circuits or solid-state starters at a maximum of 120 V ac.

(3) For solid-state starters, provide adjustable starting torque from 0 percent to 50 percent of applied voltage, minimum. Provide autotransformer starters with a minimum of three taps above 50 percent reduced voltage.

2.2.1.3 Combination Motor Controllers

The following requirements are in addition to the requirements specified for magnetic motor controller:

a. Provide combination motor controllers for the control and protection of single- and three-phase, 60 Hz ac squirrel-cage induction motors with branch-circuit disconnecting and protective devices in accordance with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6.

b. For combination motor controllers, include magnetic motor controllers and molded-case circuit breakers or motor circuit protectors (MCPs) in metal enclosures in accordance with NEMA 250 or motor control center draw-out assemblies with control-power transformers, selector switches, pushbuttons, and indicating lights as follows:

(1) Provide full-voltage, full-magnetic devices as specified in this section under paragraph REMOTE-CONTROL STATION ENCLOSURES for magnetic motor controllers and enclosures.

(2) Provide thermal-magnetic breakers as specified in paragraph MANUAL MOTOR CONTROLLERS for molded-case circuit breakers. Manufacturer's standard MCPs may be used in lieu of molded-case circuit breakers.

(3) Provide control-power transformers 120 V ac maximum, selector switches, pushbuttons, and pilot lights as required.

(4) Identify combination motor controllers with identification plates affixed to the front cover of the controller.

a. Nonreversing Combination Motor Controllers

The following requirements are in addition to the requirements for magnetic motor controllers:

(1) For the control and protection of single-speed squirrel-cage induction motors, include a magnetic controller with molded-case circuit breaker or MCPs with selector switch or start/stop pushbutton and indicating light in the cover of the enclosure.

(2) Provide rating of single and three-phase, single-speed, full-voltage magnetic controllers for nonplugging and nonjogging duty in accordance with NEMA ICS 1 and NEMA ICS 2.

(3) Provide wiring and connections for full-voltage, single-speed magnetic controllers in accordance with NEMA ICS 1 and NEMA ICS 2.

b. Reversing Combination Motor Controllers

The following requirements are in addition to the requirements for magnetic motor controllers:

(1) For the control and protection of single-speed squirrel-cage induction motors, include two interlocked magnetic controllers with molded-case circuit breaker or MCPs, with selector switch or forward/reverse/stop pushbutton and two indicating lights in the cover of the enclosure. Provide indicating lights to identify the forward and reverse running connection of the motor controller.

(2) Provide rating of single and three-phase, single-speed, full-voltage magnetic controllers for plug-stop, plug-reverse, or jogging duty in accordance with NEMA ICS 1 and NEMA ICS 2.

(3) Provide wiring and connections for full-voltage, single-speed magnetic controllers in accordance with NEMA ICS 1 and NEMA ICS 2.

c. Two-Speed Combination Motor Controllers

The following requirements are in addition to the requirements for magnetic motor controllers:

(1) For the control and protection of single- and two-winding, two-speed, three-phase, squirrel-cage induction motors, include two magnetic controllers with molded-case circuit breaker or MCPs, with selector switch or fast/slow/stop pushbutton and two indicating lights in the cover of the enclosure. Provide indicating lights to identify the high- and low-speed running connection of the motor controller.

(2) Provide rating of three-phase, two-speed, full-voltage magnetic controllers for nonplugging and nonjogging duty for constant- and variable-torque motors in accordance with NEMA ICS 1 and NEMA ICS 2.

(3) Provide rating of three-phase, two-speed, full-voltage magnetic controllers for nonplugging and nonjogging duty for constant-horsepower motors in accordance with NEMA ICS 1 and NEMA ICS 2.

(4) Provide rating of three-phase, two-speed, full-voltage magnetic controllers for plug-stop, plug-reverse, or jogging duty for constant-torque, variable-torque, and constant-horsepower motors in accordance with NEMA ICS 1 and NEMA ICS 2.

2.2.2 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3.

2.2.2.1 Molded-Case Circuit Breakers

Provide molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection as required. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering.

Locate thermal-magnetic tripping elements in each pole of the circuit breaker, and provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous magnetic tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than 100 A.

Size the breaker as required for the continuous-current rating of the circuit. Provide the breaker class as required.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required.

For meter circuit disconnects, provide circuit breakers of the motor-circuit-protector type that meet the applicable requirements of NFPA 70.

For service disconnection, provide enclosed circuit-breakers with external handles for manual operation. Provide sheet-metal enclosures with hinged covers suitable for surface mounting.

2.2.2.2 Enclosed Molded-Case Circuit Breakers

For enclosed circuit breakers, provide thermal-magnetic, molded-case circuit breakers in surface-mounted, nonventilated enclosures conforming to NEMA 250 and UL 489.

Provide enclosed circuit breakers in nonhazardous locations as follows:

a. Contain circuit breakers installed inside clean, dry locations in NEMA Type 1, general purpose, sheet-steel enclosures.

b. Contain circuit breakers installed in unprotected outdoor locations, in NEMA Type 3R, weather-resistant sheet-steel enclosures that are splashproof, weatherproof, sleetproof, and moisture-resistant.

c. Contain circuit breakers installed in wet locations, in NEMA Type 4, watertight corrosion-resistant, sheet-steel enclosures constructed to prevent entrance of water.

d. Contain circuit breakers installed in wet locations in NEMA Type 4, watertight, cast-iron enclosures, constructed to prevent entrance of water when tested in accordance with NEMA ICS 1 for Type 4 enclosures.

e. Contain circuit breakers installed in dry, noncombustible, dust-laden atmospheres in NEMA Type 5, dusttight, corrosion-resistant sheet steel enclosures, with gaskets or their equivalent to prevent the entrance of dust.

f. Contain circuit breakers installed in dry, noncombustible, dust-laden atmospheres in NEMA Type 5, dusttight, cast-iron enclosures, with gaskets or their equivalent to prevent the entrance of dust.

g. Contain circuit breakers installed in industrial locations in NEMA Type 12, industrial-use, sheet-steel enclosures, constructed to prevent the entrance of dust, lint, fibers, and flyings and the seepage of oil and coolant.

h. Fabricate steel enclosures from corrosion-resistant sheet-steel, conforming to ASTM A240/A240M, 300-series, corrosion-resistant steel. Ensure that the box dimensions and thickness of the sheet steel conform to UL 50.

i. Provide cast-iron enclosures of gray-iron castings conforming to ASTM A48/A48M with tensile-strength classification suitable for this application. Provide cast-metal enclosures that are not less than 1/8 inch thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch thick at tapped holes for conduits.

2.2.3 Fuses

Provide a complete set of fuses for all switches and switchgear. Ensure that fuses have a voltage rating of not less than the circuit voltage.

Make no change in continuous-current rating, interrupting rating, or clearing or melting time of fuses unless written permission is first obtained from the Contracting Officer.

Provide nonrenewable-cartridge-type fuses for ratings 30 A, 125 V or less. Provide renewable-cartridge-type fuses for ratings above 30 A 600 V or less with time-delay dual elements, except where otherwise indicated. Ensure that fuses conform to NEMA FU 1.

Install special fuses such as extra-high interrupting-capacity fuses, fuses for welding machines, and capacitor fuses where required. Do not use plug fuses.

Label fuses showing UL class, interrupting rating, and time-delay characteristics, when applicable.

Provide porcelain fuse holders when field-mounted in a cabinet or box. Do not use fuse holders made of such materials as ebony asbestos, Bakelite, or pressed fiber for field installation.

2.2.4 Control Devices

2.2.4.1 Magnetic Contactors

Provide magnetic contactors in accordance with NEMA ICS 1 and NEMA ICS 2 as required for the control of low-voltage, 60-Hz, tungsten-lamp loads, fluorescent-lamp loads, resistance-heating loads, and the primary windings of low-voltage transformers.

Provide core-and-coil assembly that operates satisfactorily with coil voltage between 85 percent and 110 percent of its voltage rating.

Provide contactors that are designed with a normally open holding-circuit auxiliary contact for control circuits, with a rating in accordance with NEMA ICS 1 and NEMA ICS 2.

Furnish solderless pressure wire terminal connectors, or make available for line and load connections to contactors in accordance with NEMA ICS 1 and NEMA ICS 2.

Provide magnetic contactors with a rating in accordance with NEMA ICS 1 and NEMA ICS 2.

2.2.4.2 Control-Circuit Transformers

Provide control-circuit transformers within the enclosure of magnetic contactors and motor controllers when the line voltage exceeds 120 V. Provide an encapsulated dry-type, single-phase, 60-Hz transformer, with a 120 V (or 24 V) isolated secondary winding.

Do not provide a transformer with a rated primary voltage less than the rated voltage of the controller, or a rated secondary current less than the continuous-duty current of the control circuit.

Provide voltage regulation of the transformer such that, with rated primary voltage and frequency, the secondary voltage is not less than 95 percent nor more than 105 percent of rated secondary voltage.

Provide a source of supply for control-circuit transformers at the load side of the main disconnecting device. Protect the secondary winding of the transformer and control-circuit wiring against overloads and short circuits, with fuses selected in accordance with NEMA ICS 6. Ground the secondary winding of the control-circuit transformer in accordance with NEMA ICS 6.

2.2.4.3 Magnetic Control Relays

Provide magnetic control relays for energizing and de-energizing the coils of magnetic contactors or other magnetically operated devices, in response to variations in the conditions of electric control devices in accordance with NEMA ICS 1, and NEMA ICS 2.

Ensure that the core-and-coil assembly operates satisfactorily with coil voltages between 85 percent and 110 percent of their voltage rating.

Provide relays that are designed to accommodate normally open and normally closed contacts.

Provide 120 V, 60-Hz, Class AIB magnetic control relays with a continuous--contact rating of 10 A, and with current-making and -breaking ability in accordance with NEMA ICS 1 and NEMA ICS 2, two normally open and two normally closed.

2.2.4.4 Pushbuttons and Switches

a. Pushbuttons

For low-voltage ac full-voltage magnetic pushbutton controllers, provide heavy-duty, oiltight NEMA 250, Type 12 , momentary-contact devices rated 600 V, with pilot light, and with the number of buttons and the marking of identification plates as shown. Furnish pushbutton color code in accordance with NEMA ICS 6.

Provide pushbuttons that are designed with normally open, circuit-closing contacts; normally closed circuit-opening contacts; and two-circuit normally open and normally closed circuit-closing and -opening contacts. Ensure that pushbutton-contact ratings are in accordance with NEMA ICS 1 and NEMA ICS 2, with contact designation A600.

Identify pushbuttons in remote-control stations with identification plates affixed to the front cover in a prominent location. Identify the system being controlled on the identification plate.

b. Selector Switches

Provide heavy-duty, oiltight, maintained-contact selector switches for low-voltage control circuits, with the number of positions and the marking of identification plates in accordance with NEMA ICS 1 and NEMA ICS 2.

Identify selector switches in remote-control stations with engraved identification plates affixed to the front cover in a prominent location. Identify the system being controlled on the identification plate.

c. Ammeter Selector Switches

Provide rotary, multistage, snap-action-type ammeter selector switches for switchgear in accordance with UL 20. Use silver-plated contacts rated for 600 V, ac or dc. Provide a manually operated, four-position selector switch rated for 600 V, 20 A, minimum. Ensure that the switch is designed to select the display of current readings on each bus of the main bus from a single indicating instrument. Mount the ammeter switch on the hinged front panel of the switchgear compartment, with engraved escutcheon plate. Completely isolate the switch from high-voltage circuits.

Provide a oval-type selector switch handle.

d. Voltmeter Selector Switches

Provide rotary, snap-action-type voltmeter selector switches for switchgear in accordance with UL 20. Use silver-plated contacts rated for 600 V ac or dc. Provide manually operated, four-position switches designed to select the display of voltage readings on each phase of the main bus from a single indicating instrument. Mount the voltmeter switch on the hinged front panel of the switchgear compartment, with engraved escutcheon plate. Completely isolate the switch from high-voltage circuits.

Provide a oval-type selector switch handle.

e. Miscellaneous Switches

Provide float, limit, door, pressure, proximity, and other types of switches in accordance with IPC D330 and of the types and classes indicated.

2.2.5 Finish

Protect metallic materials against corrosion. Provide equipment with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical or abrasive action) and all outdoor installations, refer to Section 09 96 00 HIGH-PERFORMANCE COATINGS.

2.3 COMPONENTS

2.3.1 Instrument Transformers

Comply with the interference requirements listed below, measured in accordance with IEEE C63.2, and IEEE C63.4 for Instrument transformers.

Insulation Class kV	Basic Insulation Level kV	Nominal System Voltage kV	Preferred Test Voltage for Potential Transformers kV	Test Voltage for Current Transformers kV	Radio Influence Voltage Level, Microvolts Dry Type Filled	Oil
0.6	10	----	----	0.76	250	250
1.2	30	0.208 0.416 0.832 1.04	0.132 0.264 0.528 0.66	0.76	250	250
2.5	45	2.40	1.52	1.6 7	250	250
5.0	60	4.16 4.80	2.64 3.04	3.34	250	250
8.7	75	7.20 8.32	4.57 5.28	5.77	250	250
15L or 15H	95 - 110	12.00 12.47 14.40	7.62 7.92 9.14	9.41	1000	250
25	150	23.00	14.60	15.70	2500	650
34.5	200	34.50	21.90	23.0	----	650
46	250	46.00	29.20	29.30	----	1250
69	350	69.00	43.80	44.00	----	1250
92	450	92.00	58.40	58.40	----	2500
115	550	115.00	73.40	73.40	----	2500
138	650	138.00	88.00	88.00	----	2500

2.3.1.1 Current Transformers

Ensure that current transformers conform to IEEE C57.13 for installation in metal-clad switchgear. Use a standard 3-A secondary transformer.

Provide wound, bushing, bar or window-type transformers, as appropriate.

Provide transformers that have single or double secondary winding.

Provide transformers that are complete with a secondary short-circuiting device.

For window-type current transformers, provide indoor, dry-type construction, with secondary current ratings as indicated with the specified burden, frequency, and accuracy.

2.3.1.2 Potential Transformers

For potential transformers, conform to IEEE C57.13 for installation in metal-clad switchgear. Use standard 120-volt secondary transformers.

Provide transformers that have single secondary winding.

Provide burden, frequency, and accuracy as required.

For disconnecting potential transformers with integral fuse mountings and current-limiting fuses, provide indoor, dry-type two-winding construction with primary and secondary voltage ratings as required.

2.3.2 Enclosures

2.3.2.1 Equipment Enclosures

Provide enclosures for equipment in accordance with NEMA 250.

Contain equipment that is installed inside clean, dry locations in a NEMA Type 1, general-purpose sheet-steel enclosure.

Contain equipment that is installed in wet locations in a NEMA Type 4, watertight, corrosion-resistant, sheet-steel enclosure. Construct the enclosure to prevent entrance of water when tested in accordance with NEMA ICS 6 for Type 4 enclosures.

Contain equipment that is installed in industrial locations in a NEMA Type 12, industrial-use, sheet-steel enclosure. Construct the enclosure to prevent the entrance of dust, lint, fibers, and flyings and the seepage of oil and coolant.

Contain equipment that is installed in Class I, Division 1, Group A, B, C, and D, hazardous locations, in NEMA Type 7 enclosures approved for the specific flammable gas or vapor that is possibly present under normal operating conditions.

Contain equipment that is installed in Class II, Division 1, Group E, F and G, hazardous locations, in NEMA Type 9 enclosures approved for use where combustible dust is possibly present under normal operating conditions.

Fabricate sheet-steel enclosures from uncoated carbon sheet-steel of commercial quality. Ensure that the box dimensions and thickness of sheet-steel conform to UL 50.

Fabricate steel enclosures from corrosion-resistant, chromium-nickel sheet-steel conforming to ASTM A240/A240M Type 300 series with ASM No. 4, general-purpose, polished finish. Ensure that the box dimensions and thickness of sheet steel conform to UL 50.

Provide cast-iron enclosures from gray-iron castings conforming to ASTM A48/A48M with a tensile-strength classification recognized as suitable for the application. Provide cast-metal enclosures that are not less than

1/8 inch thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch thick at tapped holes for conduits.

2.3.2.2 Remote-Control Station Enclosures

Provide remote-control station enclosures for pushbuttons, selector switches, and indicating lights in accordance with NEMA ICS 6 and NEMA 250.

Contain remote-control stations installed in indoor, clean, dry locations in NEMA Type 1 general-purpose, sheet-steel enclosures. Contain recessed remote-control stations in standard wall outlet boxes with matching corrosion-resistant-steel flush cover plates.

Contain remote-control stations installed in wet locations in NEMA Type 4, watertight, corrosion-resistant, sheet-steel enclosures. Construct enclosures to prevent entrance of water when tested in accordance with NEMA ICS 6 and NEMA 250 for Type 4 enclosures.

Contain remote-control stations installed in wet locations in NEMA Type 4, watertight, cast-iron enclosures. Construct enclosures to prevent entrance of water when tested in accordance with NEMA ICS 6 and NEMA 250 for Type 4 enclosures.

Contain remote-control stations installed in dry, noncombustible, dust-laden atmospheres in NEMA Type 12, dusttight, cast-iron enclosures, with gaskets or their equivalent to prevent the entrance of dust.

Contain remote-control stations installed in industrial locations in NEMA Type 12, industrial-use, sheet-steel enclosures. Construct enclosures to prevent the entrance of dust, lint, fibers, and flyings and the seepage of oil and coolant.

Contain remote-control stations installed in industrial locations in NEMA Type 12, industrial-use, cast-iron enclosures. Construct enclosures to prevent the entrance of dust, lint, fibers, and flyings and the seepage of oil and coolant.

Contain remote-control stations installed in Class I, Division 1, Group A, B, C, and D, hazardous locations in NEMA Type 7 enclosures, approved for the specific flammable gas or vapor that is possibly present under normal operating conditions.

Contain remote-control stations installed in Class II, Division 1, Group E, F and G, hazardous locations in NEMA Type 9 enclosures, approved for use where combustible dust is possibly present under normal operating conditions.

Fabricate sheet-steel enclosures from uncoated carbon steel sheets of commercial quality, with box dimensions and thickness of sheet steel conforming to UL 50.

Fabricate steel enclosures from corrosion-resistant, chromium-nickel sheet-steel, conforming to ASTM A240/A240M, Type 300 series with ASM No. 4, general-purpose, polished finish. Ensure that the box dimensions and thickness of the sheet steel conform to UL 50.

Provide cast-iron enclosures of gray-iron castings, conforming to ASTM A48/A48M, with tensile-strength classification recognized as suitable for this application. Provide cast metal enclosures that are not less than

1/8 inch thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch thick at tapped holes for conduit.

Install remote-control stations with the centerline 66 inches above the finished floor.

2.3.3 Time Switches

Provide time switches for the control of tungsten-lamp loads, fluorescent-lamp loads, resistive-heating loads, motors, and magnetically operated devices, consisting of a motor-driven time dial and switch assembly in a NEMA 250, Type 1, general-purpose enclosure.

Provide motor drives consisting of 120-V, single-phase, 60-Hz, heavy-duty, self-starting synchronous motors directly connected to the time dial through a geartrain operating mechanism. Provide a spring-wound stored-energy source of reserve power that automatically operates the mechanism for a period of at least 12 hours in case of electric power failure. Ensure that the spring automatically rewinds electrically in not more than 3 hours after electric power is restored.

Include a heavy-duty, general-purpose, precision snap-action switch conforming to UL 20 for the switch mechanism, with provisions for manual "OFF" and "ON" operation of the switch.

Provide time switches for the control of 120/240-V, two- and three-wire, single-phase, 60-Hz circuits and 120/208-V, three-phase, four-wire, 60-Hz circuits, with a continuous-current tungsten-lamp load rating of 35 A.

2.3.4 Protective Relays

2.3.4.1 Overcurrent Relays

Provide a trip unit that employs a combination of discrete components and integrated circuits to ensure the time-current protection functions as required in a modern, selectively coordinated distribution system.

Conform relays to IEEE C37.90 for overcurrent relays.

For protection against phase and ground faults, provide single-phase nondirectional, removable, induction-type overcurrent relays with built-in testing facilities designed for operation on the dc or ac control circuit indicated.

Provide ground-fault overcurrent relays with short-time inverse-time characteristics with adjustable current tap range as required.

Provide phase-fault overcurrent relays with varied inverse-time characteristics with adjustable current tap range as required. Provide attachments that indicate instantaneous trip with adjustable current range as required.

Provide solid-state, static-type trips for low-voltage power circuit breakers in accordance with EIA 443 and IEEE C37.17.

Provide complete system-selective coordination by using a combination of the following time-current curve-shaping adjustments: ampere setting; long-time delay; short-time pickup; short-time delay; instantaneous pickup;

and ground fault.

Provide switchable or easily defeatable instantaneous and ground fault trips.

Make all adjustments using nonremovable, discrete-step, highly reliable switching plugs for precise settings. Provide a sealable, transparent cover over the adjustments to prevent tampering.

Furnish trip devices with three visual indicators to denote the automatic tripping mode of the breaker, including overload, short circuit, and ground fault.

Wire the trip unit to the appropriate terminals so that an optional, remote, automatic trip accessory can be used to provide the same indication.

Make available for use a series of optional, automatic trip relays for use with the trip unit to provide remote alarm and lockout circuits.

Provide all trip units with test jacks for in-service functional testing of the long-time instantaneous and ground-fault circuits using a small handheld test kit.

2.3.4.2 Directional Overcurrent Relays

Provide directional overcurrent relays in accordance with IEEE C37.90.

For protection against reverse-power faults, provide single-phase induction relays with adjustable time-delay and instantaneous trip attachments. Provide removable-type relays with inverse-time directional and overcurrent units with built-in testing facilities.

2.3.4.3 Reclosing Relays

Ensure that reclosing relays conform to IEEE C37.90.

Provide reclosing relays that reclose circuit breakers that have tripped from overcurrent. Provide a device that automatically recloses the breaker at adjustable time intervals between reclosures and then locks out the breaker in the open position if the fault persists. Ensure that if the fault disappears after any reclosure, the circuit breaker remains closed and the reclosing relay resets automatically and is ready to start a new sequence of operation.

Provide removable reclosing relays that have built-in testing facilities and that consist of a timing unit rated at 120/240 V, single-phase, ac and solenoid and contactor units with dc rating as indicated. Arrange contacts for one instantaneous reclosure and two subsequent reclosures at 15 and 45 seconds, respectively. Set the time dial for 60-second drum speed.

2.3.4.4 Undervoltage Relays

Ensure that undervoltage relays conform to IEEE C37.90.

Provide three-phase, induction-type undervoltage relays, including inverse timing with adjustable high- and low-voltage contacts and calibrated scale. Equip relays with indicating contactor and voltage switches to provide electrically separate contact circuits. Provide relays that are removable with built-in testing facilities and that are suitable for operation on 120 V ac circuits, with contacts that are suitable for operation on dc or ac control circuits.

2.3.5 Indicating Instruments

2.3.5.1 Ammeters

Provide switchboard indicating ammeters of approximately 4 1/2 inches square with 250-degree scale and recessed cases suitable for flush mounting. Furnish white dials with black figures and black pointers. Mount instruments on the hinged front panel of the switchgear compartment, completely isolated from high-voltage circuits. Provide a standard 5-ampere-type meter for a zero-to-full-scale normal movement, 60 Hz.

2.3.5.2 Voltmeters

Provide switchboard indicating voltmeters that are approximately 4 1/2 inches square with 250-degree scale and recessed cases suitable for flush mounting. Furnish white dials with black figures and black pointers. Mount instruments on the hinged front panel of the switchgear compartment, completely isolated from high-voltage circuits. Provide a standard 120-volt-type voltmeters for zero-to-full-scale normal movement, 60 Hz.

2.3.5.3 Watt-Hour Meters/Wattmeters

Provide watt-hour meters, wattmeters, and pulse initiation meters conforming to ANSI C12.1.

Provide three-phase induction-type switchboard wattmeters for use with instrument transformers with two stators, each equipped with a current and potential coil. Provide a meter rated for 5 A at 120 V and suitable for connection to three-phase, three- and four-wire circuits. Provide the instrument complete with potential-indicating lamps, light-load and full-load adjustments, phase balance, power-factor adjustments, four-dial clock register, ratchets to prevent reverse rotation, and built-in testing facilities.

For use with demand meters or pulse recorders, provide pulse-initiating meters that are suitable for use with either mechanical or electrical pulse initiators. Ensure that the mechanical load imposed on the meter by the pulse initiator is within the limits of the pulse meter. Provide a load as constant as practical throughout the entire cycle of operation to ensure accurate meter readings. Provide a pulse-initiating meter that is capable of measuring the maximum number of pulses at which the pulse device is nominally rated. Consider the pulse-initiating meter to be operating properly when a kilowatt-hour check indicates that the demand meter kilowatt-hours are within limits of the watt-hour meter kilowatt-hours.

Locate pulse-initiating meters such that components sensitive to moisture and temperature conditions are minimized. Take precautions to protect sensitive electronic metering circuitry from electromagnetic and electrostatic induction.

Furnish removable meters with draw-out test plugs and furnish contact devices to operate remote impulse-totalizing graphic demand meters.

2.3.5.4 Graphic Demand Meters

Provide impulse-totalizing graphic demand meters conforming to ANSI C12.1.

Provide impulse-totalizing graphic demand meters that are suitable for use with switchboard watt-hour meters and include the following: a two-circuit totalizing relay, cyclometer for cumulative record of impulses, four-dial totalizing kilowatt-hour register, synchronous motor for timing mechanism, torque motor, and chart drive. Provide a positive chart-drive mechanism, consisting of chart spindles and drive sprockets, that maintains the correct chart speed for roll strip charts. Provide an instrument that records, as well as indicates, on clearly legible graph paper, the 15-minute integrated kilowatt demand of the totalized system.

Furnish the motive power for advancing the register and pen-movement mechanism with a torque motor. Provide a capillary pen containing a 1-month ink supply. Provide roll charts with a 31-day continuous record of operation capacity.

2.3.5.5 Specialty-Type Meters

Specialty-type meters are panel meters applicable to specific situations, such as pyrometers and dc parameter meters that conform to the panel layout specified. Provide meter scales that are at least 180 degrees. Do not use edgewise meters for circuit current and voltage measurements.

2.3.6 Indicating Lights

2.3.6.1 General-Purpose Type

For indicating lights, provide oiltight instrument devices with threaded base and collar for flush mounting; translucent convex lens; candelabra screw-base lampholder; and 120 V, 6 W, Type S-6 incandescent lamp in accordance with ANSI C78.23. Provide indicating lights that are color-coded in accordance with NEMA ICS 6.

Provide indicating lights in remote-control stations when pushbuttons and selector switches are out of sight of the controller.

2.3.6.2 Switchboard Indicating Lights

For switchboard indicating lights, provide the manufacturer's standard transformer-type units 120 V input using low-voltage lamps and convex lenses of the colors indicated. Provide indicating lights that are capable of being relamped from the switchboard front. Do not use indicating lights that use resistors in series with the lamps, except in dc control circuits. Provide lights that have a press-to-test feature.

2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

2.4.1 Factory Testing

Obtain factory test results on all control and low-voltage protective devices.

PART 3 EXECUTION

3.1 INSTALLATION

Clearly list fuse information on equipment drawings.

Install control devices and protective devices that are not factory-installed in equipment, in accordance with the manufacturer's recommendations. Field-adjust the devices. Perform operation tests on the control and protective devices. Conform requirements for installation of control and protective devices to NFPA 70, NEMA ICS 1, and NEMA ICS 2.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

Demonstrate the operation and controls of protective devices of non-factory-installed equipment.

Verify tap settings of instrumentation, potential, and current transformers.

Perform dielectric tests on insulating oil in oil circuit breakers before the breakers are energized. Test oil in accordance with ASTM D877/D877M, and provide breakdown voltage that is not less than 25,000 V. Provide manufacturer certification that the oil contains no PCB's, and affix a label to that effect on each breaker tank and on each oil drum containing the insulating oil.

Field-adjust reduced-voltage starting devices to obtain optimum operating conditions. Provide test meters and instrument transformers that conform to ANSI C12.1 and IEEE C57.13.

Do not energize control and protective devices until the results of the recorded test data have been approved by the Contracting Officer. Provide final test reports with a cover letter/sheet clearly marked with the system name, date, and the words final test reports to the Contracting Officer for approval.

-- End of Section --

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SECTION 26 08 00

APPARATUS INSPECTION AND TESTING
11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Acceptance Tests and Inspections; G

SD-07 Certificates

Qualifications of Organization, and Lead Engineering Technician; G

Acceptance Test and Inspections Procedure; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Contractor shall engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the electrical distribution system and generation equipment listed in paragraph entitled "Acceptance Tests and Inspections" herein. Organization shall be independent of the supplier, manufacturer, and installer of the equipment. The organization shall be a first tier subcontractor. No work required by this section of the specification shall be performed by a second tier subcontractor.

a. Submit name and qualifications of organization. Organization shall have been regularly engaged in the testing of electrical materials, devices, installations, and systems for a minimum of 5 years. The organization shall have a calibration program, and test instruments used shall be calibrated in accordance with NETA ATS.

b. Submit name and qualifications of the lead engineering technician performing the required testing services. Include a list of three comparable jobs performed by the technician with specific names and telephone numbers for reference. Testing, inspection, calibration, and adjustments shall be performed by an engineering technician, certified by NETA (Level III) or the National Institute for Certification in Engineering Technologies (NICET) with a minimum of 5 years' experience inspecting, testing, and calibrating electrical distribution and generation equipment, systems, and devices.

1.4.2 Acceptance Tests and Inspections Reports

Submit certified copies of inspection reports and test reports. Reports shall include certification of compliance with specified requirements, identify deficiencies, and recommend corrective action when appropriate. Type and neatly bind test reports to form a part of the final record. Submit test reports documenting the results of each test not more than 10 days after test is completed.

1.4.3 Acceptance Test and Inspections Procedure

Submit test procedure reports for each item of equipment to be field tested at least 45 days prior to planned testing date. Do not perform testing until after test procedure has been approved.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 ACCEPTANCE TESTS AND INSPECTIONS

Testing organization shall perform acceptance tests and inspections. Test methods, procedures, and test values shall be performed and evaluated in accordance with NETA ATS, the manufacturer's recommendations, and paragraph entitled "Field Quality Control" of each applicable specification section. Tests identified as optional in NETA ATS are not required unless otherwise specified. Equipment shall be placed in service only after completion of required tests and evaluation of the test results have been completed. Contractor shall supply to the testing organization complete sets of shop drawings, settings of adjustable devices, and other information necessary for an accurate test and inspection of the system prior to the performance of any final testing. Contracting Officer shall be notified at least 14 days in advance of when tests will be conducted by the testing organization. Perform acceptance tests and inspections on applicable equipment and systems specified in the following sections:

a. Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Functional engine shutdown tests, vibration base-line test, and load bank test shall not be performed by the testing organization. These tests shall be performed by the start-up engineer.

b. Section 26 12 19.10 THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS

c. Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS

d. Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION

e. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Medium voltage cables and grounding systems only.

f. Section 26 13 00 SF6/HIGH-FIREPOINT FLUID INSULATED PAD-MOUNTED SWITCHGEAR

g. Section 26 11 16 SECONDARY UNIT SUBSTATIONS

h. Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION

i. Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH

j. Section 26 23 00 LOW VOLTAGE SWITCHGEAR

k. Section 26 24 13 SWITCHBOARDS

3.2 SYSTEM ACCEPTANCE

Final acceptance of the system is contingent upon satisfactory completion of acceptance tests and inspections.

3.3 PLACING EQUIPMENT IN SERVICE

A representative of the approved testing organization shall be present when equipment tested by the organization is initially energized and placed in service.

-- End of Section --

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SECTION 26 09 23.00 40

LIGHTING CONTROL DEVICES

08/19

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C136.10	(2017) Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles--Physical and Electrical Interchangeability and Testing
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 20	(2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches
UL 98	(2016) UL Standard for Safety Enclosed and Dead-Front Switches
UL 773	(2016; Reprint Jul 2020) UL Standard for Safety Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2016; Reprint Jun 2020) UL Standard for Safety Nonindustrial Photoelectric Switches for Lighting Control

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in the IEEE Stds Dictionary.

b. DALI: Digital Addressable Lighting Interface used to transmit data to and from lighting control system input devices, end devices, and control equipment.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting System Drawings; G

SD-03 Product Data

Installation Instructions; G

Dimming Ballast Controls; G

Light Level Sensor; G

Dimmer Switch; G

Lighting Contactor; G

Time Switch; G

Photocell Switch; G

Occupancy Sensors; G

SD-06 Test Reports

System Operation Tests

SD-10 Operation and Maintenance Data

Lighting Control System, Data Package 5

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

1.4.3 Predictive Testing and Inspection Technology Requirements

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit lighting system drawings showing luminaire configuration, control zones, and detection range of specified control devices. Ensure lighting system drawings include photometric calculations showing lighting levels in foot candles for all areas indicated. Ensure lighting calculations and photometric plans are created using industry standard light modeling software. Hand calculations will not be accepted.

a. Provide lighting control system of the non-centralized and non-addressable type that does not include any programmable devices. Control devices are of the line-voltage or low-voltage types and are used to create specific hard-wired control zones to turn lights on and off or to provide light dimming capabilities.

b. Provide lighting control system of the centralized and addressable type that includes programmable devices. Control devices are of the digital low-voltage or wireless types and are used to create control zones which can be changed without affecting the wiring of the devices. Control zones are used to turn lights on and off or to provide light dimming capabilities.

c. Lighting control system must comply with these specifications, all applicable construction document drawings, all applicable codes, and all local authorities having jurisdiction. Lighting control system equipment includes, but is not limited to, time control switches, manual and safety switches, dimming ballasts, light level sensors, incandescent dimmer switches, lighting contactors, photocell switches, and occupancy sensors.

2.1.1 System Requirements

a. The lighting control system and lighting end devices must revert to the on position in the event of a loss of power or control signal to the system or end devices.

b. Lighting control zones consisting of one or more networked luminaires and lighting control devices must be capable of providing automatic control from sensors (occupancy and photocell) and manual control local switches.

c. Provide networked luminaires and lighting control devices that store programming in non-volatile memory such that following any loss of power the lighting control zones continue to operate according to the defined settings.

2.2 COMPONENTS

2.2.1 Manual Switches

Provide a switch mechanism consisting of a heavy-duty general-purpose precision snap-acting switch, with NEMA ICS 6 Type 1 enclosures,, single-pole, single-throw, with a minimum rating of 1,000-watts incandescent-lamp load and 1,200-volt-amperes reactive for vapor-lamp load at rated voltage and frequency suitable for operation on a 120 volt, 60 Hz, single-phase system. Provide with a selector switch having a minimum of three positions: ON, OFF, and AUTOMATIC. Use the automatic position when photoelectric or timer control is desired. Interface the selector switch with the lighting system magnetic contactor to control system activity.

Ensure switches conform to UL 98 as applicable. Provide a quick-make, quick-break type switch such that a screwdriver is required to open the switch door when the switch is on, with blades visible when the door is open. Coordinate terminal lugs with the wire size.

2.2.2 Dimming Ballast Controls

Provide a single slide dimming ballast control dimmer with on-off control, compatible with the ballast. Control the ballast light output over the full dimming range. Provide a dimmer ballast control which is approved by the ballast manufacturer.

2.2.3 Light Level Sensor
Wow a

Provide UL listed light level sensor capable of detecting changes in ambient lighting levels, with a dimming range of 20 percent to 100 percent, minimum. Ensure sensor is designed for use with dimming ballast and voltage system to which they are connected. Provide a sensor capable of controlling 40 electronic dimming ballasts, minimum, with a sensor light level adjustable with a set level range from 10 to 100 foot-candles, minimum. Provide a sensor with a bypass function to electrically override the sensor control.

2.2.4 Incandescent Dimmer Switch

Provide a single-pole, 600 watt, 120 volt ac, dimmer switch that conforms to UL 20. Ensure the switch is the full-range rotary on-off type with built-in electromagnetic interference filter.

2.2.5 Lighting Contactor

Rate contactor as indicated. Provide in a NEMA 4 enclosure conforming to NEMA ICS 6. Provide contactors with silver alloy double-break contacts and coil clearing contacts for mechanically held contactor requiring no arcing contacts. Provide contactor with hand-off-automatic selector switch, hermetically sealed.

2.2.6 Time Switch

Provide astronomic dial type or electronic type, arranged to turn "ON" at sunset and turn "OFF" at a predetermined time between 8:30 p.m. and 2:30 a.m. or at sunrise, automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise. Provide a 120 volts rated switch, having automatically wound spring mechanism or capacitor, to maintain accurate time for a minimum of 7 hours following power failure. Provide time switch with a manual on-off bypass switch. Surface mount the housing for the time switch, inside a NEMA as appropriate for the envoronment. enclosure conforming to NEMA ICS 6.

2.2.7 Photocell Switch

Ensure photocell switches conform to UL 773 or UL 773A as applicable. Provide hermetically sealed photocells that use cadmium-sulfide or silicon diode type cells. Provide photocells that are rated at 120 volts ac, 60 Hz with single-throw contacts and designed to fail to the ON position. Provide photocells that turn on at or below 3 foot-candles and off at 4 to 10 foot-candles. Provide time delay to prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

Provide a photocell with the following:

a. Integral to the luminaire, rated 1000W minimum. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

b. In a U.V. stabilized polycarbonate housing with swivel arm and adjustable window slide, rated 1800 VA, minimum.

c. In a high-impact-resistant, noncorroding and nonconductive molded plastic housing with a locking-type receptacle conforming to ANSI C136.10, rated 1800 VA, minimum.

d. In a cast weatherproof aluminum housing with adjustable window slide, rated 1800 VA, minimum.

2.2.8 Occupancy Sensors

Provide UL listed occupancy sensor complying with FCC Part 15. Design occupancy sensors and power packs to operate on the voltage indicated. Provide sensors and power packs with circuitry that only allows load switching at or near zero current crossing of supply voltage, with mounting as indicated. Provide sensor with an LED occupant detection indicator, adjustable sensitivity, and adjustable delayed-off time range of 5 minutes to 15 minutes. Provide color matching the adjacent wall plates wall mounted sensors, and white ceiling mounted sensors. Provide ceiling mounted sensors with 360 degree coverage unless otherwise indicated.

Provide sensors with:

a. A crystal controlled ultrasonic sensor which does not cause detection interference between adjacent sensors.

b. Infrared sensors with a daylight filter, and a fresnel lens that is applicable to the controlled space.

c. Ultrasonic/Infrared Combination Sensor

   (1) Occupancy detection to turn lights on requires both ultrasonic and infrared sensor detection, such that the lights remain on if either the ultrasonic or infrared sensor detects movement. Provide infrared sensor with a lens selected for indicated usage and daylight filter to prevent short wavelength infrared interference. Provide crystal controlled ultrasonic sensor frequency.

d. Microwave and audiophonic sensors.

PART 3 EXECUTION

3.1 INSTALLATION

Submit installation instructions for occupancy sensitive control devices in accordance with the manufacturer's recommended instructions for installation.

3.1.1 Photoconductive Control Devices

Install photoconductive control devices in accordance with the manufacturer's installation instructions.

3.1.2 Time Control Switches

Install switches with not less than four 1/4 inch bolts. Do not use sheet metal screws.

3.1.3 Manual and Safety Switches

Coordinate terminal lugs with the wire size. Securely fasten switches to the supporting structure or wall using not less than four 1/4 inch bolts. Do not use sheet metal screws.

3.1.4 Magnetic Contactors

Install magnetic contactors, mechanically held, electrically operated, conforming to NEMA ICS 1 and NEMA ICS 2, suitable for 120 volts, single phase, 60 Hz, with coil voltage of 120 volts. Provide contactors with maximum continuous ampere rating and number of poles as indicated on drawings. For contactors mounted indoors, provide enclosures conforming to NEMA ICS 6, Type 1. Provide each contactor with a spare, normally open auxiliary contact.

Coordinate terminal lugs with the wire size. Securely fasten switches to the supporting structure or wall using not less than four 1/4 inch bolts. Do not use sheet metal screws.

3.2 EQUIPMENT IDENTIFICATION

3.2.1 Manufacturer's Nameplate

Provide each item of equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in an inconspicuous place; the nameplate of the distributing agent is not acceptable.

3.2.2 Labels

Provide labeled control devices, clearly marked for operation of specific lighting functions according to type. Note the following devices characteristics in the format "Use Only [_____]."

Locate markings where readily visible to service personnel, but unseen from normal viewing angles when devices are in place.

3.3 FIELD QUALITY CONTROL

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Perform system operation tests in accordance with referenced standards in this section.

Demonstrate that photoconductive control devices operate satisfactorily in the presence of the Contracting Officer.

Measure and record foot-candle levels in areas indicated and compare to submitted photometric calculations. Perform all lighting measurements in the presence of the Contracting Officer. Take measurements in areas representing a minimum of 10% relative sample and as directed by the Contracting Officer. Ensure measured lighting levels are within 5% of the calculated values. Where lighting levels are determined to be deficient contractor will modify system to bring lighting levels into compliance at no additional cost to the Government.

3.4 CLOSEOUT ACTIVITIES

Submit operation and maintenance data, lighting control system, data package 5, in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. Show information for all lighting fixtures, control modules, control zones, occupancy sensors, motion sensors, light level sensors, power packs, dimming ballasts, schematic diagrams and all interconnecting control wire, conduit, and associated hardware.

-- End of Section --

SECTION 26 11 13.00 20

PRIMARY UNIT SUBSTATION
11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D117	(2018) Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Liquids
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D2472	(2000; R 2014) Standard Specification for Sulphur Hexafluoride
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D6871	(2017) Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide

http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.04	(2018; Erta 2019; Corr 2021) Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V Corrigendum 1
IEEE C37.06	(2009) Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities for Voltage Above 1000 V
IEEE C37.2	(2008) Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations
IEEE C37.20.2A	(2020) Metal-Clad Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE C37.74	(2014) Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV
IEEE C37.90	(2005; R 2011) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C37.94	(2021) IEEE Standard for N times 64 kbps Optical Fiber interfaces between Teleprotection and Multiplexer Equipment
IEEE C37.118	(2021) Standard for Synchrophasor Measurements for Power Systems
IEEE C37.121	(2012) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers

IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.96	(2013) Guide for Loading Dry-Type Distribution and Power Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61850	(2021) Communication networks and systems for power utility automation

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA ST 20	(2014) Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232	(1997f; R 2012) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation

	Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING and Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

1.3.1 [Enter Appropriate Subpart Title Here].

SD-02 Shop Drawings

Unit Substation Drawings; G,

Transformer Drawings; G

] SD-03 Product Data

Primary Unit Substations; G,

Unit Substation Transformer; G

Submittal must include manufacturer's information for each component, device and accessory provided with the equipment.

SD-05 Design Data

Capacity Calculations for Battery Charger and Batteries; G

SD-06 Test Reports

Calibration Test Reports; G

Submit report of results of Acceptance Checks and Tests specified by paragraph FIELD QUALITY CONTROL; G,

Certified Copies of Dielectric Tests Report; G

SD-09 Manufacturer's Field Reports

Switchgear Design Tests; G

Switchgear Production Tests; G

Load Interrupter Switch Design Tests; G

Load Interrupter Switch Production Tests; G

Transformer Design Tests; G

Transformer Routine and Other Tests; G

SD-10 Operation and Maintenance Data

Primary Unit Substations, Data Package 5; G,

Unit Substation Transformer, Data Package 5; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Calibration Schedule; G

Formal Request for Settings; G

Equipment Test Schedule; G

1.4 QUALITY ASSURANCE

1.4.1 Battery Power Calculations

Submit capacity calculations for battery charger and batteries. Calculation must verify that battery capacity exceeds station d.c. power requirements.

1.4.2 Unit Substation Drawings

Drawings must include, but are not limited to, the following:

a. An outline drawing with front, top, and side views

b. Ampere ratings of bus bars

c. Maximum short-circuit bracing

d. Nameplate data

e. Provisions for future extension and future forced air equipment

f. Circuit breaker and switch type(s), interrupting ratings, and trip devices including available settings

g. Elementary diagrams and wiring diagrams with terminals identified and indicating prewired interconnections between items of equipment and the interconnection between the items

h. One-line diagram, including switch(es), circuit breakers, current transformers, meters, and fuses

i. Manufacturer's instruction manuals and published time-current curves (on full size 11 by 17 inches logarithmic paper) of the fuse in the load interrupter switch, main secondary breaker, largest secondary feeder device; transformer thermal and magnetic damage information; and transformer inrush current information (magnetic inrush point). These must be used by the designer of record to verify fuse size and to provide breaker settings that will ensure protection and coordination are achieved.

1.4.3 Transformer Drawings

Drawings must include, but are not limited to the following:

a. An outline drawing, with top, front, and side views

b. ANSI nameplate data

1.4.4 Calibration Schedule

a. Provide a calibration schedule including the anticipated dates when equipment requiring coordination and protection will be installed, the anticipated date when the Contractor will submit a formal request for settings, and the anticipated date when the manufacturer's technical representative will perform settings and calibrate equipment.

b. Submit the calibration schedule, to the Contracting Officer.

1.4.5 Formal Request for Settings

a. Where settings will be provided by the Government to achieve protection and coordination via relays and protective devices, submit a formal request for settings 30 days in advance of the date that settings will be needed, to allow the Contracting Officer to forward a copy of approved shop drawings to NAVFAC SE; Code 162; Director, Utilities Engineering Division.

b. The equipment requiring protection and coordination must be installed prior to making this request.

c. Include approved shop drawings, manufacturer's instructions to set the protective devices, and manufacturer's time-current curves.

d. Submit the formal request for settings, via the Contracting Officer to: NAVFAC SE; Code 162; Director, Utilities Engineering Division.

1.4.6 Calibration Test Reports

Submit test results on protective relays via the Contracting Officer to NAVFAC SE; Code 162; Director, Utilities Engineering Division.

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5 MAINTENANCE

1.5.1 Additions to Operation and Maintenance Data

In addition to requirements of Data Package 5, include the following on the actual primary unit substations provided.

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, including front view and sectional views with items and devices identified

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Time-Current-Characteristic (TCC) curves of fuses and circuit breakers

f. Information on metering

g. Actual nameplate diagram

h. Date of purchase

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be secondary unit substations and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 PRIMARY UNIT SUBSTATIONS

IEEE C37.121, single-ended or double-ended arrangement, consisting of incoming sections, transformer sections, transition sections, the number of auxiliary sections, bus-tie sections, and outgoing sections indicated. Substation must be designed for outdoor service with ventilation openings and gasketing provided to ensure a weatherproof assembly under rain, snow, sleet, sand/dust storms, and hurricane conditions. External doors must have provisions for padlocking.

2.2.1 Incoming Sections

If required for proper connection and alignment, include a transition section with the incoming section. Connection between circuit breaker and transformer must be insulated copper bus or insulated copper cable mounted on porcelain insulators spaced no more than 2 feet apart.

2.2.1.1 Conductor Termination

Conductor terminations must be designed for terminating single conductor cables per phase and must be arranged for conduits entering from below. Provide cable terminations of the modular molded rubber or porcelain insulator type as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2.1.2 SF6 Circuit Breaker as Main Protective Device

The SF6 circuit breaker must be an electrically-operated, three-pole, circuit interrupting device rated for amperes as required.. Rating must be based on IEEE C37.04 and IEEE C37.06. Circuit breaker must be drawout-mounted with position indicator, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breaker must be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provide for manual charging of the mechanism. Circuit breaker control voltage shall be as required. SF6 circuit breakers must be shipped factory filled with SF6 gas conforming to ASTM D2472.

a. Contacts: Silver-plated, multi-finger, positive pressure, self-aligning type for main drawout contacts.

b. Each drawout breaker must be provided with three-position operation. The connected position and the test/disconnect position must be clearly identified by an indicator on the circuit breaker front panel.

(1) Connected position: Contacts are fully engaged. Breaker must be tripped before it can be racked into or out of this position.

(2) Test/disconnect position: Position must allow for complete testing and operation of the breaker without energizing the primary circuit.

(3) Withdrawn (removed) positions: Places breaker completely out of compartment, ready for removal.

2.2.1.3 Load Interrupter Switch as Main Protective Device

IEEE C37.20.3. Provide a three-pole, single-throw, deadfront, metal-enclosed, load interrupter switch with manual stored energy operator. The switch must be operated by a manually charged spring stored energy mechanism which must simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch must be deenergized when in the open position. The mechanism must enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus must extend the width of the switch enclosure and must be bolted directly thereto. Connect frame of unit to ground bus. The door must have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch ratings must be:

The switch shall be rated as required.

b. Switch must have provision for padlocking in the open and closed positions.

2.2.2 Primary Transition Section

Provide transition section for insulated copper cable or bus-bar (as required) connections to the transformer primary terminals. Support connections between high-voltage switch or breaker and transformer primary by porcelain insulators spaced no more than 2 feet apart. Size and brace bus or cable to withstand the specified available fault.

2.2.3 Transformer Sections

IEEE C57.12.00. Less-flammable liquid-insulated , two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

2.2.3.1 Transformer Ratings

a. Transformer must be rated as required.

b. Transformer voltage ratings shall be as required.

c. Audible sound levels must comply with the following:

kVA	DECIBELS (MAX)
225	55
300	55
500	56
750	58
1000	58
1500	60
2000	61
2500	62
5000	65
7500	67
10000	68

f. Diagrammatic stainless steel or laser-etched anodized aluminum nameplate.

g. Transformer must include ground pads, lifting lugs and provisions for jacking under base. The transformer base construction must be suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole. The transformer must have an insulated low-voltage neutral bushing with lugs for ground cable, and with removable ground strap.

h. Transformer must have the following accessories:

(1) Liquid-level indicator

(2) Pressure-vacuum gage

(3) Liquid temperature indicator

(4) Drain and filter valves

(5) Pressure relief device

(6) Auxiliary cooling equipment and controls

(a) Transformer must be forced-air-cooled. Forced-air-cooling fans must have automatic temperature control relay.

2.2.3.2 Specified Transformer Efficiency

Provide transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer(s) prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "kVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K. Submit certification, including supporting calculations, from the manufacturer indicating conformance.

kVA	EFFICIENCY (percent)
15	98.65
30	98.83
45	98.92
75	99.03
112.5	99.11
150	99.16
225	99.23
300	99.27
500	99.35
750	99.40
1000	99.43
1500	99.48
2000	99.51
2500	99.53
above 2500	99.54

2.2.3.3 Insulating Liquid

a. Less-flammable transformer liquids: Must meet the requirements of ASTM D6871, NFPA 70 and be approved by the FM APP GUIDE for Less or Non-Flammable Liquid Insulated Transformers. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

Provide a fluid that is a biodegradable, electrical insulating, and cooling liquid classified by UL and approved by FM as "less flammable" with the following properties:

(1) Aquatic biodegradation: EPA 712-C-98-075, 99 percent.

(2) Trout toxicity: The fluid must have passed OECD Test 203 following the methods of EPA 821-R-02-012 and be determined to be non-toxic.

b. Mineral oil: ASTM D3487, Type II, tested in accordance with ASTM D117. Provide identification of transformer as "non-PCB" and "Type II mineral oil" on the nameplate.

2.2.3.3.1 Liquid-Filled Transformer Nameplates

Provide nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.2.4 Secondary Transition and Auxiliary Section(s)

The secondary transition and auxiliary section(s) must have a hinged front panel, an insulated main bus and connections, a ground bus, necessary terminal blocks, wiring and control buses, control power transformer, and cable supports. In the auxiliary section provide a battery complete with rack and standard accessories, and a battery charger, static type, with automatic charger control, complete with ammeter, voltmeter, and rheostat.

2.2.4.1 Control Power Transformers

Transformers must be designed for continuous operation at rated kVA 24 hours a day, 365 days a year with normal life expectancy as defined in IEEE C57.96. Dry-type, two-winding type, 115 degrees C rise above 40 degrees C maximum ambient designed for mounting in switchgear cubicle or drawer. Transformer must be sized as required to serve the connected load and must have a voltage rating as required.

2.2.4.2 Primary Protection

Provide drawout-mounted, primary current limiting fuses rated for the specified transformer size and the available short-circuit current.

2.2.4.3 Secondary Protection

Provide molded-case circuit breakers or molded-case switch sized as required, mounted in same compartment with transformer and primary fuses to serve the indicated loads.

2.2.5 Metal-Clad Switchgear Outgoing Section

IEEE C37.20.2A for metal-clad medium-voltage SF6 circuit breaker type. Each steel unit forming part of the switchgear structure must be self-contained and must house two-high breaker or instrument compartments, and a full height center and rear compartment for the buses and outgoing cable connections. For two-high breaker units, provide a removable metal barrier to separate the two cable circuits. Equip individual circuit-breaker compartments with drawout contacts, rails, disconnecting mechanism, and a cell interlock to prevent moving the removable element into or out of the "connected" position while the circuit breaker is closed. Provide a steel door for each breaker compartment. Enclosures must be designed for required location and must conform to the requirements of Table A1 of Appendix A to IEEE C37.20.2A. Design the structure to allow for future additions. Provide laminated plastic nameplates for each relay, switch, meter, device, and cubicle to identify its function. Provide permanent labels for wiring and terminals corresponding to the designations on approved shop drawings. Mount nameplates on each circuit breaker compartment door.

a. Phase buses and connections: Mount bus structure on insulated supports of high-impact, non-tracking, high-quality insulating material and brace bus to withstand the mechanical forces exerted during short-circuit conditions when connected directly to the utility source. Bus bars must be rated as required and must be high conductivity copper having silver plated joints. Make bus bar connections from main buses to the incoming circuit breaker studs. Equip outgoing circuit breaker studs with mechanical clamp type cable connectors for the size of cables shown. Provide cable supports for outgoing cables. Wire secondary circuits, including heater circuits, to terminal blocks. Terminal blocks must be readily accessible for making external connections as required.

b. Ground bus: Provide a copper ground bus sized for full short-circuit capacity. Secure ground bus to each vertical structure and extend ground bus the entire length of switchgear. Include provisions for making the station ground connections.

c. DC bus: Provide an insulated copper bus or wire extending the entire length of switchgear. Bus must be rated 100 amperes at 125 Vdc. Wire must be No. 6 AWG minimum.

d. Each breaker compartment must have provision for mounting up to four sets of ANSI rated current transformers, two on line side and two on load side of each breaker.

2.2.5.1 Circuit Breaker

Each SF6 circuit breaker must be an electrically operated, three-pole, circuit interrupting device rated as indicated. Breaker must be sized as required]. Rating must be based on IEEE C37.04 and IEEE C37.06. Breaker frame size must be as indicated. Provide draw-out mounted circuit breakers with position indicators, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breaker must be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provide for manual charging of the mechanism and for slow closing of the contacts for inspection or adjustment. Circuit breaker control voltage must be 125 Vdc.

a. Contacts: Silver-plated, multi-finger, positive pressure, self-aligning type for main drawout contacts.

b. Each drawout breaker must be provided with three-position operation. The connected position and the test/disconnect position must be clearly identified by an indicator on the circuit breaker front panel.

(1) Connected position: Contacts are fully engaged. Breaker must be tripped before it can be racked into or out of this position.

(2) Test/disconnect position: Position must allow for complete testing and operation of the breaker without energizing the

primary circuit.

(3) Withdrawn (removed) positions: Places breaker completely out of compartment, ready for removal.

2.2.5.2 Space Only Compartments

Provide fully equipped with busing, control switch, indicating lights, and drawout breaker mounting and connecting straps to accommodate future breakers. Provide compartments with doors.

2.2.5.3 Breaker Lifter

Provide a portable lifter rated for lifting and lowering circuit breakers from two-high cubicles. Portable lifter must have swivel casters in front for ease of movement.

2.2.5.4 Remote Racking Device

Provide an electrically operated remote racking device for installing and removing circuit breakers. The RRD must mount on the circuit breaker compartment door by insertion of mounting pin into the RRD support bushing in the circuit breaker compartment. The RRD output shaft must be capable of activating the racking shaft through a racking port in the circuit breaker compartment door and operate with the door closed or open. Provide a remote operator control with a lanyard type cord that allows the operator to move a minimum of 50 feet from the circuit breaker compartment. Include four hours of training for the correct use and operation of RRD.

2.2.6 Protective Relays, Metering, and Control Devices

Relays shall conform to IEEE C37.90. Protective relays shall be microprocessor-based, enclosed in rack-mountable cases with indicating targets and provisions for testing in place by use of test switches. Test switches to fit each type of relay in the equipment shall be provided. Controls, relays, and protective functions shall be provided completely assembled and wired.

All Facility Related Controls Systems (FRCS), which includes at a minimum protective relays and the PAC/RTAC, must meet current Control Systems Platform Enclave/Navy Utilities Monitoring Control Systems (CSPE/NUMCS) Authority to Operate (ATO) requirements.

The following general requirements apply to all protective relays and meters:

a. All protective relays shall be of same manufacturer except for lockout relays.

b. Meters shall display positive power flow when actual primary power flows to switchgear from source circuits identified on drawings.

c. Meters shall display positive power flow when actual primary power flows from switchgear to load circuits identified on drawings.

d. For directional overcurrent relays (Device 67) shall be wired with trip direction away from switchgear bus (exporting power) unless otherwise shown.

e. Current Transformer Mounting and Polarity Marks: Position current transformers in cubicle such that primary current into protected zone results in secondary current into protective relay or meter's polarity terminal.

f. Current transformer secondary circuits shall be wired using 12 AWG minimum, tinned high-stranded SIS wire unless otherwise shown.

g. Voltage transformer secondary circuits shall be wired using 14 AWG minimum, tinned high-stranded SIS wire unless otherwise shown.

h. Control circuits shall be wired using 14 AWG minimum, tinned high-stranded SIS wire unless otherwise shown.

i. Microprocessor based relays shall have connectorized rear terminal blocks. Connectorized terminal blocks shall be arranged by input and output type (i.e. separate terminal blocks for voltage and current inputs).

j. Provide logic in relay for trip coil monitoring.

2.2.6.1 Line Current Differential Relays (MFR1)

a. Product Description: IEEE C37.90 Microprocessor-based line differential protection relay, IEEE Device numbers as specified herein.

b. Mounting: Rack-mounted in protective relay rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degree C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one high-speed, high-current contact to trip circuit breaker.

(2) Provide output contact with its own test switch. Wire test switch in series with output contact.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Relay failure.

(2) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

e. Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

f. Substation battery ground detection, adjustable.

g. Control and Status Inputs:

(1) Provide status input from a contact on circuit breaker. Contact shall be open when breaker is OPEN and closed when breaker is CLOSED.

h. Current Inputs: Provide individual inputs from current transformers for protected circuit. Route current from current transformer to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

i. Voltage Inputs: Provide three-phase, four-wire voltage inputs from potential transformer circuits shown. Route voltage circuits through non-shorting relay test switches to relay. Voltage input ratings shall be as follows.

(1) Nominal voltage shall be 120 volts phase to phase to match potential transformer secondary ratings.

(2) Continuous voltage rating shall be 300 volts.

(3) Burden shall not exceed 0.10 VA.

j. Protective Functions: Provide following adjustable protection functions and settings.

(1) Line Current Differential (87L)

(2) Phase Instantaneous Overcurrent (50P)

(3) Residual Ground Instantaneous Overcurrent (50G)

(4) Phase Time Overcurrent (51P)

(5) Loss Of Potential (60LOP)

(6) Directional Overcurrent (67)

(7) Residual Ground Time Overcurrent (51G)

(8) Breaker Failure Protection

(9) Breaker Wear Monitor

(10) Station DC Battery Monitor

k. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

(1) Line Differential Channels: The relays shall come equipped with IEEE C37.94 modulated 1300nm single-mode fiber-optic interfaces with type ST connectors.

l. Communications Protocols: The relay shall come equipped with the following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, IEEE C37.118 Synchrophasor data, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

m. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 2 shall be serial TIA-232 port supporting Mirrored Bits protocol for transfer tripping and shall support IRIG-B signals.

(3) Port 3 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(4) Port 4 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(5) Port 5 shall be dual redundant 100Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

2.2.6.2 Directional Overcurrent Relays (MFR2)

a. Product Description: IEEE C37.90 Microprocessor-based feeder protection relay configured to provide directional comparison blocking. IEEE Device numbers as specified herein.

b. Mounting: Rack-mounted in protective relay rack for protective relays.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degree C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one high-speed, high-current contact to trip circuit breaker.

(2) Provide output contact with its own test switch. Wire test switch

in series with output contact. Refer to "PROTECTIVE RELAY AND METERING TEST SWITCHES" in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Relay failure.

(2) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input from a contact on circuit breaker. Contact shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for protected circuit. Route current from current transformer to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Voltage Inputs: Provide three-phase, four-wire voltage inputs from potential transformer circuits shown. Route voltage circuits through non-shorting relay test switches to relay. Voltage input ratings shall be as follows.

(1) Nominal voltage shall be 120 volts phase to phase to match potential transformer secondary ratings.

(2) Continuous voltage rating shall be 300 volts.

(3) Burden shall not exceed 0.10 VA.

h. Protective Functions: Provide following adjustable protection functions and settings.

(1) Phase Instantaneous Overcurrent (50P)

(2) Ground (Residual) Instantaneous Overcurrent (50G)

(3) Neutral Instantaneous Overcurrent (50N)

(4) Phase Time Overcurrent (51P)

(5) Ground (Residual) Time Overcurrent (51G)

(6) Neutral Time Overcurrent (51N)

(7) Loss of Potential (60LOP)

(8) Directional Phase Time Overcurrent (67P)

(9) Directional Ground (Residual) Time Overcurrent (67G)

(10) Directional Neutral Time Overcurrent (67N)

(11) Breaker Failure Protection

(12) Breaker Wear Monitor

(13) Loss of Potential (60LOP)

(14) Station DC Battery Monitor

i. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

j. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, IEEE C37.118 Synchrophasor data, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

k. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be dual redundant 100Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover

mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

(3) Port 2 shall be serial fiber port supporting Mirrored Bits protocol for directional comparison blocking.

(4) Port 3 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(5) Port 4 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

l. Operator Interface

(1) Provide relays with front panel layout including color touch-screen human machine interface, circuit breaker control buttons, and indicators. Touch-screen shall be minimum of 800 by 480 pixels and shall be not less than 5 inches in diagonal.

2.2.6.3 Non-directional Overcurrent Relays (MFR3)

a. Product Description: IEEE C37.90 Microprocessor-based feeder protection relay, IEEE Device numbers as specified herein.

b. Mounting: Flush mounted device, installed on 19 inch mounting plates for 19 inch equipment rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degree C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one high-speed, high-current contact to trip circuit breaker.

(2) Provide output contact with its own test switch. Wire test switch in series with output contact. Refer to PROTECTIVE RELAY AND METERING TEST SWITCHES in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Relay failure.

(2) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input from a contact on circuit breaker. Contact shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for protected circuit. Route current from current transformer to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Voltage Inputs: Provide three-phase, four-wire voltage inputs from potential transformer circuits shown. Route voltage circuits through non-shorting relay test switches to relay. Voltage input ratings shall be as follows.

(1) Nominal voltage shall be 120 volts phase to phase to match potential transformer secondary ratings.

(2) Continuous voltage rating shall be 300 volts.

(3) Burden shall not exceed 0.10 VA.

h. Protective Functions: Provide following adjustable protection functions and settings.

(1) Phase Instantaneous Overcurrent (50P)

(2) Ground (Residual) Instantaneous Overcurrent (50G)

(3) Neutral Instantaneous Overcurrent (50N)

(4) Negative-Sequence Overcurrent (50Q)

(5) Phase Time Overcurrent (51P)

(6) Ground (Residual) Time Overcurrent (51G)

(7) Neutral Time Overcurrent (51N)

(8) Station DC Battery Monitor

i. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

j. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, IEEE C37.118 Synchrophasor data, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

k. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be dual redundant 100Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

(3) Port 2 shall be serial fiber port supporting Mirrored Bits protocol for transfer tripping.

(4) Port 3 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(5) Port 4 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

2.2.6.4 Transformer Differential Relays (MFR4)

Provide high-speed, microprocessor based transformer differential relays. Relays shall be configurable for single-phase and three-phase protection. Bus configurations having more than 6 terminals require additional relays to protect all busses. The relays shall utilize mirrored bits communications for transfer trip functions.

a. Product Description: IEEE C37.90 Microprocessor-based bus differential protection relay, IEEE Device number 87B.

b. Mounting: Flush mounted device, installed on 19 inch mounting plates for 19 inch equipment rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degrees C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one contact to trip lock-out relay on bus differential trip function. Wire test switch in series with this output contact.

(2) Provide multiple contacts to function as back-up overcurrent

protective devices (IEEE 50/51) for sources and loads on protected bus. Circuit breakers on protected bus shall have their own output contacts and relay test switches. Wire test switch in series with output contacts. Refer to PROTECTIVE RELAY AND METERING TEST SWITCHES in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Current transformer open.

(2) Relay failure.

(3) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input of lockout relay and wire to indicate trip condition.

(2) Provide status input from contact on circuit breakers on protected bus. Contacts shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for circuit breakers on protected buses. Route current from current transformers to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Paralleling current transformers is prohibited. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Protective Functions:

(1) Six or more low-impedance current differential circuits per phase (zone of protection).

(2) Relay shall have high sensitivity for internal faults and low sensitivity for external faults.

(3) Open and short circuit current transformer detection and alarm.

(4) Breaker failure detection.

(5) Instantaneous overcurrent protection (Device 50) for protected circuit breakers.

(6) Time-overcurrent protection (Device 51) for protected circuit breakers.

(7) End-zone protection for faults between open circuit breaker and CT.

h. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

i. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

j. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(3) Port 2 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(4) Port 3 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(5) Port 4 not used.

(6) Port 5 shall be dual redundant 100 Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

2.2.6.5 Synchronism Check Relays (MFR5)

a. Product Description: IEEE C37.90 Microprocessor-based feeder protection relay, IEEE Device numbers as specified herein.

b. Mounting: Flush mounted device, installed on 19 inch mounting plates for 19 inch equipment rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 deg C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one high-speed, high-current contact to trip circuit breaker.

(2) Provide output contact with its own test switch. Wire test switch in series with output contact. Refer to PROTECTIVE RELAY AND METERING TEST SWITCHES in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Relay failure.

(2) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input from a contact on circuit breaker. Contact shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for protected circuit. Route current from current transformer to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Voltage Inputs: Provide three-phase, four-wire voltage inputs from potential transformer circuits shown. Route voltage circuits through non-shorting relay test switches to relay. Voltage input ratings shall be as follows.

(1) Nominal voltage shall be 120 volts phase to phase to match potential transformer secondary ratings.

(2) Continuous voltage rating shall be 300 volts.

(3) Burden shall not exceed 0.10 VA.

h. Protective Functions: Provide following adjustable protection functions and settings.

(1) Sync-check, IEEE C37.2 device designation 25

(2) Breaker Failure Protection

(3) Breaker Wear Monitor

(4) Undervoltage IEEE C37.2 device designation 27

(5) Overvoltage IEEE C37.2 device designation 59

(6) Loss of Potential, IEEE C37.2 device designation 60LOP

(7) Station DC Battery Monitor

i. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

j. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, IEEE C37.118 Synchrophasor data, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability

shall include GOOSE messaging and defined logical node data points.

k. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be dual redundant 100 Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

(3) Port 2 shall be serial fiber port supporting Mirrored Bits protocol for transfer tripping.

(4) Port 3 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

(5) Port 4 shall be serial TIA-232 port supporting ASCII, DNP, MOD, EVMSG, and PMU.

2.2.6.6 Bus Differential Relays (MFR6)

Provide high-speed, microprocessor based bus differential relays. Relays shall be configurable for single-phase and three-phase protection. Bus configurations having more than 6 terminals require additional relays to protect all busses. The relays shall utilize mirrored bits communications for transfer trip functions.

a. Product Description: IEEE C37.90 Microprocessor-based bus differential protection relay, IEEE Device number 87B.

b. Mounting: 19 inch rack mounted device in equipment rack.

c. Output Contacts: Provide output contacts rated for 30 amperes making current, 6 amperes continuous current at 70 degree C. Contacts shall not be rated less than 48 volts DC.

(1) Provide one contact to trip lock-out relay on bus differential trip function. Wire test switch in series with this output contact.

(2) Provide multiple contacts to function as back-up overcurrent protective devices (IEEE 50/51) for sources and loads on protected bus. Circuit breakers on protected bus shall have their own output contacts and relay test switches. Wire test switch in series with output contacts. Refer to PROTECTIVE RELAY AND METERING TEST SWITCHES in this Section.

d. Alarm Contact: Provide alarm contact wired in series with relay test switch. Wire alarm to signal supervisory control and data acquisition system (SCADA) upon following conditions.

(1) Current transformer open.

(2) Relay failure.

(3) Battery voltage monitor. Provide dual level substation battery voltage monitor with following adjustable parameters.

(a) Low level warning adjustable from 15 to 300 volts DC.

(b) High level warning adjustable from 15 to 300 volts DC.

(c) Low level failure adjustable from 15 to 300 volts DC.

(d) High level failure adjustable from 15 to 300 volts DC.

(e) Peak to peak AC ripple detection adjustable from 1 to 300 volts AC.

(f) Substation battery ground detection, adjustable.

e. Control and Status Inputs:

(1) Provide status input of lockout relay and wire to indicate trip condition.

(2) Provide status input from contact on circuit breakers on protected bus. Contacts shall be open when breaker is OPEN and closed when breaker is CLOSED.

f. Current Inputs: Provide individual inputs from current transformers for circuit breakers on protected buses. Route current from current transformers to shorting terminal blocks, from shorting terminal blocks to shorting relay test switches, and from test switches to relay. Paralleling current transformers is prohibited. Current input ratings shall be as follows.

(1) Nominal current shall be 5 amperes to match current transformer secondary ratings.

(2) Continuous current shall be 15 amperes, linear to 100 amperes symmetrical.

(3) Burden shall not exceed 0.30 VA at 5 amperes and 3.0 VA at 15 amperes.

g. Protective Functions:

(1) Six or more low-impedance current differential circuits per phase (zone of protection).

(2) Relay shall have high sensitivity for internal faults and low sensitivity for external faults.

(3) Open and short circuit current transformer detection and alarm.

(4) Breaker failure detection.

(5) Instantaneous overcurrent protection (Device 50) for protected circuit breakers.

(6) Time-overcurrent protection (Device 51) for protected circuit breakers.

(7) End-zone protection for faults between open circuit breaker and CT.

h. IRIG-B. The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The relays shall generate a time synchronizing signal to provide a synchronizing signal to other relays.

i. Communications Protocols: The relay shall come equipped with following protocols, whether used by application or not. Refer to paragraph SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) of this Section for supervisory, control, and data acquisition requirements.

(1) Protocols shall include ASCII, Compressed ASCII, DNP3.0, IEC 61850, Telnet, FTP, and Mirrored Bits.

(2) Digital Relay-to-Relay Communications. The relay shall include send and receive logic elements and provide analog and virtual terminal service in two communications ports for dedicated relay-to-relay communication.

(3) IEC 61850 Ethernet Communications. The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.

j. Communications Ports: Provide ports as follows.

(1) Front TIA-232 serial port for uploading and downloading settings, event reports, and data via laptop computer.

(2) Port 1 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(3) Port 2 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(4) Port 3 shall be serial TIA-232 port supporting SEL ASCII, Compressed ASCII, and Settings File Transfer, SEL Fast Meter with Configuration, Fast Operate, Fast SER, Enhanced MIRRORED BITS Communications, and DNP3 Level 2 Slave Plus Dial-out.

(5) Port 4 not used.

(6) Port 5 shall be dual redundant 100Base-FX multimode fiber ports for Ethernet communications. Ports shall operate in failover mode. Ports shall support FTP file transfer protocol, IEC 61850 protocol, IEC 61850 GOOSE messaging, and DNP 3.0 protocol with up to three DNP sessions.

2.2.6.7 Lockout Relays (Device 86)

Provide manually reset lock-out relays with light emitting diode (LED) indicators. Provide green LED to indicate a healthy trip coil circuit. Provide red LED to indicate a trip condition. Provide remote annunciation of the trip coil condition that warns the SCADA operator when trip circuit continuity is lost. Provide a minimum of 8 spare contacts on each relay. Relay shall be wired to trip the all circuit breakers in the protected zone and shall block all tripped circuit breakers from being reclosed until the relay is manually reset.

2.2.6.8 Auxiliary Control Relays

Provide as required to implement protective functions and interlocking as indicated. Auxiliary relays shall have contacts rated to carry 30 amperes for one minute and 12 amperes continuously. Coils shall be a long-life design with a projected service life of 40 years.

a. Auxiliary relays used for tripping circuit breakers shall be multicontact, high-speed relays operating in one-half cycle or less.

b. Auxiliary relays for functions other than tripping circuit breakers shall be normal-speed relays operating in two cycles or less.

c. Auxiliary timing relays shall be electro-pneumatic relays with contacts rated for at least the load they are controlling.

2.2.6.9 Instrument Control Switches

Provide rotary cam-operated type with positive means of indicating contact positions. Switches shall have silver-to-silver contacts enclosed in a protective cover which can be removed to inspect the contacts.

a. Circuit breaker control switches shall be Heavy-duty type rated for 600 volts, UL listed and CSA certified. Breaker control Switches shall have a miniature pistol-grip type handle and a mechanical target to indicate the last operating position of the switch. Switches shall be hard-wired directly to the related circuit breaker for manual control. Switches shall have spring return action, 3 position with spring return to center, with the adequate number of contacts for the required operation and SCADA monitoring.

b. Red and green position indication LED lights shall be either installed immediately above each circuit breaker switch position or incorporated into the switch itself.

c. Circuit breaker control switches shall include the following positions: 1) "TRIP"; 2)"NAT" (normal after trip)/"NAC" (normal after close); 3) "CLOSE". The control switches shall have a minimum of two trip contacts with one trip contact per deck. Switch contacts shall have a minimum current rating of 30 amperes for one minute and 12 amperes continuously.

2.2.6.10 Protective Relay and Metering Test Switches

a. Product Description: Semi-flush mounted knife blade test switches for protective relays with following features:

    (1) Clear cover. Shall allow switches to be in open position when cover is on.

    (2) Every relay analog and digital input and output shall pass through a test switch.

    (3) Every current transformer circuit shall pass through a shorting test switch.

    (4) Every trip circuit shall have a red switch.

(5) All switches shall be black in color except for red trip circuit switch.

b. All switches shall be wired such that source (current transformer, voltage transformer, and other output and input) is wired to bottom terminals. The relay terminals shall be wired to top of test switch.

c. Power to protective relay shall be wired through a relay test switch or wired from a dedicated disconnecting means in cubicle to relay.

2.2.6.11 Pilot and Indicating Lights

Provide light emitting diode type indicating lights. Lights shall be red when the circuit breaker is in the "CLOSED" position and shall be green when the circuit breaker is in the "OPEN" position. Light color shall be visible from a distance not less than the full length of the switchgear and shall be visible at a 175 degree viewing angle. Match control voltage.

2.2.6.12 Instruments

a. AC wattmeters: Transformer rated for 120-volt input, 60 Hz, three-phase, four-wire, with scale range coordinated to the ratios of the associated current transformers and potential transformers.

b. Frequency meters: Rated for 120-volt input, 60 Hz nominal frequency.

c. Synchroscope: Transformer rated at 120-volt input, 60 Hz, with slow-fast scale.

d. Power-factor meters: Transformer rated 5-ampere, 120-volt input. The accuracy must be plus or minus 0.01.

e. DC ammeters: Self-contained.

f. DC voltmeters: Self-contained, 0 to 150 volt scale range. Furnish resistors, if required, with the voltmeter.

2.2.6.13 Electronic Watthour Meter

Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter must either be programmed at the factory or must be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter must be coordinated to system requirements.

a. Design: Provide meter designed for use on a 3-phase, 4-wire, system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Kilowatt-hour Register: 5 digit electronic programmable type.

d. Demand Register:

(1) Provide solid state.

(2) Meter reading multiplier: Indicate multiplier on meter face.

(3) Demand interval length: must be programmed for 15 minutes with rolling demand up to six subintervals per interval.

e. Meter fusing: Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

2.2.6.14 Instrument Transformers

IEEE C57.13, as applicable.

a. Current transformers: Transformers must be multi-ratio or single ratio as indicated, 60 Hz, and coordinated to the rating of the associated switchgear, relays, meters, and instruments.

Provide shorting blocks to create an intermediate contact point between the meter and the load where it is safe to make wiring alterations. The shorting blocks must be wired such that the negative leads of the current transformers are connected to the same node and tied to ground.

b. Potential transformers: Transformers must be drawout type, 60 Hz, with voltage ratings and ratios coordinated to the ratings of the associated switchgear, relays, meters, and instruments. Potential transformers must be with in the primary. Fuses must be current limiting and sized as recommended by the potential transformer manufacturer.

2.2.6.15 Pilot and Indicating Lights

Provide transformer, resistor, or diode type.

2.2.7 Station Batteries and Charger

Provide station batteries and charger, suitable for the requirements of the switchgear and SF6 circuit breakers. Batteries must be 125 V, 60 cells, lead-acid, sealed, totally absorbed electrolyte type.

a. Pasted plate type batteries: Positive plates must be of the manchester type and negative plates must have a life equal to or greater than the positive plates. Battery containers must be heat and impact resistant clear plastic with electrolyte level lines permanently marked on all four sides. A permanent leakproof seal must be provided between cover and container and around cell posts. Sprayproof vent plugs must be provided in covers. Sufficient sediment space must be provided so that the battery will not have to be cleaned out during its normal life. High porosity separators to provide correct spacing between plates must be provided. Capacity must be calculated by switchgear manufacturer and approved by Contracting Officer before acceptance.

b. Sealed batteries: Provide batteries with leakproof, spillproof electrolyte utilizing highly absorbent material to separate the positive and negative plates. Battery jars must be hermetically sealed with welded seams. Batteries must be maintenance-free and must not require water to be added. Capacity must be calculated by switchgear manufacturer and approved by Contracting Officer before acceptance.

c. Battery charger must be full-wave rectifier type, utilizing silicon semiconductor devices. Charger must maintain a float charge of 2.15 V per cell and an equalizing charge of 2.33 V per cell. An equalizing charge timer must be provided which operates automatically after an AC power failure of 5 seconds or more. Timer must be adjustable for any time period up to 24 hours. Timer must also be capable of being actuated manually. Adjustable float and equalizing voltage potentiometers must be provided. Charger voltage must be maintained within plus or minus 1/2 percent from no load to full load with AC line variations of plus or minus 10 percent and frequency variations of plus or minus 5 percent. DC voltmeter and ammeter with a minimum 3 1/2 inch scale and 2 percent accuracy of full scale must be provided. Output current must be limited to 115 percent of rated output current, even down to short circuit of the DC output terminals. Solid state circuit must have AC and DC transient voltage terminals. AC and DC magnetic circuit breakers must be provided. Circuit breakers must not be overloaded or actuated under any external circuit condition, including recharge of a fully discharged battery and short circuit of the output terminals. Charger must be capable of continuous operation at rated current at an ambient temperature of 40 degrees C. Output DC current capacity must match the requirements of the batteries provided. Provide alarm outputs as follows:

(1) AC power failure.

(2) DC ground detection.

(3) High DC voltage.

(4) Low DC voltage.

(5) Charger failure.

(6) Battery discharging.

(7) End of discharge.

(8) DC current limit.

(9) Common summary alarm.

d. Secure battery rack such that it can not overturn or be disrupted by lateral forces accompanying a seismic disturbance. Provide steel, three-step racks, painted with two coats of acid resistant paint for mounting batteries. Provide lead-plated copper inter-rack connectors and cell numbers with each rack.

2.2.8 Metal-Enclosed Interrupter Switchgear Outgoing Section

IEEE C37.20.3 for metal-enclosed SF6 load interrupter type switches. The metal-enclosed switchgear assembly must consist of individual, factory-assembled, freestanding modular units, each with provisions for bolt-together installation. Modules must have uniform dimensions, constructed of rigidly braced 14-gage steel with a durable corrosion-resistant finish. Units must include a removable front panel, capable of being locked, for access to cable connections and fusing, internal venting for air circulation, lifting/mounting provisions and centralized, front facing controls and identification nameplates. Modules must allow incoming/outgoing cable entry from the bottom, sides or rear with adequate access for training and connection of cable using lugs and indoor terminations. Modular units must include necessary provisions for future expansion with removable end covers and extendable high-conductivity copper main and ground bus interconnections. Main bus must be fully insulated and mounted on insulated supports of high-impact, non-tracking, high-quality insulating material. Bus must be braced to withstand the mechanical forces exerted during short-circuit conditions when connected directly to the utility source. Phase bus bars must be rated as required. Ground bus must be sized for full short-circuit capacity and must include provisions for external ground connections. Enclosures must be designed for indoor or outdoor location and must conform to the requirements of Table A1 of Appendix A to IEEE C37.20.3. Provide permanent labels for wiring and terminals corresponding to the designations on approved shop drawings. A safety glass window must be provided in the door panel in front of each interrupter switch to observe its position.

2.2.8.1 SF6-Insulated Load Interrupter Switches

SF6 filled, puffer-type load interrupter switches must be fused or non-fused as indicated. Switches must incorporate self-aligning, copper-silver plated, wiping-type contacts. SF6 puffer interrupters to minimize arcing during operation; and an internal absorbent to neutralize arc by-products. Switch contacts must be enclosed and sealed in maintenance-free, SF6 filled, molded epoxy insulated case, surrounded by dead-front metallic barriers. Switch operation must be controlled by permanently lubricated quick-make, quick-break spring operator with solid linkage connection to contact operating shaft. Switch operator must be mounted in separate dead-front compartment with access for addition of remote or automatic accessories, and must include removable operating handle with storage provision, positive position indicators, and padlock provisions. SF6 gas must conform to ASTM D2472.

2.2.9 Insulated Barriers

Where insulated barriers are required by reference standards, provide barriers in accordance with NEMA LI 1, Type GPO-3, 0.25 inch minimum thickness.

2.2.10 SF6 Refill Cylinders

Provide two SF6 refill cylinders, with a minimum of 6 pounds of SF6 in each. Include regulator, valves, and hose for connection to the fill valve of the switch.

2.2.11 Corrosion Protection

Bases frames, and channels of unit substation must be corrosion resistant and must be fabricated of stainless steel or galvanized steel. Base must include any part of unit substation that is within 3 inches of concrete pad. Paint unit substation, including bases, light gray No. 61 or No. 49. Paint coating system must comply with IEEE C57.12.28 regardless of base and substation material. The color notation is specified in ASTM D1535.

2.2.11.1 Stainless Steel

Type 304 or 304L.

2.2.11.2 Galvanized Steel

ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable. Galvanize after fabrication where practicable.

2.2.12 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers must be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification must be identical in similar units. External wiring must be color coded consistently for similar terminal boards.

2.2.13 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed white plastic tubing heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide multiple white preprinted polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve must contain multiple characters, must be elliptically shaped to fit the wire securely, and must be keyed, or otherwise arranged, in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Wire markers for factory installed conductors must indicate wire designations corresponding to the schematic drawings. Wire markers on field installed conductors must indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached, as well as the terminal number to which the wire is directly attached (near end/far end marking).

2.2.14 Surge Arresters

Provide one surge arrester for each conductor on circuits where indicated. Surge arresters must conform to IEEE C62.11 for class indicated and must be rated as required.

2.3 SOURCE QUALITY CONTROL

2.3.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

(1) The manufacturer must have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) The accuracy must be directly traceable to the National Institute of Standards and Technology.

(3) Instrument calibration frequency schedule must not exceed 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels must be visible on all test equipment.

(5) Calibrating standard must be of higher accuracy than that of the instrument tested.

(6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.3.2 Integral Assembly Test

Switchgear and substation transformer must be tested as an integral assembly at the transformer manufacturer's test facility. Once acceptance of test results is received, ship switchgear and substation.

2.3.3 Switchgear Design Tests

IEEE C37.20.2A or IEEE C37.20.3 as applicable. Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification. Required tests must be as follows:

a. Design Test

(1) Dielectric test

(2) Rated continuous current test

(3) Short-time current withstand tests

(4) Short-circuit current withstand tests

(5) Mechanical endurance tests

(6) Flame-resistance tests

(7) Rod entry tests

(8) Rain test for outdoor MV switchgear

2.3.4 Switchgear Production Tests

IEEE C37.20.2A or IEEE C37.20.3 as applicable. Furnish reports which include results of production tests performed on the actual equipment for this project. Required tests must be as follows:

a. Production Test

(1) Dielectric test

(2) Mechanical operation tests

(3) Grounding of instrument transformer case test

(4) Electrical operation and control-wiring tests

(5) Impulse withstand test.

2.3.5 Load Interrupter Switch Design Tests

IEEE C37.74 and IEEE C37.20.3. Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification. Required tests must be as follows:

a. Design Tests

(1) Dielectric:

(a) Low-frequency withstand

(b) Impulse withstand

(2) Continuous current

(3) Short-time current withstand (2 - second)

(4) Momentary current (10 cycles)

(5) Mechanical endurance

(6) Insulator supports

(a) Flame-resistance

(b) Tracking-resistance

(7) Bus-bar insulation

(a) Dielectric strength

(b) Flame-resistance

(8) Paint qualification

(9) Rain

2.3.6 Load Interrupter Switch Production Tests

IEEE C37.74 as applicable, and IEEE C37.20.3. Furnish reports of production tests performed on the actual equipment for this project. Required tests must be as follows:

a. Production Tests

(1) Dielectric

(2) Mechanical operation

(3) Grounding of instrument transformer case

(4) Electrical operation and control wiring

2.3.7 Transformer Design Tests

In accordance with IEEE C57.12.00 and IEEE C57.12.90. Additionally, IEEE C57.12.80, section 5.1.2 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for each of the specified transformer(s). Design tests must have been performed prior to the award of this contract.

a. Tests must be certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a unit-substation transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (ONAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a unit-substation transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer (if specified). Design lightning impulse tests must include both the primary and secondary windings of that transformer.

  (1) IEEE C57.12.90 paragraph entitled "Lightning Impulse Test Procedures" and IEEE C57.98.

  (2) State test voltage levels.

  (3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" for the lifting and moving devices test means a transformer in the same weight range as the transformer specified.

e. Pressure: "Basically the same design" for the pressure test means a unit-substation transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

2.3.8 Transformer Routine and Other Tests

In accordance with IEEE C57.12.00 and IEEE C57.12.90. Routine and other tests must be performed by the manufacturer on each of the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence must be as follows:

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

d. Insulation power-factor by manufacturer's recommended test method.

e. No-load losses (NLL) and excitation current

f. Load losses (LL) and impedance voltage

g. Dielectric

(1) Impulse: Per IEEE C57.12.90 paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98. Test the primary winding only.

(a) State test voltage levels

(b) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports. As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand-delivered at the factory witness test.

(2) Applied voltage

(3) Induced voltage

h. Leak

2.4 HEATERS

Provide 120-volt heaters in each switchgear section. Heaters must be of sufficient capacity to control moisture condensation in the compartments, and must be sized 250 watts minimum. Heaters must be controlled by a thermostat and humidistat located inside each section. Thermostats must be industrial type, high limit, to maintain compartments within the range of 60 to 90 degrees F. Humidistats must have a range of 30 percent to 60 percent relative humidity. Provide transformer rated to carry 125 percent of heater full load rating. Transformers must have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and must conform to NEMA ST 20. Provide din-rail mounted circuit breakers or fuse block in each switchgear assembly to serve the heaters in that switchgear assembly. The overcurrent protective devices serving the heaters must be in an accessible location with the circuit breaker racked in and the inner door closed. Energize electric heaters in switchgear assemblies while the equipment is in storage or in place prior to being placed in service. Provide method for easy connection of heater to external power source.

2.5 Field Fabricated Nameplates

Provide laminated plastic nameplates for each primary unit substation equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 0.125 inch thick, white with black center core. Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be one by 2 1/2 inches. Lettering must be a minimum of 0.25 inch high normal block style.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations must conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic welds or compression connectors. Provide compression connectors at equipment ends of ground conductors.

3.2.2 Substation Grounding

Provide bare copper cable not smaller than No. 4/0 AWG, not less than 24 inches below grade connecting to the indicated ground rods. Substation transformer neutral connections must not be smaller than No. 1/0 AWG. When work, in addition to that indicated or specified, is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply. Fence and equipment connections must not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 feet. Bond each gate section to the fence post through a 1/8 by one inch flexible braided copper strap and clamps.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors must be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, paragraph regarding GROUNDING.

3.2.4 Ground Cable Crossing Expansion Joints in Structures and Pavements

Protect from damage by means of approved devices or methods of installation to allow the necessary slack in the cable across the joint to permit movement. Provide stranded or other approved flexible copper cable across such separations.

3.2.5 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect unit substations furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Medium-Voltage Switchgear and Load Interrupter Switches

IEEE C37.20.2A and IEEE C37.20.3 as applicable.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Galvanizing Repair

Repair damage to galvanized coatings caused by handling, transporting, cutting, welding, or bolting. Make repairs in accordance with ASTM A780/A780M, zinc rich paint. Do not heat surfaces that repair paint has been applied to.

3.3.4 Field Fabricated Nameplates

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount substation and switchgear on concrete slab. Unless otherwise indicated, the slab must be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Slab must be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above finished grade. Edges above grade must have 1/2 inch chamfer. Slab must be of adequate size to project at least 8 inches beyond equipment, except that front of slab must be large enough to serve as a platform to withdraw breakers or to operate two-high breaker lifters. Provide conduit turnups and cable entrance space required by the equipment to be mounted and as indicated. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. Concrete work must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount substation and switchgear on concrete slab. Unless Otherwise indicated, the slab must be at least 4 inches thick. Top of concrete slab must be approximately 4 inches above finished floor. Edges above floor must have 1/2 inch chamfer. Slab must be of adequate size to project at least 8 inches beyond the equipment, except that front of slab must be large enough to serve as a platform to withdraw breakers or to operate two-high breaker lifters. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. Concrete work must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Interrupter Switch(es)

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved

shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify appropriate anchorage and required area clearances.

(5) Verify appropriate equipment grounding.

(6) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

(7) Verify that fuse sizes and types correspond to approved shop drawings.

(8) Verify that each fuse holder has adequate mechanical support.

(9) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic surveying is required.

(10) Test interlocking systems for correct operation and sequencing.

(11) Verify correct phase barrier materials and installation.

(12) Compare switch blade clearances with industry standards.

(13) Inspect all indicating devices for correct operation

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform over-potential tests.

(3) Measure contact-resistance across each switch blade and fuse holder.

(4) Verify heater operation.

3.5.1.2 Medium-Voltage Circuit Breakers (SF6)

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Inspect anchorage and grounding.

(5) Inspect and verify adjustments of mechanism in accordance with manufacturer's instructions.

(6) Inspect and service air compressor in accordance with

manufacturer's instructions.

(7) Test for gas leaks in accordance with manufacturer's instructions.

(8) Verify correct operation of all air and SF6 gas pressure alarms and cutouts.

(9) Slow close/open breaker and check for binding.

(10) Perform time-travel analysis.

(11) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is required.

(

(12) Record as-found and as-left operation counter readings.

b. Electrical Tests

(1) Measure contact resistances.

(2) Perform insulation-resistance tests.

(3) Verify trip, close, trip-free, and antipump functions.

(4) Trip circuit breaker by operation of each protective device.

3.5.1.3 Transformers (Liquid-Filled)

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

(3) Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.

(4) Verify operation of all alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.

(5) Verify tightness of accessible bolted electrical connection by calibrated torque-wrench method. Thermographic survey is required.

(6) Verify correct liquid level in transformer tank.

(7) Perform specific inspections and mechanical tests as recommended by manufacturer.

(8) Verify correct equipment grounding.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform turns-ratio tests.

(3) Perform insulation power-factor/dissipation-factor tests on windings.

(4) Sample insulating liquid. Sample must be tested for:

(a) Dielectric breakdown voltage

(b) Acid neutralization number

(c) Specific gravity

(d) Interfacial tension

(e) Color

(f) Visual condition

(g) Parts per million water

(h) Measure dissipation factor or power factor.

(5) Perform dissolved gas analysis (DGA).

(6) Test for presence of PCB.

(7) Verify that tap-changer is set at specified ratio.

(8) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.5.1.4 Switchgear Assemblies

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify appropriate anchorage, required area clearances, and correct alignment.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that fuse and circuit breaker sizes and types correspond to approved shop drawings.

(7) Verify that current and potential transformer ratios correspond to approved shop drawings.

(8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is required.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Clean switchgear.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier and shutter installation and operation.

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that vents are clear.

(16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform overpotential tests.

(3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

(6) Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

(7) Verify operation of heaters.

3.5.1.5 Instrument Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is required.

(6) Verify that all required grounding and shorting connections provide good contact.

(7) Verify correct operation of transformer with drawout mechanism and

grounding operation. Removal of instruments must be performed in a manner that the secondary circuits of energized current transformers are not opened.

(8) Verify correct primary and secondary fuse sizes for potential transformers.

b. Electrical Tests - Current Transformers

(1) Perform insulation-resistance tests.

(2) Perform polarity tests.

(3) Perform ratio-verification tests.

(4) Perform excitation test on transformers used for relaying applications.

(5) Measure circuit burden at transformer terminals and determine the total burden.

(6) When applicable, perform insulation resistance and dielectric withstand tests on the primary winding with secondary grounded.

(7) CAUTION: Changes of connection, insertion, and removal of instruments, relays, and meters must be performed in such a manner that the secondary circuits of energized current transformers are not opened momentarily.

c. Electrical Tests - Voltage (Potential) Transformers

(1) Perform insulation-resistance tests.

(2) Perform a polarity test on each transformer to verify the polarity marks or H1 - X1 relationships as applicable

(3) Perform a turns ratio test on all tap positions , if applicable.

(4) Measure potential circuit burdens at transformer terminals and determine the total burden.

(5) Measure circuit burden at transformer terminals and determine the total burden.

3.5.1.6 Battery Systems

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is required.

(4) Measure electrolyte specific gravity and temperature and visually check fill level.

(5) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

b. Electrical tests

(1) Set charger float and equalizing voltage levels.

(2) Verify all charger functions and alarms.

(3) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

(4) Perform a capacity load test.

3.5.1.7 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.8 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.2 Field Dielectric Tests

Perform field dielectric tests on medium-voltage switchgear according to IEEE C37.20.2A or IEEE C37.20.3 as applicable.

3.5.3 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor must show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers must be tripped by operation of each protective device. Test must require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer 10 working days in advance of the dates and times for checks, settings, and tests.

3.6 TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period will consist of a total of 8 hours of normal working time and must start after the system is functionally completed but prior to final acceptance tests. The course instruction must cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions must demonstrate all routine maintenance operations.

a. Submit 6 copies of operation and maintenance manuals, within 7 calendar days following the completion of tests and including assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked.

b. Manuals must also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements must also be included. Documents must be bound in a binder marked or identified on the spine and front cover. A table of contents page must be included and marked with pertinent contract information and contents of the manual. Tabs must be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare-parts data. Index sheets must be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers.

c. Submit a digital video recording of the entire training session and three additional copies of the instructions manual within 30 days following the approval of the manuals.

3.7 MANUFACTURER'S FIELD SERVICE

3.7.1 Installation Engineer

After delivery of the equipment, furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the on site tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment. Submit a detailed description of the Contractor's proposed procedures for on site tests.

3.7.2 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation must be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience. No part of the electrical system must be energized until all station grounding components have been tested and demonstrated to comply with the specified requirements. The following services must be performed on the equipment listed below. These services must be performed subsequent to testing but prior to the initial energization. The equipment must be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at station buses and at major equipment must be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations must be inspected to detect possible damage caused during installation. If factory tests were not performed on completed assemblies, tests must be performed after the installation of completed assemblies. Components must be inspected for damage during installation or shipment and to verify that packaging materials have been removed. Components capable of being both manually and electrically operated must be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested must be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer.

3.8 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation material or operation have been corrected.

-- End of Section --

SECTION 26 11 16

SECONDARY UNIT SUBSTATIONS
11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering
ANSI Z540.1	(1994; R 2002) Calibration Laboratories and Measuring and Test Equipment - General Requirements

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D6871	(2017) Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear

IEEE C37.121	(2012) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.01	(2020) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.50	(1981; R 1998) Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Volt 601 to 34,500 Volts
IEEE C57.12.51	(2019) IEEE Guide for Mechanical Interchangeability of Ventilated Dry-Type Transformers
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.91	(2011) Standard Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C57.124	(1991; R 2002) Recommended Practice for the Detection of Partial Discharge and the Measurement of Apparent Charge in Dry-Type Transformers
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO ISO/IEC 17025	(2017) General Requirements for the

	Competence of Testing and Calibration Laboratories

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING, Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS, and 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, must be as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

1.4.1 [Enter Appropriate Subpart Title Here]SD-02 Shop Drawings

Unit Substation Drawings; G,

Transformer Drawings; G

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams must identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings must indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals must include the nameplate data, size, and capacity. Submittals must also include applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

Fuse Curves; G

Secondary Unit Substation; G,

Unit Substation Transformer (Liquid-filled)); G

Unit Substation Transformer (Dry-type)); G

Submittal must include manufacturer's information for each component, device, and accessory provided with the transformer.

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-07 Certificates

Paint Coating System; G

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1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

1.5.1.1 Unit Substation Drawings

Drawings must include, but are not limited to the following:

a. An outline drawing, with dimensional plan view, elevation, foundation plan and side views showing incoming, transformer, and outgoing sections.

b. One-line diagram showing all components and their ratings.

c. Elementary diagrams and wiring diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

d. Three-line diagram showing bus configuration, bus rating and overcurrent protective devices.

1.5.1.2 Transformer Drawings

Drawings must include, but are not limited to the following:

a. An outline drawing, with front, top, and side views.

b. ANSI nameplate data.

1.5.2 Paint Coating System

Submit IEEE C57.12.29 coating system performance requirement tests. When interrupter switchgear and transformer are provided by two different manufacturers, each one must provide certification.

1.5.3 Transformer Efficiencies

Submit certification from the manufacturer indicating conformance with the paragraph SPECIFIED TRANSFORMER EFFICIENCIES".

1.5.4 Substation Product Data

Submittal must include manufacturer's information for each component, device, and accessory provided with the equipment.

1.5.5 Test Reports

Submit report of acceptance test results as specified by paragraph FIELD

QUALITY CONTROL.

1.5.6 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.7 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.7.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.7.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site must not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Assembled Operation and Maintenance Manuals

Manuals must be assembled in durable, hard covered, water resistant binders. The manual must be assembled and indexed in the order noted in a table of contents. The contents of the assembled operation and maintenance manuals must be as follows:

a. Manufacturer's O&M information required by the paragraph, SD-10 OPERATION AND MAINTENANCE DATA.

b. Catalog data required by the paragraph, SD-03 PRODUCT DATA.

c. Drawing required by the paragraph, SD-02 SHOP DRAWINGS.

d. Price for spare parts and supply list

e. Routine and field acceptance test reports

1.6.2 Operation and Maintenance Data

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

1.7 WARRANTY

The equipment items must be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be secondary unit substations and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 SECONDARY UNIT SUBSTATION

Secondary Unit substations must comply with IEEE C37.121 regardless of the kVA rating specified. Substation must consist of incoming sections, transformer sections, and outgoing sections. Substation must be designed for outdoor service with ventilation openings and gasketing provided to ensure a weatherproof assembly under rain, snow, sleet, and hurricane conditions. Substations must be subassembled and coordinated by one manufacturer and must be shipped in complete sections ready for connection at the site. Where practicable, substation must be shipped as one unit. External doors must have provisions for padlocking. Bus bars and conductors must be copper.

2.2.1 Incoming Sections

If required for proper connection and alignment, include a transition section with the incoming section.

2.2.1.1 Incoming Section Enclosure

The incoming section enclosure must be NEMA ICS 6 Type as indicated. Bases, frames and channels of enclosure must be corrosion resistant and must be fabricated of type 304 or 304L stainless steel or galvanized steel. Base must include any part of enclosure that is within 3 inches of concrete pad. Paint enclosure, including bases, ASTM D1535 light gray No. 61 or No. 49. Paint coating system must comply with IEEE C57.12.29.

2.2.1.2 Cable Terminations

Provide medium voltage cable terminations as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

IEEE 386. Insulated High-Voltage Connectors. Connectors must have steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

a. Provide one set of three grounding elbows[and one set of three feed-thru inserts] for each secondary unit substation. Grounding elbows and feed-thru inserts must be delivered to the contracting officer.

2.2.1.3 Surge Arresters

IEEE C62.11, rated as indicated, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap, suitable for plugging into inserts. Arresters for use at elevations in excess of 6000 feet above mean sea level must be specifically rated for that purpose. Arresters must be equipped with mounting brackets suitable for the indicated installations.

2.2.1.4 Load Interrupter Switch

IEEE C37.20.3. Provide a three-pole, single-throw, deadfront, metal-enclosed, load interrupter switch with manual stored energy operator. The switch must be operated by a manually charged spring stored energy mechanism which must simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch must be de-energized when in the open position. The mechanism must enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus must extend the width of the switch enclosure and must be bolted directly thereto. Connect frame of unit to ground bus. The door must have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch ratings shall be as required.

2.2.1.5 Primary Protective Device Connection

Connections between the primary protective device and transformer must be cable or bus mounted on porcelain insulators, and sized and braced to withstand the specified short-circuit and short-time currents.

2.2.2 Transformer (Liquid-Filled) Section[s]

IEEE C57.12.29. [Mineral oil liquid-filled][Less-flammable, bio-degradable liquid-filled]. Transformer[base][, including the tank, radiators, flanges, base, lifting provisions, and hardware,] must be fabricated of type 304, 304L, or 316 stainless steel.[Transformer base must include any part of the transformer that is within 3 inches of concrete pad.] Paint coating system must comply with IEEE C57.12.29.

2.2.2.1 Transformer Ratings

a. Cooling Class: as indicated..

b. Frequency: 60 Hz.

c. Phases: Three phase.

d. Rated Kilovolt Amperes: As indicated.

e. Voltage Rating: As indicated.

f. Impedance: As indicated.

g. Insulation Level: As indicated.

h. Temperature Rise: 65 degree C average winding temperature rise above a 30 degree ambient.

i. Audible Sound Levels: Audible sound levels must comply with the following:

kVA Range	DECIBELS (MAX)
225-300	55
301-500	56
501-700	57
701-1000	58
1001-1500	60
1501-2000	61
2001-2500	62
2501-3000	63
3001-4000	64

2.2.2.2 Transformer Accessories

The transformer must have the following accessories:

a. Four 2.5 percent full capacity taps, two above and two below rated primary voltage.

b. Tap changer, with external, pad-lockable, manual type operating handle, for changing tap setting when transformer is de-energized.

c. Dead-front high-voltage bushings; IEEE 386. 15 kV, 95 kV BIL25kV, 125 kV BIL35 kV, 150 kV BIL.

d. Parking stands: Provide a parking stand near each dead-front bushing.

e. Insulated low-voltage neutral bushing with lugs for ground cable and removable ground strap.

f. Ground pads.

g. Liquid-level indicator.

h. Pressure-vacuum gage.

i. Liquid temperature indicator.

j. Drain and filter valves.

k. Pressure relief device, top mounted.

l. Diagrammatic stainless steel or laser-etched anodized aluminum nameplate in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

m. Transformer base with provisions for jacking and for rolling in either direction.

n. Lifting provisions.

o. Bolted transformer top or welded top with bolted handhole access.

p. Auxiliary cooling equipment and controls.

(2) Transformer must be forced-air-cooled. Forced-air-cooling fans must have automatic temperature control relay.

2.2.2.3 Specified Transformer Efficiencies

Provide transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer(s) prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "KVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K. Submit certification, including supporting calculations, from the manufacturer indicating conformance.

KVA	EFFICIENCY (percent)
15	98.65
30	98.83
45	98.92
75	99.03
112.5	99.11
150	99.16
225	99.23
300	99.27
500	99.35
750	99.40
1000	99.43
1500	99.48
2000	99.51

2500	99.53
above 2500	99.54

2.2.2.4 Insulating Liquid

a. Less-flammable transformer liquids: Must meet the requirements of ASTM D6871, NFPA 70 and be approved by the FM APP GUIDE for Less or Non- Flammable Liquid Insulated Transformers. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

Provide a fluid that is a biodegradable, electrical insulating, and cooling liquid classified by UL and approved by FM as "less flammable" with the following properties:

(1) Aquatic biodegradation: EPA 712-C-98-075, 99 percent.

(2) Trout toxicity: The fluid must have passed OECD Test 203 following the methods of EPA 821-R-02-012 and be determined to be non-toxic.

2.2.3 Transformer (Dry-Type) Sections

IEEE C57.12.01, and IEEE C57.12.50 for dry-type transformers rated up to 500 kVAIEEE C57.12.51 for dry-type transformers rated 501 kVA and larger. Transformer base, including the enclosure, flanges, base, lifting provisions, and hardware, must be fabricated of type 304 or 304L stainless steel. Transformer base must include any part of the transformer that is within 3 inches of concrete pad. Paint coating system must comply with IEEE C57.12.29. Windings must be copper.

Provide a vacuum pressure impregnated (VPI) type transformer with an insulation system rated 220 degrees C, and with an 80 degree C average winding temperature rise above a 40 degrees C maximum ambient.

2.2.3.1 Transformer Ratings

a. Transformer must be rated as indicated.

b. Transformer voltage ratings shall be as indicated.

c. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Locate tap adjustments on the face of the high voltage coil. Adjustments must be accessible by removing the front panel and must be made when the transformer is de-energized.

d. Audible sound levels must comply with the following:

kVA	DECIBELS (MAX)
225	58
300	58

kVA	DECIBELS (MAX)
500	60
700	64
1000	64
1500	65
2000	66
2500	68

f. Diagrammatic stainless steel or laser-etched anodized aluminum nameplate

g. Transformer must include ground pads, lifting lugs and provisions for jacking under base. The transformer base construction must be suitable for using rollers or skidding in any direction. The transformer must have an insulated low-voltage neutral bushing with lugs for ground cable, and with removable ground strap.

h. Dry type transformer must have the following accessories.

(1) Winding temperature indicator

(2) Auxiliary cooling equipment and controls

(a) Transformer must be forced-air-cooled. Forced-air-cooling fans must have automatic temperature control relay.

2.2.4 Outgoing Section

The outgoing section must consist of a full height air terminal compartment. This compartment must contain the indicated metering, instruments, and control power transformers and must be the connection point for the secondary conductors between the transformer and the switchboard. Provide one three point latching hinged door, either full height or on the upper half of the outgoing section to provide access to metering. The upper section must contain the current transformers and a watthour meter mounted to a dead front interior barrier as defined below. If using upper half section door only, the lower section must be bolt on type and contain bus bars and lugs to terminate the service entrance conductors. Provide insulated barriers between the upper and lower sections to permit the bus bars to pass between the sections. Provide locking access handle to eliminate unauthorized access.

2.2.4.1 Outgoing Section Enclosure

Provide outgoing section enclosure in accordance with the requirements in paragraph INCOMING SECTION ENCLOSURE.

2.2.5 Watthour and Digital Meters

2.2.5.1 Electronic Watthour Meter

NEMA/ANSI C12.10. Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter must either be programmed at the factory or must be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter must be coordinated to system requirements.

a. Design: Provide meter designed for use on a 3-phase, 4-wire, system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Coordination; Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Kilowatt-hour Register: 5 digit electronic programmable type.

d. Demand Register:

   (1) Provide solid state.

   (2) Meter reading multiplier: Indicate multiplier on the meter face.

   (3) Demand interval length: must be programmed for 15 minutes with rolling demand up to six subintervals per interval.

2.2.6 Instruments

Electrical indicating switchboard style instruments, with 2 percent accuracy. The ac ammeters and voltmeters must be minimum of 2 inches square, with 250 degree scale. Provide single phase indicating instruments with flush-mounted transfer switches for reading three phases.

2.2.7 Current Transformers

IEEE C57.13. Transformers must be single ratio, 60 hertz.

2.2.8 Control Power Transformers

Transformer must conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2.9 Meter Fusing

Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to voltage sensing meters. Size fuses as recommended by the meter manufacturer.

2.2.10 Heaters

Provide 120-volt heaters in incoming section, dry-type transformer section, and outgoing section. Heaters must be of sufficient capacity to control moisture condensation in the compartments, must be 250 watts minimum, and must be controlled by a thermostat located in each section. Thermostat must be industrial type, high limit, to maintain compartments within the range of 60 to 90 degrees F. If heater voltage is different than substation equipment voltage, provide transformer rated to carry 125 percent of heater full load rating. Transformer must have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and must conform to NEMA ST 20.

2.2.11 Insulated Barriers

Where insulated barriers are required by reference standards, provide barriers in accordance with NEMA LI 1, Type GPO-3, 0.25 inch minimum thickness.

2.2.12 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers must be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification must be identical in similar units. External wiring must be color coded consistently for similar terminal boards.

2.2.13 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve must be elliptically shaped to securely grip the wire, and must be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker must indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.2.14 Grounding and Bonding

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. A continuous ground bus bar shall run the length of the switchgear, the ground bus bar shall be accessible from the back of the switchgear. The ground bus bar must be hard-drawn copper of 98 percent minimum conductivity, minimum size 1/4 by 2 inches.

2.2.15 Padlocks

Padlocks must be provided for secondary unit substation equipment and for each fence gate. Padlocks must be keyed as directed by the Contracting Officer. Padlocks must comply with Section 08 71 00 DOOR HARDWARE.

2.2.16 Cast-in-Place Concrete

Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise. All concrete must conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.3 MANUFACTURER'S NAMEPLATES

Each item of equipment must have a nameplate bearing, as a minimum, the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. Include additional information as applicable to fully identify the equipment. Nameplates must be made of noncorrosive metal. Equipment containing liquid dielectric must include the type of dielectric on the nameplate. As a minimum, provide nameplates for transformers, circuit breakers, meters, switches, and switchgear.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each secondary unit substation, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 0.125 inch thick, white with black center core. Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be one by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.5 WARNING SIGNS

Provide warning signs for the enclosures of secondary unit substations having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.29, such as for secondary unit substations, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign must be a decal and must have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" must be in white letters on a red background and the words "HIGH VOLTAGE" must be in black letters on a white background.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3 inch high white letters on a red and black field.

2.6 SOURCE QUALITY CONTROL

2.6.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Test Instrument Calibration

(1) The manufacturer must have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) The accuracy must be directly traceable to the National Institute of Standards and Technology. Test equipment must qualify for the UL standard of Scope of Accreditation ISO ISO/IEC 17025and ANSI Z540.1.

(3) Instrument calibration frequency schedule must not exceed 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels must be visible on all test equipment.

(5) Calibrating standard must be of higher accuracy than that of the instrument tested.

(6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.6.2 Load Interrupter Switch Production Tests

IEEE C37.20.3. Furnish reports of production tests performed on the actual equipment for this project. Required tests must be as follows:

Production Tests

(1) Dielectric

(2) Mechanical operation

(3) Grounding of instrument transformer case

(4) Electrical operation and control wiring

2.6.3 Transformer Design Tests (Liquid-Filled)

In accordance with IEEE C57.12.00 and IEEE C57.12.90. Additionally, IEEE C57.12.80 section 5.1.2 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the product data and shop drawings for each of the specified transformers. Design tests must have been performed prior to the award of this contract.

a. Tests must be certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a unit-substation transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (ONAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a unit-substation transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests must include both the primary and secondary windings of that transformer.

(1) IEEE C57.12.90 paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.

(2) State test voltage levels.

(3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" for the lifting and moving devices test means a transformer in the same weight range as the transformer specified.

e. Pressure: "Basically the same design" for the pressure test means a unit-substation transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

2.6.4 Transformer Routine and Other Tests (Liquid-Filled)

In accordance with IEEE C57.12.00 and IEEE C57.12.90. Routine and other tests must be performed by the manufacturer on each of the actual transformers prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence must be as follows:

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

d. Insulation power-factor by manufacturer's recommended test method

e. No-load losses (NLL) and excitation current

f. Load losses (LL) and impedance voltage

g. Dielectric

(1) Impulse: Per IEEE C57.12.90 paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98. Test the primary winding only.

(a) State test voltage levels

(b) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports. As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand-delivered at the factory witness test.

(2) Applied voltage

(3) Induced voltage

h. Leak

i. Sample insulating liquid. Sample must be tested for:

(1) Dielectric breakdown voltage

(2) Acid neutralization number

(3) Specific gravity

(4) Interfacial tension

(5) Color

(6) Visual condition

(7) Water in insulating liquid

(8) Measure dissipation factor or power factor

j. Perform dissolved gas analysis (DGA)

2.6.5 Transformer Design Tests (Dry-Type)

In accordance with IEEE C57.12.01 and IEEE C57.12.91. Additionally, IEEE C57.12.80 section 5.1.2 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports in the same submittal package as the product data, shop drawings, and certificates of transformer losses for each of the specified transformer s. Design tests must have been performed prior to the award of this contract.

a. Provide required submittals in a hard-covered binder with index and tabs.

b. Tests must be certified and signed by a registered professional engineer. Engineers stamp and signature must appear on at least the first page of the factory test reports.

c. Temperature rise:

(1) "Basically the same design" for the temperature rise test means a unit-substation transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (AA), the same temperature rise rating, the same insulating class and the same insulating medium as the transformer specified.

(2) Provide temperature rise readings, formulas, calculations of average temperature rise, and description of test method.

d. Lightning impulse:

(1) "Basically the same design" for the lightning impulse dielectric test means a unit-substation transformer with the same BIL and the same coil construction (such as wire wound primary and sheet wound secondary).

(2) IEEE C57.12.91 and IEEE C57.98. Provide design lightning impulse tests consisting of a reduced full-wave, two-chopped waves, and one full wave test for each phase of the primary and secondary windings of the same transformer.

(3) State test voltage levels.

(4) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

(5) Partial Discharge Test per IEEE C57.124. Provide transformer ratings, description and diagram of test method used, test readings and final results.

2.6.6 Transformer Routine and Other Tests (Dry-Type)

In accordance with IEEE C57.12.01 and IEEE C57.12.91. Routine and other tests must be performed by the manufacturer on each of the actual transformers prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence must be as follows:

a. Resistance measurements

b. Phase relation

c. Ratio

d. Insulation power-factor by manufacturer's recommended test method

e. No-load losses (NLL) and excitation current

f. Load losses (LL) and impedance voltage

g. Lightning impulse: Perform the complete design type impulse tests on the transformer primary winding only.

(1) IEEE C57.12.91 and IEEE C57.98

(2) State test voltage levels

(3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports. As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand delivered at the factory witness test.

h. Low frequency dielectric

(1) Applied voltage

(2) Induced voltage

2.7 STATION BATTERIES AND CHARGER

Provide station batteries and charger, suitable for the requirements of the switchgear and SF6. Batteries must be 125 V, 60 cells, lead-acid, sealed, totally absorbed electrolyte type.

a. Pasted plate type batteries: Positive plates must be of the manchester type and negative plates must have a life equal to or greater than the positive plates. Battery containers must be heat and impact resistant clear plastic with electrolyte level lines permanently marked on all four sides. A permanent leak proof seal shall must be provided between cover and container and around cell posts. Spray proof vent plugs must be provided in covers. Sufficient sediment space must be provided so that the battery will not have to be cleaned out during its normal life. High porosity separators to provide correct spacing between plates must be provided. Capacity must be calculated by switchgear manufacturer and approved by Contracting Officer before acceptance.

b. Sealed batteries: Provide batteries with leak proof, spill proof electrolyte utilizing highly absorbent material to separate the positive and negative plates. Battery jars must be hermetically sealed with welded seams. Batteries must be maintenance-free and shall must not require water to be added. Capacity must be calculated by switchgear manufacturer and approved by Contracting Officer before acceptance.

c. Battery charger must be full-wave rectifier type, utilizing silicon semiconductor devices. Charger must maintain a float charge of 2.15 V per cell and an equalizing charge of 2.33 V per cell. An equalizing charge timer must be provided which operates automatically after an AC power failure of 5 seconds or more. Timer must be adjustable for any time period up to 24 hours. Timer must also be capable of being actuated manually. Adjustable float and equalizing voltage potentiometers must be provided. Charger voltage must be maintained within plus or minus 1/2 percent from no load to full load with AC line variations of plus or minus 10 percent and frequency variations of plus or minus 5 percent. DC voltmeter and ammeter with a minimum 3 1/2 inch scale and 2 percent accuracy of full scale must be provided. Output current must be limited to 115 percent of rated output current, even down to short circuit of the DC output terminals. Solid state circuit must have AC and DC transient voltage terminals. AC and DC magnetic circuit breakers must be provided. Circuit breakers must not be overloaded or actuated under any external circuit condition, including recharge of a fully discharged battery and short circuit of the output terminals. Charger must be capable of continuous operation at rated current at an ambient temperature of 40 degrees C. Output DC current capacity must match the requirements of the batteries provided. Provide alarm outputs as follows:

(1) AC power failure

(2) DC ground detection

(3) High DC voltage

(4) Low DC voltage

(5) Charger failure

(6) Battery discharging

(7) End of discharge

(8) DC current limit

(9) Common summary alarm

d. Secure battery rack such that it can not overturn or be disrupted by lateral forces accompanying a seismic disturbance. Provide steel, three-step racks, painted with two coats of acid resistant paint for mounting batteries. Provide lead-plated copper inter-rack connectors and cell numbers with each rack.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations must conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Substation Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade interconnecting the indicated ground rods. Surge arrester and neutrals must be bonded directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Lead lengths must be kept as short as practicable with no kinks or sharp bends. Substation transformer neutral connections must not be smaller than No. 1/0 AWG. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply. Fence and equipment connections must not be smaller than No. 4 AWG. Ground fence at each gate post and cornerpost and at intervals not exceeding 10 feet. Bond each gate section to the fence post through a 1/8 by one inch flexible braided copper strap and clamps.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors must be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, paragraph regarding "Grounding".

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect unit substations furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Interrupter Switchgear

IEEE C37.20.3.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Field Applied Painting

Where field applied painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3.5 Warning Sign Mounting

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.3.6 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount unit substation on concrete slab. Unless otherwise indicated, the slab must be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh placed uniformly 4 inches from the top of the slab. Slab must be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above the finished grade. Edges above grade must have 1/2 inch chamfer. The slab must be of adequate size to project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter. Cut off and bush conduits 3 inches above slab surface.

3.4.2 Interior Location

Mount unit substation on concrete slab. Unless otherwise indicated, the slab must be at least 4 inches thick. The top of the concrete slab must be approximately 4 inches above finished floor. Edges above floor must have 1/2 inch chamfer. The slab must be of adequate size to project at least 4 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter. Cut off and bush conduits 3 inches above slab surface.

3.4.3 Cast-in-Place Concrete

Cast-in-place concrete work must conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 PADLOCKS

Provide padlocks for secondary unit substation equipment and for each fence gate.

3.6 FIELD QUALITY CONTROL

3.6.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.6.1.1 Medium-Voltage Circuit Breakers (Vacuum)

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Inspect anchorage, alignment, and grounding.

(5) Perform all mechanical operational tests on both the circuit breaker and its operating mechanism.

(6) Measure critical distances such as contact gap as recommended by manufacturer.

(7) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is required.

(8) Record as-found and as-left operation counter readings.

b. Electrical Tests

(1) Perform a contact-resistance test.

(2) Verify trip, close, trip-free, and antipump function.

(3) Trip circuit breaker by operation of each protective device.

(4) Perform insulation-resistance tests.

(5) Perform vacuum bottle integrity (overpotential) test across each bottle with the breaker in the open position in strict accordance with manufacturer's instructions. Do not exceed maximum voltage stipulated for this test.

3.6.1.2 Medium-Voltage Circuit Breakers (SF6)

a. Visual and mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application öf manufacturer's recommended lubricants.

(4) Inspect anchorage and grounding.

(5) Inspect and verify adjustments of mechanism in accordance with manufacturer's instructions.

(6) Inspect and service air compressor in accordance with manufacturer's instructions.

(7) Test for gas leaks in accordance with manufacturer's instructions.

(8) Verify correct operation of all air and SF6 gas pressure alarms and cutouts.

(9) Slow close/open breaker and check for binding.

(10) Perform time-travel analysis.

(11) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is required.

(12) Record as-found and as-left operation counter readings.

b. Electrical Tests

(1) Measure contact resistances.

(2) Perform insulation-resistance tests.

(3) Verify trip, close, trip-free, and antipump functions.

(4) Trip circuit breaker by operation of each protective device.

3.6.1.3 Transformers (Liquid-Filled)

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

(3) Verify that cooling fans and pumps operate correctly and that fan and pump motors have correct overcurrent protection.

(4) Verify operation of all alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify correct liquid level in transformer tank.

(7) Perform specific inspections and mechanical tests as recommended by manufacturer.

(8) Verify correct equipment grounding.

(9) Verify the presence of transformer surge arresters.

(10) Verify that positive pressure is maintained on gas blanketed transformers.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform dissolved gas analysis (DGA).

(3) Verify that the tap-changer is set at specified ratio.

(4) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.6.1.4 Transformers - (Dry-Type)

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify that control and alarm settings on temperature indicators are as specified.

(4) Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Perform specific inspections and mechanical tests as recommended by manufacturer.

(7) Verify that resilient mounts are free and shipping brackets have been removed.

(8) Verify that winding core, frame, and enclosure groundings are correct.

(9) Verify the presence of transformer surge arresters.

(10) Verify that as-left tap connections are as specified.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform power-factor tests or dissipation-factor tests in accordance with the test equipment manufacturer's instructions.

(3) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(4) Perform turns-ratio tests.

(5) Perform an applied-voltage test on high and low voltage windings-to-ground. See IEEE C57.12.91. The ac dielectric-withstand-voltage test result must not exceed 75 percent of factory test voltage for one-minute duration. The dc dielectric-withstand-voltage test result must not exceed 100 percent of the ac rms test voltage specified in IEEE C57.12.91 for a one-minute duration. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

(6) Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.6.1.5 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.6.1.6 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Verify accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Verify that current transformer and voltage transformer secondary circuits are intact.

3.6.1.7 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod or grounding system, indicating the location of the rod or grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.6.2 Protective Relays

Protective relays must be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests must include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings must be implemented as directed by the Contracting Officer. Relay contacts must be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers must be field tested in accordance with IEEE C57.13.

3.6.3 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation must be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services must be performed subsequent to testing but prior to the initial energization. The equipment must be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment must be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations must be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests must be performed after the installation of completed assemblies. Components must be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated must be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested must be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer.

3.6.4 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor must show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Test must require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days' advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 26 12 19.10

THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS
05/19, CHG 1: 11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity

IEEE C57.12.34	(2015) Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 260	(1996; R 2004) Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"

EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-mounted Transformer Drawings; G

SD-03 Product Data

Pad-mounted Transformers; G

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-07 Certificates

Transformer Efficiencies; G

SD-09 Manufacturer's Field Reports

Transformer Test Schedule; G

Pad-mounted Transformer Design Tests; G

Pad-mounted Transformer Routine and Other Tests; G

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5; G

1.5 QUALITY ASSURANCE

1.5.1 Pad-Mounted Transformer Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. IEEE nameplate data.

c. Elementary diagrams and wiring diagrams with terminals identified of watthour meter and current transformers.

d. One-line diagram, including switch(es), current transformers, meters, and fuses.

e. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the EasyPower computer program of the transformer high side fuses.

1.5.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, except of NFPA 70 when more stringent requirements are specified or indicated, as though the word "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated.

1.5.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. In addition to requirements of Data Package 5, include the following on the actual transformer(s) provided:

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, front, top, and side views

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Fuse curves for primary fuses

f. Information on watthour demand meter, CT's, and fuse block

g. Actual nameplate diagram

h. Date of purchase

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be pad-mounted transformers and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2 THREE-PHASE PAD-MOUNTED TRANSFORMERS

IEEE C57.12.34, IEEE C57.12.28 and as specified herein. Submit manufacturer's information for each component, device, insulating fluid, and accessory provided with the transformer.

2.2.1 Compartments

Provide high- and low-voltage compartments separated by steel isolating barriers extending the full height and depth of the compartments. Compartment doors: hinged lift-off type with stop in open position and three-point latching.

2.2.1.1 High Voltage, Dead-Front

High-voltage compartment contains: the incoming line, insulated high-voltage load-break connectors, bushing well inserts, six high-voltage bushing wells configured for loop feed application, load-break switch handle(s), dead-front surge arresters, tap changer handle, connector parking stands, protective caps, and ground pad.

Minimum high-voltage compartment dimensions: IEEE C57.12.34, Figures 16 and 17.

a. Insulated high-voltage load-break connectors: IEEE 386, rated 15 kV, 95 kV BIL. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector must have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

b. Insulated high-voltage dead-break connectors: IEEE 386, rated 15 kV, 95 kV BIL. Current rating: 600 amperes rms continuous. Short time rating: 25,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector must have a 200 ampere bushing interface for surge arresters, steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

c. Bushing well inserts and feed-thru inserts: IEEE 386, 200 amperes, 15 kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise. Provide feed-thru inserts as indicated.

d. One-piece bushings: IEEE 386, 200 amperes, 15 kV Class.

e. Load-break switch

Radial-feed two-position oil-immersed type rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Each switch must be rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches must be as follows:

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW.		LINE B SW		XFMR. SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
1	Line A connected to Line B and both lines connected to transformer		X		X		X
2	Transformer connected to Line A only		X	X			X
3	Transformer connected to Line Bonly	X			X		X
4	Transformer open and loop closed		X		X	X	

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW.		LINE B SW		XFMR. SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
5	Transformer open and loop open	X		X		X	

f. Provide bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. The bayonet fuse links sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. Include an oil retention valve inside the bayonet assembly housing, which closes when the fuse holder is removed, and an external drip shield to minimize oil spills. Display a warning label adjacent to the bayonet fuse(s) cautioning against removing or inserting fuses unless the transformer has been de-energized and the tank pressure has been released.

Bayonet fuse assembly: 150 kV BIL.

Oil-immersed current-limiting fuses: IEEE C37.47; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified. Connect current-limiting fuses ahead of the radial-feed load-break switch.

g. Surge arresters: IEEE C62.11, rated as required kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap.

h. Parking stands: Provide a parking stand near each bushing.

i. Protective caps: IEEE 386, 200 amperes, 15 kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushings.

2.2.1.2 Low Voltage

Low-voltage compartment contains: low-voltage bushings with NEMA spade terminals, accessories, metering, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Include the following accessories: drain valve with sampler device, fill plug, pressure relief device, liquid level gage, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator.

b. Metering: Provide as specified in Section 26 27 13.10 30 ELECTRIC METERS.

2.2.2 Transformer

a. Less-flammable liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Transformer rated as indicated.

c. Transformer voltage ratings: as indicated. V - V .

d. Tap changer: externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Indicate which tap setting is in use, clearly visible when the compartment is opened.

e. Minimum tested percent impedance at 85 degrees C:

2.50 for units rated 75kVA and below
2.87 for units rated 112.5kVA to 300kVA
4.03 for 500kVA rated units
5.32 for units rated 750kVA and above

f. Comply with the following audible sound level limits:

kVA	DECIBELS (MAX
75	51
112.5	55
150	55
225	55
300	55
500	56
750	57
1000	58
1500	60
2000	61
2500	62

g. Include:

(1) Lifting lugs and provisions for jacking under base, with base construction suitable for using rollers or skidding in any direction.

(2) An insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

(3) Provide transformer top with an access handhole.

(4) kVA rating conspicuously displayed using 3 inch high yellow letters on its enclosure.

2.2.2.1 Specified Transformer Efficiencies

Provide transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer(s) prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "KVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K. Submit certification, including supporting calculations, from the manufacturer indicating conformance.

kVA	EFFICIENCY (percent)
15	98.65
30	98.83
45	98.92
75	99.03
112.5	99.11
150	99.16
225	99.23
300	99.27
500	99.35
750	99.40
1000	99.43
1500	99.48
2000	99.51
2500	99.53
above 2500	99.54

2.2.3 Insulating Liquid

a. Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D877/D877M. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

Provide a fluid that is a biodegradable, electrical insulating, and cooling liquid classified by UL and approved by FM as "less flammable" with the following properties:

(1) Pour point: ASTM D97, less than -15 degree C

(2) Aquatic biodegradation: EPA 712-C-98-075, ultimately biodegradable as designated by EPA.

(3) Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass

2.2.3.1 Liquid-Filled Transformer Nameplates

Provide nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.2.4 Corrosion Protection

Provide corrosion resistant bases and cabinets of transformers, fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Base includes any part of pad-mounted transformer that is within 3 inches of concrete pad.

Paint entire transformer assembly Munsell 7GY3.29/1.5 green, with paint coating system complying with IEEE C57.12.28 regardless of base, cabinet, and tank material. The Munsell color notation is specified in ASTM D1535.

2.3 WARNING SIGNS AND LABELS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts in accordance with NEMA Z535.4 and NEMA 260.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28, such as for pad-mounted transformers, provide self-adhesive warning labels on the outside of the high voltage compartment door(s)with nominal dimensions of 7 by 10 inches with the legend "WARNING HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. Include the work "WARNING" in white letters on an orange background and the words "HIGH VOLTAGE" in black letters on a white background.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "WARNING HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3 inch high white letters on an orange and black field.

2.4 ARC FLASH WARNING LABEL

Provide arc flash warning label for the enclosure of pad-mounted transformers. Locate this self-adhesive warning label on the outside of the high voltage compartment door warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.5 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.6 PADLOCKS

Provide padlocks for pad-mounted equipment and for each fence gate, keyed as directed by the Contracting Officer. Comply with Section 08 71 00 DOOR

HARDWARE.

2.7 CAST-IN-PLACE CONCRETE

Provide concrete associated with electrical work for other than encasement of underground ducts rated for 4000 psi minimum 28-day compressive strength unless specified otherwise. Conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.8 SOURCE QUALITY CONTROL

2.8.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

(1) Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) Accuracy: Traceable to the National Institute of Standards and Technology.

(3) Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels: visible on all test equipment.

(5) Calibrating standard: higher accuracy than that of the instrument tested.

(6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.8.2 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for each of the specified transformer(s), with design tests performed prior to the award of this contract.

a. Tests: certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (KNAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests includes the primary windings only of that transformer.

(1) IEEE C57.12.90, paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.

(2) State test voltage levels.

(3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.34.

e. Pressure: "Basically the same design" for the pressure test means a pad-mounted transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer specified.

2.8.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests: performed in accordance with IEEE C57.12.90 by the manufacturer on each of the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence as follows:

a. Phase relation

b. Ratio

c. No-load losses (NLL) and excitation current

d. Load losses (LL) and impedance voltage

e. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

f. Leak

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Pad-Mounted Transformer Grounding

Provide a ground ring around the transformer with 4/0 AWG bare copper. Provide four ground rods in the ground ring, one per corner. Install the ground rods at least 10 feet apart from each other. Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect pad-mounted transformers furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.4 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.5 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.6 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

Mount transformer on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inches - W2.9 by W2.9 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that top of concrete slab is approximately 4 inches above the finished grade with gradual slope for drainage.

d. Provide edges above grade with 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.6.1 Cast-In-Place Concrete

Provide cast-in-place concrete work in accordance with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.6.2 Sealing

When the installation is complete, seal all entries into the equipment enclosure with an approved sealing method. Provide seals of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.7 FIELD QUALITY CONTROL

3.7.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS. Submit reports, including acceptance criteria and limits for each test in accordance with NETA ATS "Test Values".

3.7.1.1 Pad-Mounted Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

(3) Inspect anchorage, alignment, and grounding.

(4) Verify the presence of PCB content labeling.

(5) Verify the bushings and transformer interiors are clean.

(6) Inspect all bolted electrical connections for high resistance

using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(7) Verify correct liquid level in tanks and bushings.

(8) Verify that positive pressure is maintained on gas-blanketed transformers.

(9) Perform specific inspections and mechanical tests as recommended by manufacturer.

(10) Verify de-energized tap changer position is left as specified.

(11) Verify the presence of transformer surge arresters.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

(3) Perform insulation-resistance tests, winding-to-winding and each winding-to-ground. Calculate polarization index. Verify that the tap changer is set at the specified ratio.

(4) Perform turns-ratio tests at all tap positions.

(5) Perform insulation power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer's published data.

(6) Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests.

(7) Measure the resistance of each high-voltage winding in each de-energized tap-changer position. Measure the resistance of each low-voltage winding in each de-energized tap-changer position, if applicable.

(8) Remove and test a sample of insulating liquid for the following: Dielectric breakdown voltage, Acid neutralization number, Specific gravity, Interfacial tension, Color, Visual Condition, Water in insulating liquids (Required on 25 kV or higher voltages and on all silicone-filled units.), and Power factor or dissipation factor.

(9) Perform dissolved-gas analysis (DGA) on a sample of insulating liquid.

3.7.1.2 Current Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit wiring.

(5) Verify the unit is clean.

(6) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(7) Verify that all required grounding and shorting connections provide good contact.

(8) Verify correct operation of transformer withdrawal mechanism and grounding operation.

(9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance test.

(3) Perform a polarity test.

(4) Perform a ratio-verification test.

3.7.1.3 Watthour Meter

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical tests

(1) Calibrate watthour meters according to manufacturer's published data.

(2) Verify that correct multiplier has been placed on face of meter, where applicable.

(3) Verify that current transformer secondary circuits are intact.

3.7.1.4 Grounding System

a. Visual and mechanical inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.7.1.5 Surge Arresters, Medium- and High-Voltage

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, grounding, and clearances.

(4) Verify the arresters are clean.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform an insulation-resistance test on each arrester, phase terminal-to-ground.

(3) Test grounding connection.

3.7.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer 5 working days in advance of the dates and times of checking and testing.

-- End of Section --

SECTION 26 12 21

SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
05/17, CHG 2: 11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.25	(1990) Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution

	Transformers With Separable Insulated High-Voltage Connectors; High Voltage, 34,500 Grdy/ 19,920 Volts and Below; Low Voltage, 240/120 Volts; 167 kVa and Smaller Requirements
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 260	(1996; R 2004) Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"

EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this Section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-Mounted Transformer Drawings; G

SD-03 Product Data

Single-Phase Pad-Mounted Transformers (Dead-Front); G

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-07 Certificates

Transformer Efficiencies; G

SD-09 Manufacturer's Field Reports

Transformer Test Schedule; G

Pad-Mounted Transformer Design Tests; G

Pad-Mounted Transformer Routine and Other Tests; G

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5; G,

1.5 QUALITY ASSURANCE

1.5.1 Pad-Mounted Transformer Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. IEEE nameplate data.

c. Elementary diagrams and wiring diagrams with terminals identified of meter and current transformers.

d. One-line diagram, including switch(es), current transformers, meters, and fuses.

e. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the EasyPower computer program of the transformer high side fuses.

1.5.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated.

1.5.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. In addition to requirements of Data Package 5, include the following on the actual transformer(s) provided:

a. An instruction manual with pertinent items and information highlighted.

b. An outline drawing, front, top, and side views.

c. Prices for spare parts and supply list.

d. Routine and field acceptance test reports.

e. Fuse curves for primary fuses.

g. Actual nameplate diagram.

h. Date of purchase.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be pad-mounted transformers and related accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS (DEAD-FRONT)

IEEE C57.12.25, IEEE C57.12.28 and as specified herein. Submit manufacturer's information for each component, device, insulating fluid, and accessory provided with the transformer.

2.2.1 Compartment Construction

b. Two compartment: Provide high- and low-voltage compartments separated by steel isolating barriers extending the full height and depth of the compartments. Compartment doors:

   (1) Hinged lift-off type with stop in open position and three-point latching.

   (2) High voltage door fastening accessible only after the low voltage door has been opened.

2.2.1.1 High Voltage

High-voltage portion contains: the incoming line, insulated high-voltage load-break connectors, bushing well inserts, four high-voltage bushing wells configured for loop feed application, access to oil-immersed fuses, dead-front surge arresters, tap changer handle, connector parking stands, protective caps, and ground pad.

a. Insulated high-voltage load-break connectors: IEEE 386, rated 15 kV, 95 kV BIL. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Provide connectors and inserts from the same manufacturer. Provide connectors with a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

c. Bushing well inserts and feed-through inserts: IEEE 386, 200 amperes, 15 kV class. Provide a bushing well insert for each bushing well unless indicated otherwise.

d. Provide bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. The bayonet fuse links sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. Include an oil retention valve inside the bayonet assembly housing, which closes when the fuse holder is removed, and an external drip shield to minimize oil spills. Display a warning label adjacent to the bayonet fuse(s) cautioning against removing or inserting fuses unless the transformer has been de-energized and the tank pressure has been released.

   Bayonet fuse assembly: 150 kV BIL.

   Oil-immersed current-limiting fuses: IEEE C37.47; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified.

e. Surge arresters: IEEE C62.11, rated 15 kV, fully shielded, dead-front metal-oxide-varistor, elbow type with resistance-graded gap suitable for plugging into inserts as indicated.

g. Parking stands: Provide a parking stand near each bushing well.

h. Protective caps: IEEE 386, 200 amperes, 15 kV class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushing well inserts.

2.2.1.2 Low Voltage

Low-voltage portion contains: low-voltage bushings with NEMA spade terminals, accessories, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Include the following accessories: drain plug, fill plug, pressure relief device and a liquid level sight gage.

b. Metering

   For two-compartment transformers, provide as specified in Section 26 27 13.10 30 ELECTRIC METERS.

2.2.2 Transformer

a. Less-flammable liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Voltage ratings: As indicated..

c. Tap changer: externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Indicate which tap setting is in use, clearly visible when the compartment is opened.

d. Minimum tested percent impedance at 85 degrees C:

2.50 for units rated 25 kVA and below
2.87 for units rated 37.5 kVA to 100 kVA
4.03 for 167 kVA rated units

e. Comply with the following audible sound level limits:

kVA	DECIBELS (MAX)
10	48
15	48
25	48
37.5	48
50	48
75	51
100	51
167	55

g. Include:

(1) Lifting lugs and provisions for jacking under base, with base construction suitable for using rollers or skidding in any direction.

(2) An insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

(3) kVA rating conspicuously displayed using 3 inch high yellow letters on its enclosure.

2.2.2.1 Specified Transformer Efficiencies

Provide transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer(s) prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "KVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K. Submit certification, including supporting calculations, from the manufacturer indicating conformance.

kVA	EFFICIENCY (percent)
10	98.70
15	98.82
25	98.95
37.5	99.05
50	99.11
75	99.19
100	99.25
167	99.33

2.3 INSULATING LIQUID

a. Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D877/D877M. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

Provide a fluid that is a biodegradable, electrical insulating, and cooling liquid classified by UL and approved by FM as "less flammable" with the following properties:

(1) Pour point: ASTM D97, less than -15 degree C.

(2) Aquatic biodegradation: EPA 712-C-98-075, 100 percent.

(3) Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass.

2.4 LIQUID-FILLED TRANSFORMER NAMEPLATES

Provide nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.5 CORROSION PROTECTION

Provide corrosion resistant bases and cabinets of transformers, fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Base includes any part of pad-mounted transformer that is within 3 inches of concrete pad.

Paint entire transformer assembly Munsell 7GY3.29/1.5 green, with paint coating system complying with IEEE C57.12.28 regardless of base, cabinet, and tank material. The Munsell color notation is specified in ASTM D1535.

2.6 WARNING SIGNS AND LABELS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts in accordance with NEMA Z535.4 and NEMA 260.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28, such as for pad-mounted transformers, provide self-adhesive warning labels on the outside of the high voltage compartment door(s) with nominal dimensions of 7 by 10 inches with the legend "WARNING HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. Include the word "WARNING" in white letters on an orange background and the words "HIGH VOLTAGE" in black letters on a white background.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "WARNING HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3 inch high white letters on an orange and black field.

Provide arc flash warning label for the enclosure of pad-mounted transformers. Locate this self-adhesive warning label on the outside of the high voltage compartment side warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.7 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.8 PADLOCKS

Provide padlocks for pad-mounted equipment and for each fence gate, keyed as directed by the Contracting Officer. Comply with Section 08 71 00 DOOR HARDWARE.

2.9 CAST-IN-PLACE CONCRETE

Provide concrete associated with electrical work for other than encasement of underground ducts rated for 4000 psi minimum 28-day compressive strength unless specified otherwise. Conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.10 SOURCE QUALITY CONTROL

2.10.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

2.10.2 Test Instrument Calibration

a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels: visible on all test equipment.

e. Calibrating standard: higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.10.3 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for each of the specified transformer(s), with design tests performed prior to the award of this contract.

a. Tests: certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (ONAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests includes the primary windings only of that transformer.

(1) IEEE C57.12.90, paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.

(2) State test voltage levels.

(3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.25.

e. Pressure: "Basically the same design" for the pressure test means a pad-mounted transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer specified.

2.10.4 Routine and Other Tests

IEEE C57.12.00. Routine and other tests: performed by the manufacturer on each of the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests include:

a. Polarity.

b. Ratio.

c. No-load losses (NLL) and excitation current.

d. Load losses (LL) and impedance voltage.

e. Dielectric.

(1) Impulse.

(2) Applied voltage.

(3) Induced voltage.

f. Leak.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Pad-Mounted Transformer Grounding

Provide a ground ring around the transformer with 4/0 AWG bare copper. Provide four ground rods in the ground ring, one per corner. Install the ground rods at least 10 feet apart from each other. Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect pad-mounted transformers furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.4 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.5 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.6 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

Mount transformer on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inches - W2.9 by W2.9 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that top of concrete slab is approximately 4 inches above the finished grade with gradual slope for drainage.

d. Provide edges above grade with 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.6.1 Cast-In-Place Concrete

Provide cast-in-place concrete work in accordance with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.6.2 Sealing

When the installation is complete, seal all entries into the equipment enclosure with an approved sealing method. Provide seals of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.7 FIELD QUALITY CONTROL

3.7.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS. Submit reports, including acceptance criteria and limits for each test in accordance with NETA ATS "Test Values".

3.7.1.1 Pad-Mounted Transformers

a. Visual and mechanical inspection.

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

(3) Inspect anchorage, alignment, and grounding.

(4) Verify the presence of PCB content labeling.

(5) Verify the bushings and transformer interiors are clean.

(6) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(7) Verify correct liquid level in tanks.

(8) Verify that positive pressure is maintained on gas-blanketed transformers.

(9) Perform specific inspections and mechanical tests as recommended by manufacturer.

(10) Verify correct equipment grounding.

(11) Verify the presence of transformer surge arresters.

b. Electrical tests.

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

(3) Perform insulation-resistance tests, winding-to-winding and each winding-to-ground. Calculate polarization index.

(4) Perform turns-ratio tests at all tap positions.

(5) Perform insulation power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer's published data.

(6) Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests.

(7) Measure the resistance of each high-voltage winding in each de-energized tap-changer position. Measure the resistance of each low-voltage winding in each de-energized tap-changer position, if applicable.

(8) Remove and test a sample of insulating liquid for the following: Dielectric breakdown voltage, Acid neutralization number, Specific gravity, Interfacial tension, Color, Visual Condition, Water in insulating liquids (Required on 25 kV or higher voltages and on all silicone-filled units.), and Power factor or dissipation factor.

(9) Perform dissolved-gas analysis (DGA) on a sample of insulating liquid.

3.7.1.2 Current Transformers

a. Visual and mechanical inspection.

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit wiring.

(5) Verify the unit is clean.

(6) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(7) Verify that all required grounding and shorting connections provide good contact.

(8) Verify correct operation of transformer withdrawal mechanism and grounding operation.

(9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical tests.

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance test.

(3) Perform a polarity test.

(4) Perform a ratio-verification test.

3.7.1.3 Watthour Meter

a. Visual and mechanical inspection.

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical tests.

(1) Calibrate watthour meters according to manufacturer's published data.

(2) Verify that correct multiplier has been placed on face of meter, where applicable.

(3) Verify that current transformer secondary circuits are intact.

3.7.1.4 Grounding System

a. Visual and mechanical inspection.

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests.

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.7.1.5 Surge Arresters, Medium- and High-Voltage

a. Visual and mechanical inspection.

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, grounding, and clearances.

(4) Verify the arresters are clean.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical tests.

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform an insulation-resistance test on each arrester, phase terminal-to-ground.

(3) Test grounding connection.

3.7.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer 5 working days in advance of the dates and times of checking and testing.

-- End of Section --

SECTION 26 18 23.00 40

MEDIUM-VOLTAGE SURGE ARRESTERS
08/16

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Surge Arrester; G

SD-08 Manufacturer's Instructions

Installation Instructions

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

Products manufactured more than 3 years prior to date of delivery to site are not to be used, unless specified otherwise.

1.3.3 Predictive Testing and Inspection Technology Requirements

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

PART 2 PRODUCTS

Submit surge arrester equipment and performance data including life, test, system functional flows, safety features, and fabrication drawings that show assembly and fabrication details performed in the factory.

Submit manufacturer's installation instructions for surge arresters including special provisions required to install equipment components and system packages. Provide special notices that detail impedances, hazards and safety precautions.

2.1 EQUIPMENT

Provide arresters that comply with IEEE C62.11 for design, fabrication, testing, and performance.

Provide gapped metal oxide varistor (MOV) type, single-phase, single-pole surge arresters that comply with IEEE C62.11 for design, fabrication, testing, and performance. Ensure surge arresters are rated minimum 15 kilovolts (kV) duty cycle and 15.3 kV Maximum Continuous Operating Voltage (MCOV) with creepage distance in accordance with manufacturer's specifications for the duty cycle and specific type of arrester. Ensure arrester is designed as non-fragmenting.

Provide porcelain surge arrestors consisting of tube style fiberglass reinforced plastic epoxy resin structural hollow core surrounding the MOV elements with silicon rubber polymer or porcelain housing. Ensure end fittings are attached to the structural hollow core using a pressure controlled crimping process. Seal the interface between the structural hollow core and end fittings to prevent ingress of moisture.

2.1.1 Distribution Class

Provide heavy duty distribution class arresters. Provide corrosion resistant mounting hardware and insulated brackets for riser-pole type arrestors. Provide arrestors installed in a pre-molded rubber elbow for underground distribution systems in accordance with IEEE 386.

2.1.2 Intermediate Class

Provide arresters for cubicle, pedestal, platform, or bracket mounting as indicated.

2.1.3 Station Class

Provide single-phase, single-pole, self-supporting type arresters for pedestal, platform, or bracket mounting as indicated.

2.1.4 Mounting Brackets

Provide arresters equipped with suitable mounting brackets for the applicable method of mounting. For arresters utilizing a hanger frame type mounting bracket, provide a frame that is a non-corrosive track resistant glass filled polyester or other suitable non-corrosive and non-conductive material that provides high mechanical strength.

PART 3 EXECUTION

3.1 INSTALLATION

Install and connect arresters in accordance with the manufacturer's installation instructions.

Make ground connection to a driven ground rod, counterpoise, or station grounding system and meet the intent of the National Electrical Code, NFPA 70.

Connect lightning arresters as close as practicable to the apparatus being protected. When connecting arresters to overhead conductors, use a hot line clamp. Provide a hot line clamp that is compatible with the conductor material being used, i.e. aluminum or copper.

Ensure all installations comply with the requirements and recommendations of NFPA 70 and IEEE C2.

3.2 FIELD QUALITY CONTROL

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

3.3 CLOSEOUT ACTIVITIES

Submit operation and maintenance manuals for the specified surge arresters.

-- End of Section --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM
08/19, CHG 3: 11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA NEIS 1	(2015) Standard for Good Workmanship in Electrical Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)

ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
ANSI C80.5	(2020) American National Standard for Electrical Rigid Aluminum Conduit
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA BU 1.1	(2010) General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing

NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-569	(2019e) Telecommunications Pathways and Spaces
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment
29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.303	Electrical, General

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2020) UL Standard for Safety Flexible Metal Conduit
UL 5	(2016; Reprint Aug 2020) UL Standard for Safety Surface Metal Raceways and Fittings
UL 5A	(2015; Reprint Aug 2020) Nonmetallic

	Surface Raceways and Fittings
UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 6A	(2008; Reprint Mar 2021) UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 20	(2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Jul 2020) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 248-4	(2010; Reprint Apr 2019) Low-Voltage Fuses - Part 4: Class CC Fuses
UL 248-8	(2011; Reprint Aug 2020) Low-Voltage Fuses - Part 8: Class J Fuses
UL 248-10	(2011; Reprint Aug 2020) Low-Voltage Fuses - Part 10: Class L Fuses
UL 248-12	(2011; Reprint Aug 2020) Low Voltage Fuses - Part 12: Class R Fuses
UL 248-15	(2018) Low-Voltage Fuses - Part 15: Class T Fuses
UL 360	(2013; Reprint Aug 2021) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Sep 2021) UL Standard for Safety Attachment Plugs and Receptacles

UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 674	(2011; Reprint Dec 2020) UL Standard for Safety Electric Motors and Generators for Use in Hazardous (Classified) Locations
UL 797	(2007; Reprint Mar 2021) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 845	(2021) UL Standard for Safety Motor Control Centers
UL 857	(2009; Reprint Apr 2021) UL Standard for Safety Busways
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1063	(2017; Reprint Jun 2020) UL Standard for Safety Machine-Tool Wires and Cables
UL 1203	(2013; Reprint Apr 2022) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1660	(2019) Liquid-Tight Flexible Nonmetallic Conduit
UL 1699	(2017; Reprint Feb 2022) UL Standard for Safety Arc-Fault Circuit-Interrupters
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 4248-1	(2022) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Busway; G

Cable Trays; G

Motor Control Centers; G

Wireways; G,

Load Centers for Housing Units; G

Marking Strips Drawings; G

SD-03 Product Data

Receptacles; G

Circuit Breakers; G

Switches; G

Transformers; G

Enclosed Circuit Breakers; G

Motor Controllers; G,

Combination Motor Controllers; G

Load Centers for Housing Units; G

Manual Motor Starters; G,

Residential Load Centers; G

Metering; G

Meter Base Only; G

CATV Outlets; G

Secondary Bonding Busbar; G

Surge Protective Devices; G

Cable Trays; G,

SD-05 Design Data

Cable Tray Design; G

SD-06 Test Reports

600-volt Wiring Test; G

Grounding System Test; G

Transformer Tests; G

Ground-fault Receptacle Test; G

Arc-fault Receptacle Test; G

SD-07 Certificates

Fuses; G

SD-09 Manufacturer's Field Reports

Transformer Factory Tests

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G,

Metering, Data Package 5; G

1.4 QUALITY ASSURANCE

1.4.1 Fuses

Submit coordination data as specified in paragraph, FUSES of this section.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated. NECA NEIS 1 shall be considered the minimum standard for workmanship.

1.4.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.5 MAINTENANCE

1.5.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein. Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. Include the following:

a. Single line diagram of the "as-built" building electrical system.

b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

c. Manufacturers' operating and maintenance manuals on active electrical equipment.

1.6 WARRANTY

Provide equipment items supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7 SEISMIC REQUIREMENTS

Provide seismic details conforming to Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and to Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT as indicated.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

2.2 CONDUIT AND FITTINGS

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40, and EPC-80 in accordance with NEMA TC 2,UL 651.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40(40 mils thick).

2.2.6 Flexible Metal Conduit

UL 1, limited to 6 feet.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360, limited to 6 feet.

2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with UL 514B.

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

Die Cast compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every 12 inches.

2.3.2 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type.

2.4 BUSWAY

NEMA BU 1.1, UL 857. Provide the following:

a. Buses: copper.

b. Busways: rated as indicated.

c. Short circuit rating: as indicated.

d. Busway systems: suitable for use indoors.

e. Enclosures: steel .

f. Hardware: plated or otherwise protected to resist corrosion.

g. Joints: one-bolt type with through-bolts, which can be checked for tightness without de-energizing system.

h. Maximum hot spot temperature rise at any point in busway at continuous rated load: do not exceed 55 degrees C above maximum ambient temperature of 40 degrees C in any position.

i. Internal barriers to prevent movement of superheated gases.

j. Coordinate proper voltage phasing of entire bus duct system, for example where busway interfaces with transformers, switchgear, switchboards, motor control centers, and other system components.

2.4.1 Feeder Busways

Provide unventilated, totally enclosed low-impedance busway. Provide bus bars fully covered with insulating material, except at stabs. Provide an entirely polarized busway system.

2.4.2 Plug-In Busways

Unventilated type. Provide the following:

a. Plug-in units: fusible, handle-operated, switch type, horsepower-rated circuit breaker-type handle-operated, switch type, equipped with high interrupting-capacity, current-limiting fuses.

b. Bus bars: covered with insulating material throughout, except at joints and other connection points.

c. A hook stick of suitable length for operating plug-in units from the floor.

2.5 CABLE TRAYS

NEMA VE 1. Provide the following:

Submit cable tray design, including dimensional layout, load and seismic calculations, and fill calculations. Dimensional layout includes cable spacings, cable tray splices, and supports. Fill calculations include an index of cables for each section and identification of the lb/ft, cross sectional area, and insulation voltage class for each cable.

a. Cable trays: form a wireway system, with a nominal depth as indicated.

b. Cable trays: constructed of steel that has been zinc-coated after fabrication.

c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.

d. Edges, fittings, and hardware: finished free from burrs and sharp edges.

e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.

f. Radius of bends: as indicated.

2.5.1 Basket-Type Cable Trays

Provide size as indicated with maximum wire mesh spacing of 2 by 4 inch.

2.5.2 Trough-Type Cable Trays

Provide size as indicated.

2.5.3 Ladder-Type Cable Trays

Provide size as indicated with maximum rung spacing of 6 inches.

2.5.4 Channel-Type Cable Trays

Provide size as indicated. Provide trays with one-piece construction having slots spaced not more than 4 1/2 inches on centers.

2.5.5 Solid Bottom-Type Cable Trays

Provide size as indicated. Provide solid covers.

2.5.6 Cantilever

Cantilever-type, center-hung cable trays may be provided at the Contractor's option in lieu of other cable tray types specified.

2.6 OPEN TELECOMMUNICATIONS CABLE SUPPORT

2.6.1 Open Top Cable Supports

Provide open top cable supports in accordance with UL 2043. Provide zinc-coated steel open top cable supports.

2.6.2 Closed Ring Cable Supports

Provide closed ring cable supports in accordance with UL 2043. Provide zinc-coated steel closed ring cable supports.

2.7 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.7.1 Floor Outlet Boxes

Provide the following:

a. Boxes: adjustable and concrete tight.

b. Each outlet: consisting of nonmetallic or cast-metal body with threaded openings, or sheet-steel body with knockouts for conduits, adjustable ring, and cover plate with 3/4 inch threaded plug.

c. Telecommunications outlets: consisting of surface-mounted, horizontal flush, aluminum or stainless steel housing with a receptacle as specified and 3/4 inch top opening.

d. Receptacle outlets: consisting of surface-mounted, horizontal flush aluminum or stainless steel housing with duplex-type receptacle as specified herein.

e. Provide gaskets where necessary to ensure watertight installation.

2.7.2 Outlet Boxes for Telecommunications System

Provide the following:

a. Standard type 4 11/16 inches square by 2 1/8 inches deep.

b. Outlet boxes for wall-mounted telecommunications outlets: 4 by 2 1/8 by 2 1/8 inches deep.

c. Depth of boxes: large enough to allow manufacturers' recommended conductor bend radii.

d. Outlet boxes for fiber optic telecommunication outlets: include a minimum 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum one inch conduit system.

e. Outlet boxes for handicapped telecommunications station: 4 by 2 1/8 by 2 1/8 inches deep.

2.7.3 Clock Outlet for Use in Other Than Wired Clock System

Provide the following:

a. Outlet box with plastic cover, where required, and single receptacle with clock outlet plate.

b. Receptacle: recessed sufficiently within box to allow complete insertion of standard cap, flush with plate.

c. Suitable clip or support for hanging clock: secured to top plate.

d. Material and finish of plate: as specified in paragraph DEVICE PLATES of this section.

2.8 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than 100 cubic inches, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet, damp, or corrosive environments, NEMA Type as indicated.

2.9 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

2.9.1 Conductors

Provide the following:

a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.

b. Conductors No. 8 AWG and larger diameter: stranded.

c. Conductors No. 10 AWG and smaller diameter: solid.

d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.

e. All conductors: copper.

2.9.1.1 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

2.9.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.9.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

a. Grounding conductors: Green.

b. Neutral conductors: White.

c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: white with a different colored (not green) stripe for each.

2.9.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

d. On three-phase, four-wire delta system, high leg: orange, as required by NFPA 70.

2.9.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where equipment or devices require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.9.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.9.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607 with No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 750 kcmil.

2.9.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (PBB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

2.10 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.11 DEVICE PLATES

Provide the following:

a. UL listed, one-piece device plates for outlets to suit the devices installed.

b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.

c. For nonmetallic boxes and fittings, other suitable plates may be provided.

d. Plates on finished walls: nylon or lexan, minimum 0.03 inch wall thickness and same color as receptacle or toggle switch with which they are mounted.

e. Plates on finished walls: satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.

f. Screws: machine-type with countersunk heads in color to match finish of plate.

g. Sectional type device plates are not be permitted.

h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.12 SWITCHES

2.12.1 Toggle Switches

NEMA WD 1, UL 20, single pole, double pole, three-way, and four-way, totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

a. Handles: ivory thermoplastic.

b. Wiring terminals: screw-type, side-wired.

c. Contacts: silver-cadmium and contact arm - one-piece copper alloy.

d. Switches: rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.12.2 Switch with Red Pilot Handle

NEMA WD 1. Provide the following:

a. Pilot lights that are integrally constructed as a part of the switch's handle.

b. Pilot light color: red and illuminate whenever the switch is closed or "on".

c. Pilot lighted switch: rated 20 amps and 120 volts or 277 volts as indicated.

d. The circuit's neutral conductor to each switch with a pilot light.

2.12.3 Breakers Used as Switches

For 120- and 277-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.12.4 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA , enclosure as indicated per NEMA ICS 6.

2.13 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible switch panel and control center. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers or other circuit protective devices for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.13.1 Fuseholders

Provide in accordance with UL 4248-1.

2.13.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 248-12, Class RK-1 RK-5 time-delay type. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.13.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 248-8, UL 248-10, UL 248-4, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.13.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 248-15, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.14 RECEPTACLES

Provide the following:

a. UL 498, general purpose specification grade,UL 498, hospital grade, grounding-type. Residential grade receptacles are not acceptable.

b. Ratings and configurations: as indicated.

c. Bodies: ivory as per NEMA WD 1.

d. Face and body: thermoplastic supported on a metal mounting strap.

e. Dimensional requirements: per NEMA WD 6.

f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.

g. Grounding pole connected to mounting strap.

h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

i. Controlled receptacles: as required per ASHRAE 90.1. Provide marking for controlled receptacle per NFPA 70.

2.14.1 Split Duplex Receptacles

Provide separate terminals for each ungrounded pole. One receptacle must be controlled separately.

2.14.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations" with integral GFCI protection. Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, die-cast metal/aluminum cover plate.

2.14.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak when the current to ground is 6 milliamperes or higher, and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.14.4 Plugs

Provide heavy-duty, rubber-covered wire cord of required size, install plugs thereon, and attach to equipment. Provide UL listed plugs with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.14.5 Range Receptacles

NEMA 14-50 configuration, flush mounted for housing units, rated 50 amperes, 125/250 volts. Furnish one matching plug with each receptacle.

2.14.6 Dryer Receptacles

NEMA 14-30 configuration, rated 30 amperes, 125/250 volts. Furnish one matching plug with each receptacle.

2.14.7 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.14.8 Arc-Fault Circuit Interrupter Receptacles

UL 1699, duplex type for mounting in standard outlet box. Provide device capable of detecting series arcing current when the current to ground is 5 amperes or higher, and tripping per requirements of UL 1699.

2.14.9 Transient Voltage Surge Suppression (TVSS)

a. The transient voltage surge suppressor shall be a permanently connected, flush mounted, duplex receptacle device. The TVSS receptacle shall provide equal surge protection of not less than 6500A in all three modes: hot to neutral, hot to ground and neutral to ground.

b. The TVSS receptacle shall also provide RFI and EMI noise filtration at an average 7:1 reduction from 500 KHz to 30MHz. It shall also be available in an isolated ground version for further noise protection. The TVSS (straight blade) receptacle shall be heavy duty hospital grade construction and provide both back and side wiring ability.

c. The TVSS receptacle shall be provided with a long life LED,with a wide viewing lens for positive indication of surge protection.

d. The TVSS receptacle shall meet the latest version of the following standards:

(1) UL 1449 for both category A & B tests.

(2) ANSI/IEEE 62.41.

(3) CSA TIL #1-11B/Standard C22.2 #8-M.

(4) UL 498 Hospital Grade Receptacle (straight blade only).

e. TVSS Receptacle color shall match the other device colors in the room.

2.14.10 Isolated Ground Receptacles (IG)

a. The isolated ground receptacle shall be a hospital grade, permanently connected, flush mounted, duplex receptacle device. The IG receptacle shall provide isolation of the ground contacts to the mounting strap which will allow the device to be directly mounted to metal boxes.

b. The Isolated ground receptacle shall have the hospital grade and IG triangle symbol clearly displayed on the device. It shall also have the amperage and voltage clearly displayed on the face.

c. The IG receptacle shall have side and back wiring capability for solid or stranded conductors and a green grounding screw for the IG conductor.

d. The IG receptacle shall meet the latest version of the following standards:

(1) NEMA WD-6

(2) ANSI C73

(3) UL 498 Hospital Grade Receptacle

(4) For use I.A.W. NEC Art. 250-146 (d).

(5) Federal Specification WC 896.

2.14.11 Combination Isolated Ground and TVSS Receptacles (IG/TVSS)

a. The IG/TVSS receptacle shall be a hospital grade, permanently connected, flush mounted, duplex receptacle device. It shall incorporate the features of the TVSS Device and IG device as stated previously in this in this section.

b. The IG/TVSS receptacle shall have the hospital grade, IG triangle and TVSS symbol clearly displayed on the device. When illuminated, the LED shall be clearly viewable. The receptacle shall also have the amperage and voltage clearly displayed on mounting tabs.

2.15 PANELBOARDS

Provide panelboards in accordance with the following:

a. UL 67 and UL 50 having a short-circuit current rating as indicated .

b. Panelboards for use as service disconnecting means: additionally conform to UL 869A.

c. Panelboards: circuit breaker-equipped.

d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

e. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the design drawings. If it is not possible to match "specific breaker placement" during construction, obtain Government approval prior to device installation.

f. Use of "Subfeed Breakers" is not acceptable.

g. Main breaker: "separately" mounted "above" or "below" branch breakers.

h. Where "space only" is indicated, make provisions for future installation of breakers.

i. Directories: indicate load served by each circuit in panelboard.

j. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).

k. Provide new directories for existing panels modified by this project as indicated.

l.Type directories and mount in holder behind transparent protective covering.

m. Panelboards: listed and labeled for their intended use.

n. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.15.1 Enclosure

Provide panelboard enclosure in accordance with the following:

a. UL 50.

b. Cabinets mounted outdoors or flush-mounted: .

c. Cabinets: painted in accordance with paragraph PAINTING.

d. Outdoor cabinets: NEMA 3R raintight with conduit hubs welded to the cabinet or a removable steel plate 1/4 inch thick in the bottom for field drilling for conduit connections.

e. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.

f. All cabinets: fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch.

g. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 1/2 inch clear space between the back of the cabinet and the wall surface.

h. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.

i. Each door: fitted with a combined catch and lock latch.

j. Keys: two provided with each lock, with all locks keyed alike.

k. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.15.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.15.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:.

a. UL listed, with panelboard type specifically UL heat rise tested for use on non-linear loads.

b. Panelboard: heat rise tested in accordance with UL 67, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing.

c. Verification of the testing procedure: provided upon request.

d. Two neutral assemblies paralleled together with cable is not acceptable.

e. Nameplates for panelboard rated for use on non-linear loads: marked "SUITABLE FOR NON-LINEAR LOADS" and in accordance with paragraph FIELD FABRICATED NAMEPLATES.

f. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

2.15.3 Circuit Breakers

UL 489, thermal magnetic-type or solid state-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided. Where indicated on the drawings, provide circuit breakers with shunt trip devices. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.15.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.15.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

2.15.3.3 Arc-Fault Circuit Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated. Provide with "push-to-test" button.

2.16 RESIDENTIAL LOAD CENTERS

Provide residential load centers (RLCs) in accordance with the following:

a. UL 67 and UL 50.

b. RLCs for use as service disconnecting means: additionally conform to UL 869A.

c. Circuit breaker equipped.

d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

e. Where "space only" is indicated, make provisions for future installation of breakers sized as indicated.

f. Provide load centers with keyed locks.

g. Provide printed directories.

2.16.1 RLC Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated groundable neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.16.2 Circuit Breakers

UL 489, thermal magnetic-type with interrupting capacity as indicated. Breaker terminals: UL listed as suitable for the type of conductor provided.

2.16.2.1 Multipole Breakers

Provide common trip-type with single operating handle. Provide a breaker design such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any two adjacent breaker poles are connected to alternate phases in sequence.

2.16.2.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

2.16.2.3 Arc-Fault Circuit-Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated. Provide with "push-to-test" button.

2.17 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated. Provide solid neutral.

2.18 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

Motor short-circuit protectors, also called motor circuit protectors (MCPs): UL 508 and UL 489, and provided as shown. Provide MSCPs that consist of an adjustable instantaneous trip circuit breaker used only in conjunction with a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection. Rate MSCPs in accordance with the requirements of NFPA 70.

2.19 TRANSFORMERS

Provide transformers in accordance with the following:

a. NEMA ST 20, general purpose, dry-type, self-cooled, unventilated.

b. Provide transformers in NEMA enclosure as required for the environment used.

c. Transformer insulation system:

   (1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C.

   (2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.

d. Transformer of 150 degrees C temperature rise is not acceptable.

e. Transformer of 115 degrees C temperature rise: capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.

f. Transformer of 80 degrees C temperature rise: capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.

g. Transformers: quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.19.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient type. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in 10 CFR 431, Subpart K.

2.19.2 Transformers With Non-Linear Loads

Provide transformers for non-linear loads in accordance with the following:

a. Transformer insulation: UL recognized 220 degrees C system. Neither the primary nor the secondary temperature is allowed to exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load.

b. Transformers are to be UL listed and labeled for K-4 in accordance with UL 1561.

c. Transformers evaluated by the UL K-Factor evaluation: listed for 115 degrees C average temperature rise only.

d. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise are not acceptable.

e. K-Factor rated transformers impedance: allowed range of 3 percent to 5 percent, with a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

2.20 MOTORS

Provide motors in accordance with the following:

a. NEMA MG 1 except provide fire pump motors as specified in Section 21 30 00 FIRE PUMPS.

b. Hermetic-type sealed motor compressors: Also comply with UL 984.

c. Provide the size in terms of HP, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified.

d. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.

e. Rate motors for operation on 208-volt, 3-phase circuits with a terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits with a terminal voltage rating of 460 volts.

f. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.

g. Unless otherwise indicated, use continuous duty type motors if rated 1 HP and above.

h. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.

2.20.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: high efficiency types are not acceptable. In exception, for special purpose motors and motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.20.2 Premium Efficiency Polyphase and Single-Phase Motors

Select polyphase and continuous-duty single phase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10 and NEMA MG 11. In addition, continuous rated, polyphase squirrel-cage medium induction motors must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.20.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.20.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment , and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, assemblies, or other power sources to equipment as specified herein. Power wiring and conduit: conform to the requirements specified herein. Control wiring: provided under, and conform to, the requirements of the section specifying the associated equipment.

2.21 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

a. UL 508, NEMA ICS 1, and NEMA ICS 2, except fire pump controllers as specified in Section 21 30 00 FIRE PUMPS.

b. Provide controllers with thermal overload protection in each phase, and one spare normally open auxiliary contact, and one spare normally closed auxiliary contact.

c. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage.

d. Provide protection for motors from immediate restart by a time adjustable restart relay.

e. When used with pressure, float, or similar automatic-type or maintained-contact switch, provide a hand/off/automatic selector switch with the controller.

f. Connections to selector switch: wired such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position.

g. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices: connected in motor control circuit in "hand" and "automatic" positions.

h. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device: made in accordance with indicated or manufacturer's approved wiring diagram.

i. Provide selector switch with the means for locking in any position.

j. Provide a disconnecting means, capable of being locked in the open position, for the motor that is located in sight from the motor location and the driven machinery location. As an alternative, provide a motor controller disconnect, capable of being locked in the open position, to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.

k. Overload protective devices: provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case.

l. Cover of combination motor controller and manual switch or circuit breaker: interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position.

m. Provide controllers in hazardous locations with classifications as indicated.

2.21.1 Control Wiring

Provide control wiring in accordance with the following:

a. All control wire: stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards.

b. Hinge wire: Class K stranding.

c. Current transformer secondary leads: not smaller than No. 10 AWG.

d. Control wire minimum size: No. 14 AWG.

e. Power wiring for 480-volt circuits and below: the same type as control wiring with No. 12 AWG minimum size.

f. Provide wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.21.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

a. NEMA ICS 4.

b. Control circuit terminal blocks for control wiring: molded or fabricated type with barriers, rated not less than 600 volts.

c. Provide terminals with removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts.

d. Terminals: not less than No. 10 in size with sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal.

e. Terminal arrangement: subject to the approval of the Contracting Officer with not less than four spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.

f. Modular, pull apart, terminal blocks are acceptable provided they are of the channel or rail-mounted type.

g. Submit data showing that any proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.21.2.1 Types of Terminal Blocks

a. Short-Circuiting Type: Short-circuiting type terminal blocks: furnished for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks: comply with the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity: provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. Provide terminals of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Provide each connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.21.3 Control Circuits

Control circuits: maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers: conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits: provide primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side. Provide fuses in each ungrounded primary feeder. Provide one fused secondary lead with the other lead grounded. For designated systems, as indicated, provide backup power supply, including transformers connected to emergency power source. Provide for automatic switchover and alarm upon failure of primary control circuit.

2.21.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.21.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers: include compelling relays and multiple-button, station-type with pilot lights for each speed.

2.21.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations: heavy duty, oil-tight design.

2.21.7 Pilot and Indicating Lights

Provide LED cluster lamps.

2.21.8 Reduced-Voltage Controllers

Provide for polyphase motors 10 horsepower and larger. Reduced-voltage starters: single-step, closed transition solid state-type, or as indicated, with an adjustable time interval between application of reduced and full voltages to motors. Wye-delta reduced voltage starter or part winding increment starter having adjustable time delay between application of voltage to first and second winding of motor may be used in lieu of the reduced-voltage starters for starting of motor-generator sets, centrifugally operated equipment, or reciprocating compressors provided with automatic unloaders.

2.22 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single, Double or Three pole designed for flush or surface mounting with overload protection and pilot lights.

2.22.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color: red.

2.23 MOTOR CONTROL CENTERS

Submit wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices.

Provide motor control centers in accordance with the following:

a. UL 845, NEMA ICS 2, NEMA ICS 3.

d. Incoming power feeder: cable entering at the top or bottom of enclosure and terminating on main protective device.

e. Main protective device: molded case circuit breaker rated and configured as indicated..

f. Arrange busing so that control center can be expanded from both ends.

g. Interconnecting wires: copper.

h. Terminal blocks: plug-in-type so that controllers may be removed without disconnecting individual control wiring.

2.23.1 Bus Systems

Provide the following bus systems. Power bus: be braced to withstand the required fault current. Wiring troughs: isolated from horizontal and vertical bus bars.

2.23.1.1 Horizontal and Main Buses

Horizontal bus: continuous current rating of as indicated. Main bus: copper, tin-plated enclosed in isolated compartment at top of each vertical section. Main bus: isolated from wire troughs, starters, and other areas.

2.23.1.2 Vertical Bus

Vertical bus: continuous current rating as indicated, and shall be copper, tin-plated. Vertical bus: enclosed in flame-retardant, polyester glass "sandwich."

2.23.1.3 Ground Bus

Copper ground bus: provided full width of motor control center and equipped with necessary lugs.

2.23.1.4 Neutral Bus

Insulated neutral bus: provided continuous through the motor control center; neutral full rated. Provide lugs of appropriate capacity, as required.

2.23.2 Combination Motor Controllers

UL 508 and other requirements in paragraph, MOTOR CONTROLLERS. Provide in controller a molded case circuit breaker or fusible switch with clips for R -type fuses for branch circuit protection. Circuit breakers for combination controllers: thermal magnetic.

2.23.3 Space Heaters

Provide space heaters where indicated on the drawings, controlled using an adjustable 50 to 90 degrees F thermostat, magnetic contactor, and a molded-case circuit breaker. Provide space heaters equipped with 250-watt, 240 volt strip elements operated at 120 volts and wired to terminal blocks for connection to 120-volt single-phase power sources located external to the control centers. Contactors: open type, electrically-held, rated 30 amperes, 2-pole, with 120-volt ac coils.

2.24 LOCKOUT REQUIREMENTS

Provide circuit breakers, disconnecting means, and other devices that are electrical energy-isolating capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147, NFPA 70E and 29 CFR 1910.303. Comply with requirements of Division 23, "Mechanical" for mechanical isolation of machines and other equipment.

2.25 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires wireways, cable trays, and other accessories for telecommunications outlets and pathway in accordance with TIA-569 and as specified herein. Additional telecommunications requirements are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.26 COMMUNITY ANTENNA TELEVISION (CATV) SYSTEM

Additional CATV requirements are specified in Section 27 05 13.43 TELEVISION DISTRIBUTION SYSTEM.

2.26.1 CATV Outlets

Provide flush mounted, 75-ohm, F-type connector outlet rated from 5 to 1000 MHz in standard electrical outlet boxes with mounting frame.

2.26.2 CATV Faceplates

Provide modular faceplates for mounting of CATV Outlets. Faceplate: include designation labels and label covers for circuit identification. Faceplate color: match outlet and switch coverplates.

2.26.3 Backboards

Provide void-free, fire rated interior grade plywood, 3/4 inch thick, 4 by 8 feet. Do not cover the fire stamp on the backboard.

2.27 GROUNDING AND BONDING EQUIPMENT

2.27.1 Ground Rods

UL 467. Ground rods: cone pointed copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional type rods may be used for rods 20 feet or longer.

2.27.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as indicated.

2.27.3 Secondary Bonding Busbar

Provide corrosion-resistant grounding busbar suitable for indoor or outdoor installation in accordance with TIA-607. Busbars: plated for reduced contact resistance. If not plated, clean the busbar prior to fastening the conductors to the busbar and apply an anti-oxidant to the contact area to control corrosion and reduce contact resistance. Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility and a Secondary bonding busbar (SBB) in all other telecommunications rooms and equipment rooms. The Primary bonding busbar (PBB) and the Secondary bonding busbar (SBB): sized in accordance with the immediate application requirements and with consideration of future growth. Provide Secondary bonding busbars with the following:

a. Predrilled copper busbar provided with holes for use with standard sized lugs,

b. Minimum dimensions of 0.25 in thick by 4 in wide for the PBB and 2 in wide for SBBs with length as indicated;

c. Listed by a nationally recognized testing laboratory.

2.28 HAZARDOUS LOCATIONS

Electrical materials, equipment, and devices for installation in hazardous locations, as defined by NFPA 70: specifically approved by Underwriters' Laboratories, Inc., or Factory Mutual for particular "Class," "Division," and "Group" of hazardous locations involved. Boundaries and classifications of hazardous locations: as indicated. Equipment in hazardous locations: comply with UL 1203 for electrical equipment and industrial controls and UL 674 for motors.

2.29 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.30 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

a. ASTM D709.

b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.

c. Each nameplate inscription: identify the function and, when applicable, the position.

d. Nameplates: melamine plastic, 0.125 inch thick, white with black center core.

e. Provide red laminated plastic label with white center core where indicated.

f. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.

g. Minimum size of nameplates: one by 2.5 inches.

h. Lettering size and style: a minimum of 0.25 inch high normal block style.

2.31 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.32 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00 FIRESTOPPING.

2.33 WIREWAYS

UL 870. Material: steel epoxy painted 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with screw- cover NEMA enclosure per NEMA ICS 6.

2.34 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance, load centers, panelboards, MCC and as indicated. Provide surge protectors in a NEMA enclosure suitable for the environment per NEMA ICS 6. SPD must have the same short-circuit current rating as the protected equipment and must not be installed at a point of system where the available fault current is in excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
- Phase to phase (L-L)
- Each phase to neutral (L-N)
- Neutral to ground (N-G)
- Phase to ground (L-G)

FOR DELTA CONNECTIONS-
- Phase to phase (L-L)
- Phase to ground (L-G)

SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G) and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G).

Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, and N-G Voltage Protection Rating:

600V for 120V, single phase system
1,000V for 120/240V, single phase system
600V for 120/240V, three phase system
600V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-G Protection Rating:
700V for 120V, single phase system
1,000V for 120/240V, single phase system
700V for 120/240V, three phase system
700V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 120/240V, three phase system
1,200V for 208Y/120V, three phase system
1,800V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120 percent of nominal voltage for 240 volts and below; 115 percent of nominal voltage above 240 volts to 480 volts.

Provide EMI/RFI filtering per UL 1283 for each mode with the capability to attenuate high frequency noise. Minimum attenuation: 20db.

2.35 FACTORY APPLIED FINISH

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI Light Gray.

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.36 SOURCE QUALITY CONTROL

2.36.1 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

2.37 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces: conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.1.2 Overhead Service

Overhead service conductors into buildings: terminate at service entrance fittings or weatherhead outside building. Overhead service conductors and support bracket for overhead conductors are included in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.1.3 Hazardous Locations

Perform work in hazardous locations, as defined by NFPA 70, in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Provide conduit with tapered threads.

3.1.4 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.1.4.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.1.5 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00 FIRESTOPPING.

3.1.5.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.1.5.2 Metal-Clad Cable

Install in accordance with NFPA 70, Type MC cable.

3.1.6 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project. Run conduits in crawl space under floor slab as if exposed.

3.1.6.1 Restrictions Applicable to Aluminum Conduit

a. Do not install underground or encase in concrete or masonry.

b. Do not use brass or bronze fittings.

c. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.6.2 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use in hazardous areas.

e. Do not use outdoors.

f. Do not use in fire pump rooms.

g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.6.3 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40.

(1) Do not use where subject to physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.

(2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

b. PVC Schedule 40 and Schedule 80.

(1) Do not use where subject to physical damage, including but not limited to, hospitals, power plant, missile magazines, and other such areas.

(2) Do not use in hazardous (classified) areas.

(3) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

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3.1.6.4 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.6.5 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab. Plastic coating: extend minimum 6 inches above floor.

3.1.6.6 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.6.7 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier. Use NECA NEIS 1 Table 2a (Minimum Raceway Spacing) to determine under floor slab conduit spacing unless greater spacing is required elsewhere in this section.

3.1.6.8 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab. Where conduit rises through slab-on grade, seal all electrical penetrations to address radon mitigation and prevent infiltration of air, insects, and vermin.

3.1.6.9 Conduit Installed in Concrete Floor Slabs

PVC, Type EPC-40, unless indicated otherwise. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab. Where nonmetallic conduit is used, convert raceway to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.

3.1.6.10 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.6.11 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Plastic cable ties are not acceptable. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 10 foot maximum intervals. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.6.12 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.6.13 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.6.14 Flexible Connections

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquid tight flexible conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections. Plastic cable ties are not acceptable as a support method.

3.1.6.15 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569.

a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room: installed and cabling length requirements in accordance with TIA-568.1. Size conduits, wireways, and cable trays in accordance with TIA-569 and as indicated.

b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling): installed in accordance with TIA-569. Size conduits, wireways, and cable trays for telecommunications risers in accordance with TIA-569 and as indicated.

3.1.6.16 Community Antenna Television (CATV) System Conduits

Install a system of CATV wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires wireways, cable trays, and other accessories for CATV outlets and pathway in accordance with TIA-569. Provide distribution system with star topology with empty conduit and pullwire from each outlet to the headend equipment location.

3.1.7 Busway Installation

Comply at minimum with NFPA 70. Install busways parallel with or at right angles to ceilings, walls, and structural members. Support busways at 5 foot maximum intervals, and brace to prevent lateral movement. Provide fixed type hinges on risers; spring-type are unacceptable. Provide flanges where busway makes penetrations through walls and floors, and seal to maintain smoke and fire ratings. Provide waterproof curb where busway riser passes through floor. Seal gaps with fire-rated foam and caulk. Provide expansion joints, but only where bus duct crosses building expansion joints. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.8 Cable Tray Installation

Install and ground in accordance with NFPA 70. In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Cable tray and tray supports must not partially nor completely obstruct access to the room. Support in accordance with manufacturer recommendations but at not more than 6 foot intervals. Coat contact surfaces of aluminum connections with an antioxidant compound prior to assembly. Adjacent cable tray sections: bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum. Terminate cable trays 10 inches from both sides of smoke and fire partitions. Install conductors run through smoke and fire partitions in 4 inch rigid steel conduits with grounding bushings, extending 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Firestop penetrations in accordance with Section 07 84 00, FIRESTOPPING. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.9 Telecommunications Cable Support Installation

Install open top and closed ring cable supports on 4 ft to 5 ft centers to adequately support and distribute the cable’s weight. Use these types of supports to support a maximum of 50 0.25 in diameter cables. Install suspended cables with at least 3 in of clear vertical space above the ceiling tiles and support channels (T-bars). Open top and closed ring cable supports: suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight.

3.1.10 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways: cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 7 feet above floors and walkways, and when specifically indicated. Boxes in other locations: sheet steel, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit system. Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures: minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls: square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixtures for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.10.1 Boxes

Boxes for use with raceway systems: minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet. Telecommunications outlets: a minimum of 4 inches square by 2 1/8 inches deep. Mount outlet boxes flush in finished walls.

3.1.10.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.10.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

3.1.11 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of center of grip of the operating handle of the switch or circuit breaker at its highest position is maximum 79 inches above floor or working platform or as allowed in Section 404.8 per NFPA 70. Mount lighting switches 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Measure mounting heights of receptacle outlet boxes in the hazardous area to the bottom of the outlet box.

3.1.12 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.12.1 Marking Strips

Provide marking strips for identification of power distribution, control, data, and communications cables in accordance with the following:

a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.

b. Use permanent ink for the wire numbers

c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.

d. Size marking strips to accommodate the two sets of wire numbers.

e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.

f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.

g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.13 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.14 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.1.15 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.16 Grounding and Bonding

Provide in accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, access flooring support system, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and neutral conductor of wiring systems. Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70. In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA-607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.16.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. If this resistance cannot be obtained with a single rod, add additional rods. Spacing for additional rods must be a minimum of 6 feet, or if sectional type rods are used, additional sections may be coupled and driven with the first rod. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.16.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or high compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make high compression connections using a hydraulic or electric compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.16.3 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment: effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 4 inches above the floor. Make connections and splices of the brazed, welded, bolted, or pressure-connector type, except use pressure connectors or bolted connections for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, provide a minimum of four, one at each corner, ground buses connected to the building grounding system. Use bolted connections in lieu of thermoweld, so they can be changed as required by additions and alterations.

3.1.16.4 Resistance

Maximum resistance-to-ground of grounding system: do not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Contracting Officer for further instructions.

3.1.16.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

a. Telecommunications Grounding Busbars: Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility. Install the PBB as close to the electrical service entrance grounding connection as practicable. Provide a Secondary bonding busbar (SBB) in all other telecommunications rooms and telecommunications equipment rooms. Install the SBB as close to the telecommunications room panelboard as practicable, when equipped. Where a panelboard for telecommunications equipment is not installed in the telecommunications room, locate the SBB near the backbone cabling and associated terminations. In addition, locate the SBB to provide for the shortest and straightest routing of the grounding conductors. Where a panelboard for telecommunications equipment is located within the same room or space as a SBB, bond that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure to the SBB. Install Secondary bonding busbars to maintain clearances as required by NFPA 70 and insulated from its support. A minimum of 2 inches separation from the wall is recommended to allow access to the rear of the busbar and adjust the mounting height to accommodate overhead or underfloor cable routing.

b. Telecommunications Bonding Conductors: Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the PBB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum. Provide a telecommunications bonding backbone (TBB) that originates at the PBB extends throughout the building using the telecommunications backbone pathways, and connects to the SBBs in all telecommunications rooms and equipment rooms. Install the TBB conductors such that they are protected from physical and mechanical damage. The TBB conductors should be installed without splices and routed in the shortest possible straight-line path. Make the bonding conductor between a TBB and a SBB continuous. Where splices are necessary, the number of splices should be a minimum. Make the splices accessible and located in telecommunications spaces. Connect joined segments of a TBB using exothermic welding, irreversible compression-type connectors, or equivalent. Install all joints to be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, bond the TBBs together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. Do not connect the TBB and GE to the pathway ground, except at the PBB or the SBB.

c. Telecommunications Grounding Connections: Telecommunications grounding connections to the PBB or SBB: utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the PBB or SBB to the PBB or SBB respectively. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each PBB and SBB to the vertical steel metal frame using a minimum No. 6 AWG conductor. Where the metal frame is external to the room and readily accessible, bond the metal frame to the SBB or PBB with a minimum No. 6 AWG conductor. When practicable because of shorter distances and, where horizontal steel members are permanently electrically bonded to vertical column members, the SBB may be bonded to these horizontal members in lieu of the vertical column members. All connectors used for bonding to the metal frame of a building must be listed for the intended purpose.

3.1.17 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

3.1.18 Elevator

Provide circuit to line terminals of elevator controller, and disconnect switch on line side of controller, outlet for control power, outlet receptacle and work light at midheight of elevator shaft, and work light and outlet receptacle in elevator pit.

3.1.19 Government-Furnished Equipment

Contractor make connections to Government-furnished equipment to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

3.1.20 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing electrical distribution systems as follows:

3.1.20.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.20.2 Existing Concealed Wiring to be Removed

Disconnect existing concealed wiring to be removed from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

3.1.20.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment includes equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings, back to equipment's power source as indicated.

3.1.21 Watthour Meters

ANSI C12.1.

3.1.22 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet avoiding 90 degree bends. Do not locate surge protective devices inside a panelboard or switchboard enclosure.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting: as specified in Section 09 90 00 PAINTS AND COATINGS.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test. Where applicable, test electrical equipment in accordance with NETA ATS.

3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of 1,000 volts DC for 600 volt rated wiring and 500 volts DC for 300 volt rated wiring per NETA ATS to provide direct reading of resistance. All existing wiring to be reused must also be tested.

3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.5.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 943.

3.5.5 Arc-Fault Receptacle Test

Test arc-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 1699.

3.5.6 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.5.7 Watthour Meter

a. Visual and mechanical inspection

(1) Examine for broken parts, shipping damage, and tightness of connections.

(2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests

(1) Determine accuracy of meter.

(2) Calibrate watthour meters to one-half percent.

(3) Verify that correct multiplier has been placed on face of meter, where applicable.

3.5.8 Phase Rotation Test

Perform phase rotation test to ensure proper rotation of service power prior to operation of new or reinstalled equipment using a phase rotation meter. Follow the meter manual directions performing the test.

-- End of Section --

SECTION 26 22 00.00 10

480-VOLT STATION SERVICE SWITCHGEAR AND TRANSFORMERS
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1 (1981; R 1992) Requirements for Electrical Analog Indicating Instruments

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1 (2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASTM INTERNATIONAL (ASTM)

ASTM B187/B187M (2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

ASTM B188 (2015; E 2016) Standard Specification for Seamless Copper Bus Pipe and Tube

ASTM B236 (2007) Standard Specification for Aluminum Bars for Electrical Purposes (Bus Bars)

ASTM B317/B317M (2007; R 2015; E 2016) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, Structural Profiles, and Profiles for Electrical Purposes (Bus Conductor)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.13 (2015) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures

IEEE C37.16 (2009) Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC 3200 V and below) Power Circuit Breakers

IEEE C37.17 (2012) Standard for Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers

IEEE C37.20.1A	(2020) Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit-Breaker Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.90	(2005; R 2011) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.12.01	(2020) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.12.50	(1981; R 1998) Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Volt 601 to 34,500 Volts
IEEE C57.12.51	(2019) IEEE Guide for Mechanical Interchangeability of Ventilated Dry-Type Transformers
IEEE C57.12.91	(2011) Standard Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA C37.50	(2018) Switchgear--Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures
NEMA C37.51	(2018) Switchgear--Metal Enclosed Low-Voltage AC Power, Circuit-Breaker Switchgear Assemblies-Conformance Test Procedures
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA TR 1	(2013) Transformers, Regulators, and Reactors

NEMA WC 70	(2021) Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

1.2 SUMMARY

a. The location and general arrangement of the low-voltage metal-enclosed switchgear assembly, metal-enclosed bus structures and station service transformers are shown. Modifications of the equipment arrangement or the equipment device requirements shown shall be subject to approval. The switchgear assembly shall be completely assembled and wired at the factory. Assemble at the factory the metal-enclosed bus structures in sections of sufficient length for convenience of tests, shipment, and installation. After complete assembly, disassemble the switchgear group into sections, for convenience of handling, shipment, and installation.

b. Each shipping section of the switchgear shall be properly matchmarked to facilitate reassembly, and shall be provided with removable lifting channels with eye bolts for attachment of crane slings to facilitate lifting and handling. The equipment shall be shipped as completely assembled and wired as feasible so as to require a minimum of installation work. Switchgear groups and metal-enclosed buses which are disassembled into sections for shipment shall have the associated parts properly matchmarked to facilitate installation by the Government. Any relay (, indicating instrument) or other device which cannot withstand the hazards of shipment when mounted in place on the switchgear shall be carefully packed and shipped separately. These pieces shall be marked with the number of the panel on which they are to be mounted and fully identified so they can be readily mounted and connected.

c. All finished painted surfaces and metal work shall be wrapped suitably or otherwise protected from damage during shipment. All parts shall be prepared for shipment so that slings for handling may be attached readily while the parts are in a railway car or transport truck.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G
Installation; G
Terminal Blocks; G

SD-03 Product Data

Switchgear
Power Circuit Breakers
Transformers
Spare Parts
Metal-Enclosed Bus

SD-04 Samples

Nameplates; G

SD-06 Test Reports

Factory Inspection and Tests

1.4 EXTRA MATERIALS

Submit a list of spare parts as specified herin. Spare parts shall be duplicates of the original parts furnished, and shall be interchangeable therewith. Furnish the following spare parts for each type and frame size of drawout circuit breaker, except that only one spare is required where parts are applicable to all types and frame sizes of the circuit breakers:

a. One complete set of main, intermediate and arcing contacts and associated springs for one three pole breaker.

b. One complete set of arc chute assemblies for one three pole breaker.

c. One set of primary disconnecting devices for one three pole breaker.

d. One set of secondary disconnecting devices for one three pole breaker.

e. One shunt trip coil.

f. One Spring-charging motor or solenoid for electrically-operated breakers.

g. One Control relay of each type and rating for electrically-operated breakers.

h. One Auxiliary switch complete for electrically-operated breakers.

i. One manual operating mechanism handle for drawout feeder air circuit breakers.

j. Twelve fuses of each type and size for voltage transformers.

k. Six Indicating lamp assemblies (three red lens and three green lens.)

l. Ten Indicating lamp color caps of each color.

m. One spring for stored-energy closing mechanism.

n. Four spare blank nameplates for operating unit doors.

o. One lot spare bulbs for indicating lamp assemblies, package to contain not less than 20.

PART 2 PRODUCTS

2.1 NAMEPLATES

Submit samples of engraved nameplates with a schedule of nameplate sizes and lettering. The Contractor will be permitted to supply and attach to the switchgear assembly a nameplate or trademark. Include a drawing or illustration showing the proposed nameplate, its size and location. Provide each item of equipment mounted on the switchgear, which does not have a suitable designation included as an integral part of the device, with an engraved nameplate or with other approved suitable means of identification. Nameplates shall be made of laminated sheet plastic or of anodized aluminum approximately 1/8 inch thick, engraved to provide white letters on a black background. Provide equipment of the withdrawal type with nameplates mounted on the removable equipment in locations visible when the equipment is in place. The nameplates shall be fastened to the panels in proper positions with black finished roundhead screws. Each control switch shall be provided with an escutcheon clearly marked to show each operating position. The switch identifications shall be engraved on the escutcheon plates or on separate nameplates. The escutcheon and nameplate markings shall be subject to approval.

2.2 COPPER AND ALUMINUM BARS AND RODS

Copper or aluminum bars and shapes for main bus and ground bus conductors may be provided at the option of the Contractor and shall conform to the requirements of ASTM B187/B187M, ASTM B188, ASTM B236, and ASTM B317/B317M.

2.3 CONDUIT AND ELECTRICAL METALLIC TUBING

Rigid conduit shall conform to ANSI C80.1 and shall, be zinc-coated (galvanized) both inside and outside by the hot-dip method. Electrical metallic tubing shall conform to ANSI C80.3. Fittings for rigid metal conduit and electrical metallic tubing shall conform to NEMA FB 1.

2.4 CONNECTIONS

All bolts, studs, machine screws, nuts, and tapped holes shall be in accordance with ASME B1.1. Threads for sizes 1/4 to 1 inch, inclusive, shall be NC or UNC series. The sizes and threads of all valves, pipe and fittings, conduit and fittings, tubing and fittings, and connecting equipment shall be in accordance with ASME B1.20.1. Manufacturer's standard thread and construction may be used on small items which, in the opinion of the Contracting Officer, are integrally replaceable, except that threads for external connections to these items shall meet the above requirements.

2.5 480-VOLT STATION SERVICE SWITCHGEAR

2.5.1 General

Except as otherwise specified or indicated, the design, construction and tests of the switchgear shall conform to the applicable requirements of

IEEE C37.13, and IEEE C37.20.1A. The switchgear assembly shall contain two main bus sections connected by a bus tie circuit breaker. Each main bus section will be connected to a supply transformer through a main supply circuit breaker. The two main supply circuit breakers and the bus tie circuit breaker shall be electrically operated and will normally be remotely controlled. Automatic bus transfer shall be provided as specified in paragraph Automatic Bus Transfer. The switchgear shall have instruments, control accessories, and other equipment mounted on the front panels and inside the switchgear as shown and as specified. The annunciator window group will be furnished by the Government for mounting and wiring by the Contractor.

2.5.2 Enclosure and Framework

2.5.2.1 Switchgear

The switchgear shall be of the totally-enclosed, free-standing, dead-front type built on a suitable framework of structural steel, or by an equivalent approved method, which shall provide a self-supporting and stable structure. Metal-enclosed switchgear construction consisting of ribbed side sheets and fabricated framework which is functionally equivalent to the structural steel framework specified will be acceptable. The framework and structure shall be sufficiently rigid to withstand operation of the equipment or any stresses due to short circuits. Each shipping assembly shall also be sufficiently rigid, with the addition of temporary members if required, to withstand handling during shipment and installation.

2.5.2.2 Enclosure

The enclosure shall be made of selected smooth sheet steel panels, suitably supported. Doors and panels used to support instruments and other devices and barriers between compartments shall not be less than No. 11 MSG. Exposed panels on the front and ends of the enclosure shall be bent angle or channel edges with all corner seams welded and ground smooth, or shall be the manufacturer's equivalent construction as approved. The front outside surfaces shall not be drilled or welded for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front.

2.5.2.3 Drawout Circuit Breaker

Each drawout type circuit breaker shall be completely enclosed in a metal compartment. Access to the circuit breakers shall be provided through hinged steel doors. Access to instrument and relay wiring, instrument transformers and fuses, shall also be through hinged doors. All hinged doors shall have bent angle or channel edges, invisible hinges and suitable latches or fastenings. Access to bus compartments shall be through removable bolted panels, cover plates or hinged doors.

2.5.2.4 Ventilating Opening

Ventilating openings shall be provided as required and shall preferably be of the grille type. All ventilating openings shall be provided with corrosion-resistant insect-proof screens on the inside.

2.5.2.5 Foundations

Continuous channel iron foundations, complete with bolts and drilled holes for grouting and anchoring to the floor, shall be furnished by the

Contractor for the complete length (front and rear) of each switchgear assembly. Channel construction and drilling shall be as required for mounting the equipment. The channels shall be designed for flat mounting and maximum channel depth shall be 2-1/2 inches. The foundation channels shall be placed on top of the floor, fastened in place, and then filled with grout. Additional channel or substantial metal trim shall be provided flush with the end panels to completely enclose the bases across the ends of the equipment assemblies where exposed to view.

2.5.3 Buses and Connections

a. The buses in each main bus section shall have a continuous current-carrying capacity without exceeding the temperature limits specified in IEEE C37.20.1A. The buses shall have mechanical and thermal capacities coordinated with the interrupting rating of the power supply circuit breakers. Bus bars shall be of hard-drawn copper, aluminum, or aluminum-alloy. Shop splices and tap connections shall be brazed, pressure-welded or bolted. All splices for field assembly shall be bolted. Where bolted connections are used, contact surfaces shall be silver-plated except that contact surfaces for aluminum-alloy may be tin-plated and shall be equipped with provisions for adequate clamping. The buses shall be mounted on insulating supports of wet process porcelain, glass polyester, or suitable molded material. All primary connections including the power connections to the line side of the circuit breakers shall be by bus bar.

b. The standard phasing within equipment housing for AC power circuits shall be A-B-C from left to right when facing the front of the equipment, A-B-C from top to bottom, and A-B-C from front to back. Nonstandard phasing in any compartment will be permitted only upon approval and providing each phase is identified and a warning sign, "Nonstandard Phasing," is incorporated within such a compartment.

c. Blank compartments without buses and small spare compartments with buses and complete provisions for installing future feeder circuit breakers shall be provided where shown.

2.5.4 Power Circuit Breakers

2.5.4.1 General

The power supply, bus tie, and feeder air circuit breakers shall be 3-pole, dead-front, drawout type rated 600 volts AC, conforming to the requirements of IEEE C37.13; IEEE C37.16; and IEEE C37.17. All circuit breakers of the same frame size and type of operation (electrical or manual) shall be interchangeable. Suitable means shall be provided for removing and handling the drawout circuit breakers. These means may include support from the top of the switchgear enclosure without interference with incoming or outgoing wiring. The Government reserves the right to change the indicated current ratings, within frame limits, of the tripping devices at the time the shop drawings are submitted for approval. Overcurrent trip alarm contacts, with means for manual reset, shall be furnished as indicated. Covers shall be provided over readily accessible energized portions to prevent hazards to personnel when withdrawing or inserting the breakers.

2.5.4.2 Power Supply and Bus Tie Circuit Breakers

The 2 power supply circuit breakers and the bus tie circuit breaker shall be electrically-operated drawout type with the closing mechanism designed for operation on 125 volts DC. The circuit breakers shall be rated as indicated. Each circuit breaker shall be provided with functional components in accordance with Table 1 of IEEE C37.13, including means for manual emergency tripping and manual closing for maintenance operation. Each power supply breaker and the bus tie circuit breaker shall be provided with a solid-state direct-acting over-current tripping device consisting of long-time-delay and short-time-delay elements. The bus tie circuit breaker shall be furnished without an overcurrent trip device but shall be provided with a 125-volt DC shunt trip device. Long-time and short-time-delay operation bands shall be selected to provide maximum selectivity between the primary supply protective relays, power supply breakers, bus tie breaker, feeder breakers and motor control center molded case breakers for a fault on a feeder circuit. Information on primary relays and molded case breakers will be supplied to the Contractor. The 2 power supply circuit breakers and the bus tie circuit breaker shall be electrically interlocked so that only 2 of the 3 breakers can be in the closed position at the same time. A local test control switch shall be provided for each electrically-operated circuit breaker which shall be electrically interlocked through cell switches or secondary disconnects to prevent breaker operation except when the breaker is in the test position. Sufficient breaker auxiliary switch contacts and cell switches shall be provided to accomplish the required breaker control and interlocking system as shown. At least 4 auxiliary switch contacts shall be provided on each breaker. At least 2 spare auxiliary switch contacts, one normally-open and one normally-closed, shall also be provided on each electrically-operated breaker.

2.5.4.3 Feeder Air Circuit Breakers

Feeder breakers shall be independent manually-operated type with manually-charged stored energy closing mechanism and with frame sizes as indicated, and shall be rated 600 volts AC. Circuit breakers with 600-ampere frames shall have a short-circuit interrupting capacity of not less than 22,000 rms symmetrical amperes at 600 volts AC. Each feeder breaker, except as specified otherwise, shall be provided with a solid-state direct-acting overcurrent tripping device consisting of a long-time-delay element and a short-time-delay element. The long-time-delay trip elements for direct-acting overcurrent tripping devices shall be adjustable over an approximate range of 80 to 110 percent of the trip ampere rating. The short-time-delay trip elements, for the direct-acting overcurrent tripping devices shall be adjustable over a range of approximately 4 to 10 times the ampere rating. Manually-operated drawout type circuit breakers shall be fitted with suitable operating handles, preferably of the pistol grip type, or vertical lever type, designed to close the breaker with a rotary motion of less than 180 degrees. All breakers shall be designed for tripping by a rotary motion in the opposite direction or by pressing a readily accessible trip button. The operating handles shall be easily removable when it is necessary to open the compartment door and easily replaceable for operating the breaker in the withdrawn or test position. Duplicate feeder breakers shall be key interlocked. Each breaker shall be equipped with a conspicuous mechanical target visible with the breaker in the normal operating position to indicate whether the breaker is open or closed and shall be provided with a manually-reset bell alarm contact to energize the annunciator circuit only when the breaker is automatically tripped on a fault or overload. The circuit breaker for the powerhouse crane feeder shall be manually-operated type equipped with a 125-volt DC shunt trip attachment for emergency operation from remote stations.

2.5.4.4 Automatic Bus Transfer

The stations shall be provided with automatic bus transfer. The automatic transfer arrangement shall be as shown by the schematic diagrams and shall incorporate the following (normal operation will be with both supply breakers closed and the bus tie breaker open):

a. Loss of voltage on one bus shall cause the associated supply breaker to trip and the bus tie breaker to close.

b. Automatic transfer control will cease to function if either of the supply breakers or the bus tie breaker trip on overcurrent.

c. Recovery of voltage from 1 of the 2 normal sources shall (after a time delay) open the bus tie breaker and close the associated supply breaker.

d. Recovery of voltage from both normal sources shall (after a time delay) open the bus tie breaker and close the supply breakers.

e. After pickup by the voltage relays, the bus transfer operation shall be accomplished within approximately 1 second.

2.5.5 Wiring

2.5.5.1 Control Panel and Power Wiring

Control panel wiring shall be stranded copper switchboard wire with 600-volt insulation. The wire shall be Type SIS as listed in NFPA 70 and shall meet the requirements of NEMA WC 70. Hinge wire shall have class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of wire for all other control wiring shall be No. 14 AWG. Power wiring for 480-volt circuits and below shall be of the same type as control panel wiring and the minimum size shall be No. 12 AWG.

2.5.5.2 Terminals and Installation

a. Control wiring within the assembly housings shall be furnished and installed by the Contractor as specified. All control wiring leaving equipment shall be run to and terminated on terminal blocks. Terminal blocks and internal wiring shall be provided for connection of remote circuits to all spare auxiliary and alarm contacts, remote annunciators, remote control switches, and pilot devices and remote indicating lights where such devices are specified and applicable to the equipment involved. Each individual potential transformer lead shall be brought out to a terminal block. Potential transformers for ground detecting circuits shall be grounded at the equipment. Potential transformers for metering circuits will be remotely grounded by the Government. There shall be no splices in the wiring and all connections shall be made at terminal studs or blocks. Terminal blocks shall be added for wiring to devices having leads instead of terminals. Indented terminals, Burndy Type YAV10 or an approved equal, shall be used on all wires terminated on screw or stud terminals. All screw terminals shall have toothed lock washers and all stud terminals shall have contact nuts and either locking nuts or lock washers.

b. Matching openings shall be provided in the switchgear to permit the entrance of the bus into the switchgear through the concrete openings. Clam-style terminals of sizes indicated shall be provided for all main power cable leaving the switchgear. The terminals shall be of the heavy-duty, full clamp type, Burndy "Qiklug", or approved equal. Adequate provisions shall be included for supporting the Government's cables between the conductor terminating points and where they enter or leave the switchgear.

2.5.5.3 Terminal Blocks

Submit prints of wiring and terminal drawings in accordance with Contract Clause CONTRACTOR'S DRAWINGS AND DATA, which will be marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

a. Terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts. The terminals shall be removable binding, fillister or washer head screw type, or stud type with contact and locking nuts. The terminals shall be not less than No. 10 in size and shall have sufficient length and space for connecting at least 2 indented terminal connectors for No. 19/22 AWG conductors to each terminal. The terminal arrangement shall be subject to approval. Not less than 10 percent, but in no case less than 2, spare terminals shall be provided on each block or group of blocks.

b. Short-circuiting type terminal blocks shall be furnished for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. These terminal blocks shall be made by the same manufacturer as the terminal blocks for control wiring listed above.

c. White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for control wire designations. The manufacturer's wire number and the Government's wire number shall both be shown for each connected terminal on the marking strips with permanent marking fluid. The marking strips shall be reversible to permit marking both sides, or two marking strips shall be furnished with each block, to accommodate the two sets of wire numbers.

d. Load terminal blocks rated not less than 600 volts and of adequate capacity shall be provided for the conductors of power circuits except those supplied from air circuit breakers. The terminals shall be of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminal connectors of the size required on the conductors to be terminated. For conductors rated more than 50 amperes all screws shall have hexagonal heads. For conductors rated 50 to 99 amperes the minimum screw size shall be 5/16 inch. Conducting parts between connected terminals shall have adequate contact surface and cross section to operate without overheating. Each connected terminal shall have the circuit designation or wire number marked on or near the terminal in permanent contrasting color.

e. Give special attention to wiring the terminal arrangement on the terminal blocks to permit the individual conductors of each external Government-furnished cable to be terminated on adjacent terminal points. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, additional wire and cable designations for identification of remote (external) circuits may be required.

2.5.6 Grounding

The switchgear assembly shall include a full-length interior ground bus of copper or aluminum bar to which the housing, framework, cable supports, bus supports, and non-current carrying metallic parts of all equipment and conduits shall be grounded insofar as practicable. No soldered connections shall be used in the ground leads. If the operating mechanism of drawout units is not permanently grounded, ground contacts shall be provided to automatically connect the movable element to the ground buses. These connections shall make before the main disconnecting devices upon insertion, and break after the main disconnecting devices upon withdrawal. Grounding shall conform toIEEE C37.20.1A except that the ground bus shall have a continuous current-carrying capacity not less than 25 percent of the continuous rating of the power supply circuit breakers.

2.5.7 Molded Case Circuit Breakers

2.5.7.1 General

Molded case circuit breakers shall conform to the applicable requirements of UL 489 and NEMA AB 3, shall be fully rated, and shall have voltage ratings and interrupting ratings stated. For circuit breakers of the same ampere frame size, 3 pole and 2 pole circuit breakers shall be the same width as 3 single pole and 2 single pole circuit breakers respectively. The circuit breakers shall be manually-operated and shall have trip-free operating mechanisms of the quick-make, quick-break type. All poles of each breaker shall be operated simultaneously by means of a common handle, and shall be enclosed in a common molded plastic case. The contacts of multi-pole breakers shall open simultaneously when the breaker is tripped manually or automatically. The operating handles shall clearly indicate whether the breakers are in "On", "Off", or "Tripped" position. The circuit breakers shall be of the individually-mounted, stationary type, shall all be products of the same manufacturer, and shall be interchangeable when of the same frame size. Each circuit breaker shall be provided with mechanical pressure type terminal lugs for single-conductor stranded copper cables of the size required by the specifications or shown.

2.5.7.2 Trip Units

The circuit breakers shall be of the automatic type provided with combination thermal and instantaneous magnetic trip units. Instantaneous magnetic trip units shall be set at approximately 10 times the continuous current ratings of the circuit breakers.

2.5.7.3 480-Volt AC Circuits

Circuit breakers for 480-volt AC circuits shall be rated 600 volts AC, and shall have a minimum NEMA interrupting capacity of 14,000 symmetrical amperes at 600 volts AC.

2.5.7.4 120-Volt and 208-Volt AC Circuits

Circuit breakers for 120-volt and 208-volt AC circuits shall be rated not less than 250 volts DC, and either 120/240 or 240 volts AC, and shall have a minimum NEMA interrupting capacity of 10,000 symmetrical amperes.

2.5.7.5 125 Volt DC Circuits

Circuit breakers for 125 volt DC circuits shall be 2-pole rated 125/250 or 250 volts DC, and shall have a minimum NEMA interrupting capacity of 10,000 amperes DC.

2.5.8 Instrument Transformers

2.5.8.1 Voltage Transformers

Five 480-120 volt, 200 volt-ampere capacity, voltage transformers shall be provided for each main 480-volt bus section. Two of the transformers shall be used for metering and 3 of the transformers shall be used with the ground detection equipment. Voltage transformers shall conform to IEEE C57.13 and shall have an ANSI accuracy classification of 0.3W, 0.3X, and 1.2Y or better. The full-wave impulse level shall be not less than 10 kV. Each voltage transformer shall be protected with removable primary and secondary fuses. Fuses shall be installed in each ungrounded lead and located adjacent to the transformers in an easily accessible place.

2.5.8.2 Current Transformers

Dry type current transformers as shown shall be furnished, installed and wired to the specified terminal blocks. These current transformers shall conform to IEEE C57.13, and shall have the ratios indicated. The current transformers shall be rated not less than 600 volts AC, 10 kV BIL, and the ANSI accuracy classification shall be in accordance with IEEE C37.20.1A, or better. If cable connections to the transformer primary are required, terminals of an approved solderless type and proper size shall be furnished. If transformers are connected to buses, proper connections shall be furnished, complete with bolts, nuts, washers and other accessories.

2.5.9 Ground Detection Equipment

Ground detection equipment shall be furnished for each bus section of the switchgear, to be used for indication and annunciation of grounds of the 480-volt system. The equipment shall consist of 3 instrument voltage transformers complete with primary and secondary fuses, connected wye-delta, with neutral of primary wye grounded and with the coil of a voltage ground detector relay connected in the broken delta corner of the secondary windings of the 3 voltage transformers in accordance with IEEE C37.20.1A. Two ground detector relays shall be provided, one for each bus section of the switchgear.

2.5.10 Relays

2.5.10.1 General

a. Relays shall conform to the applicable requirements of IEEE C37.90. The relays shall be back-connected, semi-flush-mounted, switchboard type with black, rectangular, dust-tight cases, removable covers with windows, and means of sealing against tampering. Relays, except auxiliary relays, shall be drawout type with built-in test facilities arranged so that the relays can be tested in position or withdrawn from the fronts of the cases without opening current transformer secondary circuits, disturbing external circuits, or requiring disconnection of leads from the relay terminals. The test devices shall permit testing with energy from either the instrument transformers or an external power supply.

b. Submit descriptive data, including manufacturer types and catalog numbers for equipment. Curve sheets for power supply and bus tie circuit breakers combining characteristics of the trip elements to show the proposed selectivity. In addition, characteristic curves of the individual breaker trip elements shall be included to permit checking and for power supply and bus tie circuit breakers. The breaker trip ampere ratings and lug sizes shall be as indicated.

c. Protective relays shall be provided with all required auxiliaries, including auxiliary instrument transformers and reactors, to adjust currents, potentials and phase angles for proper operation. External relay auxiliaries shall be mounted in compact assemblies back of the panels and adjacent to the relays. AC relays shall be suitable for use on 60-Hz circuits and for operation with the instrument transformer ratings and connections shown. Relay current coils shall be able to withstand 35 times normal current for 1/2 second, and relay voltage coils shall be able to withstand 110 percent rated voltage continuously without damage. Time delay features shall not depend upon oil dashpots or other devices which are appreciably affected by temperature. Each relay shall be provided with 1 or more operation indicators and/or indicating Contractor switches with targets and external target reset devices, and the circuits shall be arranged for positive target operation. Seal-in Contractor and suitable loading resistors shall be provided where required. Separate relay operating function, such as instantaneous trip attachments and different zones for distance relays, shall have separate targets and contacts.

d. Relay contacts shall be silver-to-silver, electrically independent, chatterproof and non-bouncing, and suitable for use on 125-volt ungrounded DC circuits unless otherwise specified or shown. Where more than one electrically-independent relay contact is required, as indicated , and it is not feasible to provide more than 1 such contact, or if 2 contacts are available but are not electrically independent, auxiliary relays shall be furnished to provide the required additional contacts.

2.5.10.2 AC Voltage Relays

Voltage relays other than ground detector relays shall be induction-disc inverse-time type with adjustable time and voltage settings and with semiflush mounting. Ground detector relays shall be induction-disc inverse-time overvoltage type rated 199 volts AC with low pickup, semiflush mounting in drawout case with circuit closing contacts suitable for 125-volt DC ungrounded circuits. They shall be from the same manufacturer as the AC voltage relays.

2.5.10.3 Auxiliary relays

Auxiliary relays for bus transfer control shall be semiflush back-connected type for front-of-panel mounting. The semiflush cases shall be black and shall match in appearance other relay cases on the switchgear. Auxiliary relays for interior mounting shall be provided with covers. Relay coils and contacts shall be suitable for continuous operation at 125 volts DC, shall be furnished with resistors where required, and shall be of a type to require a minimum continuous current. The auxiliary relays shall be high-speed, multi-contact, self-reset type, from the same manufacturer as the AC voltage relays.

2.5.11 Control and Instrument Switches

2.5.11.1 General

All control switches shall be of the rotary switchboard type with handles on the front and the operating contact mechanisms on the rear of the panels. Each switch shall be provided with ample contact stages to perform the functions of the control system. Contacts shall be self-aligning and shall operate with a wiping action. A positive means of maintaining high pressure on closed contacts shall be provided. Compression springs or pivotal joints shall not carry current. The covers or plates on the switches shall be readily removable for inspection of contacts. All control switches shall be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches shall be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. The switches shall be capable of continuously carrying 20 amperes without exceeding a temperature rise of 30 degrees C. The single-break inductive load interrupting rating of switches shall be not less than 1.5 amperes for 125 volts DC or 10 amperes for 115 volts AC.

2.5.11.2 Switch Features

a. Control and instrument switches shall be suitable for the intended use and shall have the features shown on the schematic diagrams and switch development drawings. The switches shall have modern handles or keys of pistol grip, oval, round notched or knurled type, and shall be black color unless otherwise specified.

b. Control switches for electrically-operated circuit breakers shall be 3 position momentary-contact type with spring return to neutral position, and shall have modern-black, heavy duty pistol grip handles. Circuit breaker control switches shall have mechanical operation indicators to show the last manual operation of the switches, and shall have slip contacts when so indicated or required.

c. Instrument and meter transfer switches and selector switches shall be the maintained-contact type with the required number of positions, and shall have round notched or knurled handles. Ammeter switches shall not open the secondary circuits of current transformers at any time. Instrument switches for potential selection shall have oval handles.

2.5.12 Indicating Lamp Assemblies

Indicating lamp assemblies shall be of the switchboard type, insulated for 125-volt DC service, with appropriately colored caps and integrally mounted resistors for nominal 125-volt DC service (140 volts maximum). Lamps shall be long-life low-wattage type replaceable from the front of the panels and any special tools required for lamp replacement shall be furnished. Color caps shall be made of transparent or translucent material which will not be softened by the heat from the lamps. Insofar as practicable, all color caps shall be similar and interchangeable, and all lamps shall be of the same type and rating.

2.5.13 Indicating Instruments

2.5.13.1 General

Electrical indicating instruments shall conform to the applicable requirements of ANSI C39.1 and the accuracy rating shall be within 1 percent of full-scale value. The instruments shall be back-connected semiflush mounting. Instruments shall have white dials, circular scales, black scale markings, and black tapered antiparallax pointers. Instrument cases shall be dust tight with shadowproof covers and anti-glare windows. Taut-band suspension shall be provided where this design is available. Zero adjustments accessible from the front without removal of covers shall be provided for instruments with spring control. AC instruments shall be designed and calibrated for use on 60-Hz circuits and for operation from 120-volt secondaries of voltage transformers and 5-ampere secondaries of current transformers, as shown. AC instrument potential coils shall be designed for continuous operation at 150-volts, and AC instrument current coils shall be capable of withstanding 40 times rated current for two seconds. Instrument identification legends shall be neatly printed on the dials or on separate legend plates inside the cases. Instrument scales shall be as specified, or as approved if scales are not specified, and appropriate for the application.

2.5.13.2 Rectangular Switchboard Instruments

Instruments shall be 4-1/4 inch minimum rectangular type with nominal 250-degree scale angle and zero-left scales

2.5.13.3 AC Voltmeters

AC voltmeters shall be provided with expanded type scales.

2.6 METAL-ENCLOSED BUS

Submit the proposed methods for grounding bus housing.

2.6.1 General

The electrical connections between the 480-volt terminals of the station service transformers and the power supply air circuit breakers in the main 480-volt station service switchgear shall consist of 3-phase, nonventilated, nonsegregated-phase, metal-enclosed bus conforming to the applicable requirements of IEEE C37.20.1A. The bus shall be rated as indicated. The metal-enclosed bus shall be fabricated in sections to suit the arrangement shown. Necessary frames and flange sections required at the bus terminals at the transformers and switchgear, and all required structural supports for the bus structures shall be provided. Expansion sections shall be provided wherever the bus crosses a contraction joint in the building. All electrical and mechanical connections at the station service transformers shall be coordinated with the station service transformer manufacturer. Flexible connections shall be provided at the switchgear and transformer connections. Connections at the switchgear shall be coordinated with the design of the 480-volt station service switchgear.

2.6.2 Conductors

The bus phase conductors shall be of bare copper, aluminum or aluminum-alloy, and when assembled shall withstand the specified dielectric tests. Field joints in the conductors shall be silver-plated except that contact surfaces of aluminum-alloy conductors may be tin plated. The joints shall be provided with sufficient bolts to provide adequate low-resistance contacts.

2.6.3 Enclosure

The three phase conductors with insulating supports and spacers shall be mounted inside a common nonventilated dust tight enclosure made of sheet metal not less than No. 14 MSG. Covers for enclosure openings shall be not less than No. 14 MSG. The design of the enclosure shall permit the installation and alignment of all bus sections and the completion of field joints in the conductors before the enclosure is completely closed.

2.6.4 Grounding

All sections of the housing shall be connected to the powerhouse ground system. Bus housing sections shall be bonded together or connected to a common ground bus to facilitate connection to the powerhouse ground system. The proposed method of metal-enclosed bus grounding shall be subject to approval.

2.7 SECONDARY UNIT SUBSTATION

2.7.1 General

The secondary unit substation shall be indoor metal-enclosed secondary selective (double-ended) type rated as indicated. Except as otherwise specified or indicated, the unit substation shall conform to the applicable requirements of NEMA TR 1.

2.7.2 Incoming Sections

Incoming sections for terminating the high-voltage power cables shall be as specified for Station Service Transformers.

2.7.3 Transforming Sections

The transforming section shall be metal enclosed containing ventilated dry type (Class AA) transformers as specified for Station Service Transformers.

2.7.4 Transformer Bus Connections

The transformer low-voltage terminals shall be connected to the power supply breakers in the adjacent 480-volt, outgoing switchgear section by means of copper or aluminum bus with thermal and mechanical capacities coordinated with the ratings of the 480-volt power supply circuit breakers. The transformer high-voltage and low-voltage bus connections shall be arranged so that the front of the transformer enclosures will line up with the front of adjoining incoming sections and the 480-volt outgoing switchgear section. Suitable bus transition compartments shall be provided if required.

2.7.5 Outgoing Section

The outgoing section shall be an indoor metal-enclosed 480-volt power circuit breaker switchgear assembly, with drawout type circuit breakers, as specified for 480-volt Station Service Switchgear.

2.8 STATION SERVICE TRANSFORMER

2.8.1 Type and Rating

The station service transformers shall be indoor ventilated dry-type, self-cooled, NEMA Class AA, with 300 or 428 degrees F limiting temperature insulation and shall conform to the applicable requirements of IEEE C57.12.01, IEEE C57.12.50 IEEE C57.12.51, IEEE C57.12.91, and NEMA TR 1. The transformers shall be rated as indicated. The transformer impedance shall be subject to ANSI standard tolerance. The transformer shall be designed to carry rated load continuously without exceeding 176 degrees F (Class 302 degrees F) or 302 degrees F (Class 428 degrees F) temperature rise above 104 degrees F ambient temperature when installed in its ventilated sheet metal enclosure and cooled by natural air circulation.

2.8.2 Core and Coils

The core, coils and metal enclosure of the transformer shall be rigidly attached to a structural steel base suitable for moving the complete transformer by the use of rollers. Jacking facilities and removable lifting eyes shall be provided on the core and coil assembly. The core laminations shall be free from burrs which may puncture the insulation between laminations and shall be securely fastened to prevent excessive vibration in normal service or displacement under short-circuit conditions. Four 2-1/2 percent full-capacity taps, 2 above rated voltage and 2 below rated voltage, shall be provided in the high-voltage windings, and suitable means shall be provided for changing the taps while the transformer is de-energized. The terminal board shall be accessible through a door or removable panel in the enclosure. All transformer leads and taps shall be securely braced to prevent displacement or injury during transit or installation and under short-circuit condition. Wiring for transformer accessories shall be adequately supported to prevent breaking of the conductors due to vibration of the transformer and shall be connected to accessible terminal blocks.

2.8.3 Enclosure

The transformer shall be provided with a ventilated sheet steel enclosure as specified for 480-volt Station Service Switchgear, except that a formed enclosure of not less than No.13 MSG may be used. Doors or removable panels shall be provided in the enclosure to permit access to the transformer, and suitable removable lifting eyes or other approved means shall be provided to permit lifting the enclosure alone and also the complete transformer by the use of a crane. The enclosure shall be adequately braced and stiffened on the inside, and shall be coated with sound-deadening material if necessary, so that the audible sound level of the enclosed transformer when operating at rated load will not exceed the value permitted in Table 0-3 of NEMA TR 1.

2.8.4 Incoming Sections

Metal-enclosed compartments shall be provided for terminating the incoming high-voltage power cables with stress cones as indicated. Access to the interior of the compartment shall be through removable bolted panels or bolted hinged doors. Connections between the terminals of the incoming cables and the high-voltage winding terminals of the adjacent transformers shall be by means of copper bus. Heavy-duty clamp type terminal lugs shall be provided for connecting the high-voltage cables to the transformer high-voltage bus.

2.9 ACCESSORIES

Furnish handling and testing accessories needed to remove, replace, test and maintain the drawout type air circuit breakers. The accessories shall include the following:

a. One Closing Lever for manually closing the electrically-operated circuit breakers.

b. One set of couplers (if required) for test operation of the electrically-operated breakers.

c. One set of test plugs for drawout relays.

d. Two sets of keys for key interlocks.

e. One Hoist, cart or other suitable means for breaker removal and handling.

f. One complete set of all special wrenches and tools required for the installation, maintenance and repair of the switchgear.

g. Four one-quart containers of paint for outside finish.

h. One portable test set by the same manufacturer as the static trip devices to check the operation of the static trip devices without the need for high primary circuit current.

i. One indicating lamp replacement tool (if required).

2.10 FACTORY INSPECTION AND TESTS

Submit five certified copies of the reports of all tests, including complete test data, and five sets of calibration curves for each trip.

2.10.1 General

Each item of equipment supplied under this contract shall be given the manufacturer's routine factory tests and also other tests, as specified below, to insure successful operation of all parts of the assemblies. All tests required shall be witnessed by the Contracting Officer, unless waived in writing, and no equipment shall be shipped until it has been approved for shipment. Notify the Contracting Officer sufficiently in advance of the test date, so that the Contracting Officer can make arrangements to be present. The factory test equipment and test methods used shall conform to the applicable requirements of ANSI, IEEE and NEMA standards, and shall be subject to approval. The witnessing representatives of the Contractor and the Contracting Officer shall sign all test reports.

2.10.2 Switchgear Assembly Tests

Each low-voltage air circuit breaker switchgear assembly shall be subjected to the "Production Tests" described in IEEE C37.20.1A, except as modified or supplemented below:

2.10.2.1 Assembled Equipment

The assembled equipment shall be checked for mechanical adjustment, alignment of panels and devices mounted thereon, adequacy of fastenings and general good workmanship.

2.10.2.2 Wiring

Control, instrument and relay wiring shall be given a point-to-point check, and the correctness of the control wiring shall be verified by actual operation of the compartment devices.

2.10.2.3 Switchgear Assembly

Each switchgear assembly, with all circuit breakers in operating position and contacts closed, shall be subjected to a 1-minute power frequency withstand dielectric test of 2,200 volts AC. Control, instrument and relay wiring shall be subjected to a 1-minute, power frequency withstand dielectric test of 1,500 volts AC to ground.

2.10.2.4 Circuit Breaker

Each low-voltage power circuit breaker shall be given the production tests described in NEMA C37.50NEMA C37.51. Each circuit breaker shall be thoroughly checked for proper operation and all necessary adjustments shall be made. Shunt trip coils shall be checked for proper operation.

2.10.3 Instrument Transformer Test

The voltage and current transformers shall be subjected to routine tests in accordance with paragraph 4.7.2 of IEEE C57.13.

Five copies of typical ratio and phase angle tests shall be furnished for each type and rating of instrument transformer.

2.10.4 Metal-enclosed Bus Test

Each shop-assembled section of metal-enclosed bus shall be subjected to a low-frequency dielectric withstand test of 2,200 volts for 1 minute between each conductor and the other conductors, and between all conductors connected together and the grounded metal housing in accordance with IEEE C37.20.1A.

2.10.5 Station Service Transformer Test

The station service transformers shall be subjected to the routine tests listed in paragraph 8.3 of IEEE C57.12.01, except that the temperature tests, if made, shall be made with the transformers in their enclosures in order to simulate actual operating conditions.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

3.2.1 NFPA 70 and IEEE C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1.1 Grounding Electrodes

3.2.1.2 Provide driven ground rods as specified in 33 70 02.00 10 Electrical Distribution System, Underground. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Station Grounding

3.2.2.1 Provide bare copper cable not smaller than No. 4/0 AWG not less than (24 inches) below grade interconnecting the indicated ground rods. Surge arrester and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends. Substation transformer neutral connections shall not be smaller than No. 1/0 AWG. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and cornerpost and at intervals not exceeding (10 feet). Bond each gate section to the fence post through a (1/8 by one inch) flexible braided copper strap and clamps.

3.2.3 Connections

3.2.3.1 Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in 33 70 02.00 10 Electrical Distribution System, Underground, paragraph entitled "Grounding".

3.2.4 Grounding and Bonding Equipment

3.2.4.1 UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

3.3.1 Install and connect unit substations furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.2 Meters and Instrument Transformers

3.3.2.1 NEMA C12.1

3.3.3 Field Applied Painting

3.3.3.1 Where field applied painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Field Fabricated Nameplate Mounting

3.3.4.1 Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3.5 Warning Sign Mounting

3.3.5.1 Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of (30 feet) apart.

3.3.6 Galvanizing Repair

3.3.6.1 Repair damage to galvanized coatings using ASTM A 780, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

3.4.1.1 Mount equipment on concrete slab. Unless otherwise indicated, the slab shall be at least (8 inches) thick, reinforced with a (6 x 6 -W2.9 x W2.9) mesh placed uniformly (4 inches) from the top of the slab. Slab shall be placed on a (6 inch) thick, well-compacted gravel base. Top of concrete slab shall be approximately (4 inches) above the finished grade. Edges above grade shall have (1/2 inch) chamfer. The slab shall be of adequate size to project at least (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oilresistant caulking or sealant. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter. Cut off and bush conduits (3 inches) above slab surface.

3.4.2 Interior Location

3.4.2.1 Mount equipment on concrete slab. Unless otherwise indicated, the slab shall be at least (4 inches) thick. The top of the concrete slab shall be approximately (4 inches) above finished floor. Edges above floor shall have (1/2 inch) chamfer. The slab shall be of adequate size to project at least (4 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter. Cut off and bush conduits (3 inches) above slab surface.

3.4.3 Cast-in-Place Concrete

3.4.3.1 Cast-in-place concrete work shall conform to the requirements of Section 03 30 00.00 20 Cast-In-Place Concrete.

3.5 PADLOCKS

3.5.1 Provide padlocks for equipment and for each fence gate.

3.6 FIELD QUALITY CONTROL

3.6.1 Performance of Acceptance Checks and Tests

3.6.1.1 Transformers - (Dry-Type)

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify that control and alarm settings on temperature indicators are as specified.

(4) Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Perform specific inspections and mechanical tests as recommended manufacturer.

(7) Verify that resilient mounts are free and shipping brackets have been removed.

(8) Verify that winding core, frame, and enclosure groundings are correct.

(9) Verify the presence of transformer surge arresters.

(10) Verify that as-left tap connections are as specified.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform power-factor tests or dissipation-factor tests in accordance with the test equipment manufacturer's instructions.

(3) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(4) Perform turns-ratio tests.

(5) Perform overpotential test on all high- and low-voltage windings-to-ground.

(6) Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.6.1.2 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.6.1.3 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Verify accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Verify that current transformer and voltage transformer secondary circuits are intact.

3.6.1.4 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod or grounding system, indicating the location of the rod or grounding system. Include the test method and test setup

(i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.6.2 Pre-Energization Services

3.6.2.1 Calibration, testing, adjustment, and placing into service of the installation shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with theinstructions of the equipment manufacturer.

3.6.3 Follow-Up Verification

3.6.3.1 Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days' advance notice of the dates and times for checks, settings, and tests.

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-- End of Section --

SECTION 26 23 00

LOW-VOLTAGE SWITCHGEAR
05/15, CHG 2: 11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D149	(2020) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.20.1A	(2020) Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit-Breaker Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.20.7	(2017; Corr 2021) Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA ST 20	(2014) Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 1558	(2016; Reprint Nov 2019) UL Standard for Safety Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

a. Switchgear Drawings; G

(1) Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordination installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

Switchgear; G

SD-06 Test Reports

Switchgear Design Tests; G

Switchgear Production Tests; G

Acceptance Checks and Tests; G

SD-10 Operation and Maintenance Data

Switchgear Operation and Maintenance, Data Package 5; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G

Equipment Test Schedule; G,

Request for Settings; G

Required Settings; G

Service Entrance Available Fault Current Label; G

1.5 QUALITY ASSURANCE

1.5.1 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchgear including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings.

b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchgear Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military, industry, and technical society publication references on submittals. Include the following:

a. One-line diagram including breakers, fuses, current transformers, and meters.

b. Outline drawings including front elevation, section views, footprint, and overall dimensions.

c. Bus configuration including dimensions and ampere ratings of bus bars.

d. Markings and NEMA nameplate data, including fuse information (manufacturer's name, catalog number, and ratings).

e. Circuit breaker type, interrupting rating, and trip devices, including available settings.

f. Wiring diagrams and elementary diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device. Use this information (designer of record) to provide breaker settings that ensures protection and coordination are achieved.

h. Provisions for future expansion by adding switchgear sections.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Switchgear Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.2 Assembled Operation and Maintenance Manuals

Assemble and securely bind manuals in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents:

a. Manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA.

b. Catalog data required by the paragraph SD-03, PRODUCT DATA.

c. Drawings required by the paragraph SD-02, SHOP DRAWINGS.

d. Prices for spare parts and supply list.

e. Information on metering.

f. Design test reports.

g. Production test reports.

1.6.3 Spare Parts

Provide spare parts as specified below. Provide spare parts that are of the same material and workmanship, meet the same requirements, and are interchangeable with the corresponding original parts furnished.

a. Quantity 2 - Fuses of each type and size.

1.7 WARRANTY

Provide equipment items that are supported by service organizations reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be switchgear and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 SWITCHGEAR

IEEE C37.20.1A and UL 1558.

2.2.1 Ratings

Provide equipment with the following ratings:

a. Voltage rating: as indicated.

b. Continuous current rating of the main bus: as indicated.

c. Short-circuit current rating: as indicated.

d. UL listed and labeled for its intended use.

2.2.2 Construction

Provide the following:

a. Switchgear: consisting of vertical sections bolted together to form a rigid assembly and aligned as indicated.

b. All circuit breakers: front accessible with rear load connections.

c. Compartmentalized switchgear: vertical insulating barriers between the front device section, the main bus section, and the cable compartment with full front to rear vertical insulating barriers between adjacent sections.

d. Where indicated, "space for future" or "space" means to include all necessary components and hardware to be fully equipped for racking in a circuit breaker element.

e. Insulating barriers: provided in accordance with NEMA LI 1, Type GPO-3, 0.25 inch minimum thickness.

f. Moisture resistant coating: applied to all rough-cut edges of barriers.

2.2.2.1 Enclosure

Provide the following:

a. Enclosure: NEMA ICS 6 Type as indicatedfabricated entirely of 12 gauge ASTM A240/A240M type 304 or 304L stainless steel.

b. Enclosure: bolted together with removable bolt-on side].

c. Bases, frames and channels of enclosure: corrosion resistant and fabricated of ASTM A240/A240M type 304 or 304L stainless steel or galvanized steel.

d. Base: includes any part of enclosure that is within 3 inches of concrete pad.

e. Galvanized steel: ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable. Galvanize after fabrication where practicable.

f. Paint color: ASTM D1535 light gray No. 61 or No. 49 over rust inhibitor.

g. Paint coating system: comply with IEEE C57.12.28 for galvanized steel and IEEE C57.12.29 for stainless steel.

2.2.2.2 Bus Bars

Provide the following:

a. Bus bars: copper with silver-plated contact surfaces.

(1) Phase bus bars: insulated with an epoxy finish coating powder or insulating sleeve providing a minimum breakdown voltage of 16,000 volts per ASTM D149.

(2) Neutral bus: rated 100 percent of the main bus continuous current rating as indicated.

b. Make bus connections and joints with hardened steel bolts.

c. Main-bus (through bus): rated at the full ampacity of the main throughout the switchgear.

d. Minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the switchgear.

2.2.2.3 Main Section

Provide the main section consisting of as indicated.

2.2.2.4 Distribution Sections

Provide the distribution section as indicated.

2.2.2.5 Auxiliary Sections

Provide auxiliary sections as indicated.

2.2.2.6 Handles

Provide handles for individually mounted devices of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.4 Drawout Breakers

Equip drawout breakers with disconnecting contacts, wheels, and interlocks for drawout application. Provide main, auxiliary, and control disconnecting contacts with silver-plated, multifinger, positive pressure, self-aligning type. Provide drawout compartment shutters to protect operators from accidental contact with breaker stabs when the breaker is withdrawn from its cubicle. Provide each drawout breaker with four-position operation with each position clearly identified by an indicator on the circuit breaker front panel as follows.

a. Connected Position: Primary and secondary contacts are fully engaged. Breaker must be tripped before racking into or out of position.

b. Test Position: Primary contacts are disconnected but secondary contacts remain fully engaged. This position allows complete test and operation of the breaker without energizing the primary circuit.

c. Disconnected Position: Primary and secondary contacts are disconnected.

d. Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker actuates assembly that isolates the primary stabs.

2.2.5 Electronic Trip Units

Equip main and distribution breakers with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true rms sensing adjustable time-current circuit protection. Include the following:

a. Current sensors ampere rating: as indicated.

b. Trip unit ampere rating: as indicated.

c. Ground fault protection: as indicated.

d. Electronic trip units: provide additional features:

(1) Breakers: include long delay pick-up and time settings, and indication of cause of circuit breaker trip.

(2) Main breakers: include short delay pick-up and time settings and, instantaneous settings and ground fault settings as indicated.

(3) Distribution breakers: include short delay pick-up and time settings, instantaneous settings, and ground fault settings as indicated.

(4) Main Breakers: include a digital display for phase and ground current.

(5) Breakers: include a digital display for watts, vars, VA, kWh, kvarh, and kVAh.

(6) Breakers: include a digital display for phase voltage, and percent THD voltage and current.

(7) Breakers: include provisions for communication via a network twisted pair cable for remote monitoring and control.

(8) For electronic trip units that are rated for or can be adjusted to 1,200 amperes or higher, provide arc energy reduction capability with an energy-reducing maintenance switch with local status indicator.

2.2.6 Metering

2.2.6.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in a sealed case with the following features.

a. Display capability:

(1) Multi-Function Meter: Display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected

PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. Include a Form C KYZ pulse output relay on the meter.

(2) Power Meter: Display Watts, VARs, and selected KVA/PF. Detected alarm conditions include over/under KVA, over/under PF, over/under VARs, over/under reverse power.

(3) Volt Meter: Provide capability to be selectable between display of the three phases of phase to neutral voltages and simultaneous display of the three phases of the phase to phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, over percent THD.

(4) Ammeter: Display phase A, B, and C currents. Detected alarm conditions include over/under current, over percent THD.

(5) Digital Watthour Meter: Provide a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). Include a Form C KYZ pulse output relay on the meter.

b. Design meters to accept input from standard 5A secondary instrument transformers and direct voltage monitoring range to 600 volts, phase to phase.

c. Provide programming via a front panel display and a communication interface accessible by a computer.

d. Provide password secured programming stored in non-volatile EEPROM memory.

e. Provide digital communications shall be a protocol compatible with the Base/Post EMCS.

f. Provide meter that calculates and stores average max/min demand values with time and date for all readings based on a user selectable sliding window averaging period.

g. Provide meter with programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.

h. Provide meter with a display of Total Harmonic Distortion (THD) measurement to a minimum of the thirty-first order.

i. Include historical trend logging capability with the ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. Provide a unit that can store and time stamp up to 1000 programmable triggered conditions.

j. Provide event waveform recording triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Store waveforms for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.

2.2.6.2 Electronic Watthour Meter

Provide as specified in Section 26 27 14.00 20 ELECTRICITY METERING and 26 27 13.10 30 ELECTRIC METERS.

ANSI C12.1. Provide a switchgear style electronic programmable watthour meter, semi-flush mounted, as indicated. Meter can be either programmed at the factory or programmed in the field. Turn field programming device over to the Contracting Officer at completion of project. Coordinate meter to system requirements.

a. Design: Provide meter designed for use on specified system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Class: 20. Accuracy: plus or minus 1.0 percent. Finish: Class II.

d. Kilowatt-hour Register: five digit electronic programmable type.

e. Demand Register:

(1) Provide solid state.

(2) Display actual values and readings of the metered circuit. No multipliers must be required.

(3) Demand interval length: programmed for 15 minutes with rolling demand up to six subintervals per interval.

f. Meter fusing: Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

g. Provide meter with a communications port, RS485, with Modbus RTU serial or Ethernet, Modbus-TCP communications.

IEEE C57.13. Provide single ratio transformers, 60 hertz, with primary ampere ratio, as required.

Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to voltage sensing meters. Size fuses as recommended by the meter manufacturer.

2.2.7 Transformer

Provide transformer section in switchgear in accordance with UL 1558 and as indicated. Provide the transformer and section that is suitable for the installation. Provide a transformer conforming to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2.8 Heaters

Provide 120-volt heaters in each switchgear section. Provide heaters of sufficient capacity to control moisture condensation in the section, 250 watts minimum, and controlled by a thermostat located in the section. Provide industrial type thermostat, high limit, to maintain sections within the range of 60 to 90 degrees F. Obtain supply voltage for the heaters from a control power transformer within the switchgear. If heater voltage is different than switchgear voltage, provide transformer rated to carry 125 percent of heater full load rating. Provide transformer with a 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and conforming to NEMA ST 20.

2.2.9 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Provide terminal board identification that is identical in similar units. Provide color coded external wiring that is color coded consistently for similar terminal boards.

2.2.10 Wire Marking

Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Provide a nameplate on each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchgear, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates of melamine plastic, 0.125 inch thick, white with black center core. Provide red laminated plastic label with white center core where indicated. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Provide nameplates with minimum size of one by 2.5 inches. Provide lettering that is a minimum of 0.25 inch high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Provide the following as part of test equipment calibration:

a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels: visible on all test equipment.

e. Calibrating standard: higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchgear Design Tests

IEEE C37.20.1A, IEEE C37.20.7, and UL 1558.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test.

b. Enclosure tests.

c. Dielectric test.

2.5.2.2 Additional Design Tests

In addition to normal design tests, perform the following tests on the actual equipment. Furnish reports which include results of design tests performed on the actual equipment.

a. Temperature rise tests.

b. Continuous current.

2.5.3 Switchgear Production Tests

IEEE C37.20.1A and UL 1558. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 60-hertz dielectric tests.

b. Mechanical operation tests.

c. Electrical operation and control wiring tests.

d. Ground fault sensing equipment test.

2.5.4 Cybersecurity Equipment Certification

Furnish a certification that control systems are designed and tested in accordance with DoD Instruction 8500.01, DoD Instruction 8510.01, and as required by individual Service Implementation Policy.

2.6 ARC FLASH WARNING LABEL

Provide warning label for switchgear. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems with a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchgear

IEEE C37.20.1A.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount switchgear on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inch No. 6 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

d. Provide edges above grade 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

f. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

g. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

h. Cut off and bush conduits 3 inches above slab surface.

i. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount switchgear on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 4 inches thick.

b. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

c. Provide edges above grade 1/2 inch chamfer.

d. Provide slab of adequate size to project at least 8 inches beyond the equipment.

e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

g. Cut off and bush conduits 3 inches above slab surface.

h. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Submit Required Settings of breakers to the Contracting Officer after approval of switchgear and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Switchgear

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Verify appropriate anchorage, required area clearances, and correct alignment.

(4) Clean switchgear and verify shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that fuse and circuit breaker sizes and types correspond to approved shop drawings as well as to the circuit breaker’s address for microprocessor-communication packages.

(7) Verify that current transformer ratios correspond to approved shop drawings.

(8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Confirm correct application of manufacturer's recommended lubricants.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier and shutter installation and operation.

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that filters are in place and vents are clear.

(16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform dielectric withstand voltage tests.

(3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

(6) Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

(7) Verify operation of switchgear heaters.

3.5.1.2 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, and grounding.

(4) Verify that all maintenance devices are available for servicing and operating the breaker.

(5) Inspect arc chutes.

(6) Inspect moving and stationary contacts for condition, wear, and alignment.

(7) Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

(8) Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

(9) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(10) Verify cell fit and element alignment.

(11) Verify racking mechanism.

(12) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests

(1) Perform contact-resistance tests on each breaker.

(2) Perform insulation-resistance tests.

(3) Adjust Breaker(s) for final settings in accordance with Government provided settings.

(4) Determine long-time minimum pickup current by primary current injection.

(5) Determine long-time delay by primary current injection.

(10) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

(11) Verify operation of charging mechanism.

3.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) IEEE 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions

to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.1.6 Cybersecurity Installation Certification

Furnish a certification that control systems are installed in accordance with DoD Instruction 8500.01, DoD Instruction 8510.01, and as required by individual Service Implementation Policy.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 26 23 00.00 40

SWITCHBOARDS AND SWITCHGEAR
11/17

PART 1 GENERAL

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.1 PRODUCT COORDINATION

Products and materials that are not considered to be[switchboards][or][switchgear] and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B317/B317M	(2007; R 2015; E 2016) Standard Specification for Aluminum-Alloy Extruded

	Bar, Rod, Tube, Pipe, Structural Profiles, and Profiles for Electrical Purposes (Bus Conductor)
ASTM D149	(2020) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.13	(2015) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1A	(2020) Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit-Breaker Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.01	(2020) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing

	Specifications for Electrical Power Equipment and Systems

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA PB 2.1	(2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA PB 2	(2011) Deadfront Distribution Switchboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2019) UL Standard for Safety Switchboards
UL 1558	(2016; Reprint Nov 2019) UL Standard for Safety Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
UL 4248-12	(2018) UL Standard for Safety Fuseholders - Part 12: Class R

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

[Switchboard][Switchgear] Drawings; G[, [____]]

SD-03 Product Data

[Switchboard][Switchgear]; G[, [____]]

Spare Parts List; G[, [____]]

SD-06 Test Reports

Acceptance Checks and Tests; G[, [____]]

SD-07 Certificates

Equipment Test Schedule

[Switchboard][Switchgear] Design Tests

[Switchboard][Switchgear] Production Tests

SD-10 Operation and Maintenance Data

[Switchboard][Switchgear] Operation and Maintenance, Data Package 5

SD-11 Closeout Submittals

Warranty

Assembled Operation and Maintenance Manuals

Request for Settings

1.5 QUALITY CONTROL

1.5.1 Predictive Testing And Inspection Technology Requirements

This section addresses systems or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure that building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system or its components. Satisfactory completion of all acceptance requirements is required in order to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

1.5.2 [Switchboard][Switchgear] Product Data

Include on each submittal the manufacturer's information for each component, device and accessory provided with the [switchboard][switchgear] including the following:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings

b. Manufacturer's instruction manuals and published time-current curves (on full-size logarithmic paper) of the main secondary breaker and largest secondary feeder device

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure that equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products that are of equal material, design and workmanship. Ensure that the products have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Use products that have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, use products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record are acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years before the date of delivery to the site, unless specified otherwise.

1.6 WARRANTY

Provide the Contracting Officer with warranties associated with the equipment. Ensure that the equipment items are supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 DESIGN REQUIREMENTS

Show wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items to ensure a coordinated installation.

2.1.1 [Switchboard][Switchgear] Drawings

Drawings include the following:

a. One-line diagram, including breakers[, fuses][, current transformers, and meters]

b. Outline drawings, including front elevation, section views, footprint, and overall dimensions

c. Bus configuration, including dimensions and ampere ratings of bus bars

d. Markings and NEMA nameplate data[, including fuse information (manufacturer's name, catalog number, and ratings)]

e. Circuit breaker type, interrupting rating, and trip devices, including available settings

f. Three-line diagrams, elementary diagrams, and wiring diagrams. with terminals identified and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (on full-size logarithmic paper) of the main secondary breaker and largest secondary feeder device.

[h. Provisions for future extension.

]2.1.2 Ratings

The voltage rating of the [switchboard][switchgear] is [480Y/277][208Y/120][125][_____] volts [AC][DC], [2][3][4]-wire [[single][3] phase][as indicated]. The continuous-current rating of the main bus is [[_____] amperes][as indicated]. The short-circuit current rating is [[_____] RMS symmetrical amperes][as indicated]. Provide a [switchboard][switchgear] that is UL-listed and labeled[for its intended use][as service entrance equipment].

2.2 COMPONENTS

Provide[SWITCHBOARD][SWITCHGEAR] that conforms to [NEMA PB 2 and UL 891][IEEE C37.20.1A and UL 1558].

2.2.1 Construction

[Provide dead front switchboards conforming to NEMA PB 2 and labeled under UL 891. Ensure that the switchboards are completely enclosed self-supporting metal structures with the required number of vertical panel sections, buses, molded-case circuit breakers, [and other devices] as shown on the drawings. Provide switchboards that are fully rated for a short-circuit current of [14,000] [22,000] [65,000] [_____] symmetrical amperes RMS AC.

] [Switchboard][Switchgear] consists of vertical sections bolted together to form a rigid assembly and is [rear-][front- and rear-] aligned[as indicated]. All circuit breakers are front-accessible.[Rear-aligned switchboards have front-accessible load connections.][Front- and rear-aligned switchboards have rear-accessible load connections.][Ensure that compartmentalized [switchboards have][switchgear has] vertical insulating barriers between the front device section, the main bus section, and the cable compartment[with full front-to-rear vertical insulating barriers between adjacent sections].] Where indicated, "space for future" or "space" means to include bus, device supports, and connections. Provide insulating barriers in accordance with NEMA LI 1, Type GPO-3, 0.25 inch minimum thickness. Apply moisture-resistant coating to all rough-cut edges of barriers. Provide a switchboard that is completely factory-engineered and factory-assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.1.1 Enclosure

Ensure that the [switchboard][switchgear] enclosure is [an outdoor] NEMA ICS 6 Type [3R][1][_____][as indicated][fabricated entirely of 12-gauge ASTM A240/A240M type 304 or 304L stainless-steel]. Bolt the enclosure together with removable bolt-on side and[hinged] rear covers[, and slope the roof downward toward the rear].[Provide front[and rear] doors with[stainless-steel] padlockable vault handles with a three-point catch.] Ensure that bases, frames and channels of enclosure are corrosion resistant and fabricated of[ASTM A240/A240M type 304 or 304L stainless-steel][or][galvanized steel]. Base includes any part of enclosure that is within 3 inches of concrete pad.[Galvanized steel conforms to ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable. Galvanize after fabrication where practicable.] Paint the enclosure, including the bases, ASTM D1535 light gray No. 61 or No. 49. Ensure that the paint coating system complies with[IEEE C57.12.28 for galvanized steel][and][IEEE C57.12.29 for stainless-steel].

[Provide a NEMA Type [2] [3R] switchboard enclosure, built with selected smooth sheet steel panels of not less than No. 14 gage. Ensure that the exposed panels on the front and ends have bent-angle or channel edges with all corner seams welded and ground smooth. Ensure that the front outside surfaces are not drilled or welded for the purpose of attaching wires or mounting devices if such holes or fastenings are visible from the front. Make the front panels in sections, flanged on four sides and attached to the framework by screws, and arranged for ready removal for inspection or maintenance. [Provide rear access to the bus and device connections.]Provide grille ventilating openings. Provide all ventilating openings with corrosion-resistant insectproof screens on the inside. [Provide each switchboard with a channel iron base at front, rear, and sides, with exposed ends covered by welded steel plates. Provide grout holes. Bolt the switchboard sections to the base.][Mount switchboards as shown on the drawings and furnish mounting materials as indicated.]Treat all interior and exterior steel parts to inhibit corrosion and paint the enclosure .

]2.2.1.2 Bus Bars

[Ensure that the bus bars are[copper with silver-plated contact surfaces][or][aluminum with tin-plated contact surfaces]. Ensure that plating is at least 0.0002 inches thick. Make bus connections and joints with

hardened-steel bolts. Rate the through-bus at the full ampacity of the main throughout the switchboard. Provide a copper ground bus at least 0.25 inch by 2 inches secured to each vertical section along the entire length of the [switchboard][switchgear]. Rate the neutral bus [100][_____] percent of the main bus continuous-current rating[as indicated].[Insulate bus bars with an epoxy finish coating powder providing a minimum breakdown voltage of 16,000 volts in accordance with ASTM D149.]
]
[Ensure that all buses are copper [or aluminum] and [all bolted splices and connections between buses and for extensions or taps for equipment] are tin-plated or silver-plated [throughout]. Ensure that copper [or aluminum] bars and shapes for bus conductors conform to the applicable requirements of ASTM B187/B187M [, and ASTM B317/B317M]. Bolt all splices for field assembly with at least two bolts, and employ the use of "Belleville" washers in the connection. Ensure that horizontal and vertical power buses have the minimum current ratings shown on the drawings. Insulate buses for not less than 600 volts. Braze, pressure-weld, or bolt, splices and tap connections. Bolt the splices for field assembly. Mount the buses on insulating supports of wet-process porcelain, glass polyester, or suitable molded material, and brace to withstand not less than [14,000] [22,000] [65,000] [_____] symmetrical amperes ac. Near the bottom of the enclosure, mount a copper [or aluminum] ground bus, rated not less than 300 amperes, extending the entire length of the assembled structure. Provide a full-clamp solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable at each end of the bus for connection to the station grounding system.

]2.2.1.3 Main Section

The main section consists of[main lugs only][an individually mounted[drawout][air power circuit breaker[with current-limiting fuses]][insulated-case circuit breaker][molded-case circuit breaker][bolted pressure switch][fusible switch]][and utility transformer compartment].

2.2.1.4 Distribution Sections

The distribution section[s] consist of[[individually mounted,][drawout,]][air power circuit breakers[with current-limiting fuses]][insulated-case circuit breakers][molded-case circuit breakers][bolted pressure switches][fusible switches][and utility transformer compartments] as indicated.

[2.2.1.5 Combination Sections

Combination sections consist of[molded-case circuit breakers][fusible switches] for the[main and] branch devices as indicated.

][2.2.1.6 Auxiliary Sections

Auxiliary sections consist of indicated[instruments,][metering equipment,][control equipment,][transformer,][and][current transformer compartments] as indicated.

][2.2.1.7 Handles

Ensure that handles for individually mounted devices are of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color-coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

]2.2.2 Protective Device

Provide[main and] branch protective devices as indicated.

[2.2.2.1 Power Circuit Breaker

Provide breakers conforming to IEEE C37.13. Provide [120 Vac][electrically][manually] operated [stationary][drawout], [unfused][fused],[steel frame,] low-voltage power circuit breaker with a short-circuit current rating[of [_____] RMS amperes symmetrical][as indicated] at [_____] volts. The breaker frame size is[as indicated][[_____] amperes].[Equip the electrically operated breakers with a motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.]

][2.2.2.2 Insulated-Case Breaker

Provide a UL-listed, 100-percent rated,[stationary][drawout],[120 Vac],[electrically] [manually] operated, low-voltage, insulated-case circuit breaker, with a short-circuit current rating[of [_____] RMS symmetrical amperes][as indicated] at [_____] volts. The breaker frame size is [[_____] amperes][as indicated].[Equip the electrically operated breaker with a motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.]

][2.2.2.3 Molded-Case Circuit Breaker

Provide breakers conforming to UL 489. Ensure that breakers are UL-listed and labeled, 100-percent rated,[stationary][drawout],[120 Vac],[electrically][manually] operated, low-voltage molded-case circuit breaker, with a short-circuit current rating of[[_____] RMS symmetrical amperes][as indicated] at [_____] volts. Breaker frame size is [[_____] amperes][as indicated]. Series-rated circuit breakers are unacceptable.

[Equip each switchboard with molded-case circuit breakers with trip ratings and terminal connectors for attachment of outgoing power cables as shown on the drawings. Ensure that the circuit breakers are operable and removable from the front. Where shown on the drawings, enclose circuit breakers in individual compartments.

]][2.2.2.4 Fusible Switches

Provide quick-make, quick-break, hinged-door fusible switches.[Ensure that the switches serving as motor disconnects are horsepower-rated.] Ensure that the fuses have current-limiting cartridges conforming to[UL 198M, Class J for 0 to 600 amperes and Class L for 601 to 6000 amperes][UL 198M, Class [RK1][RK5] for 0 to 600 amperes].

Ensure that fuseholders conform to UL 4248-12.

][2.2.2.5 Integral Combination Breaker and Current-Limiting Fuses

Provide fuses conforming to UL 489. Provide integral combination molded-case circuit breaker and current-limiting fuses[as indicated][rated [_____] amperes] with a minimum short-circuit current rating equal to the short-circuit current rating of the [switchboard][switchgear] in which the circuit breaker is mounted. Series-rated circuit breakers are unacceptable. Ensure that overcurrent devices of the circuit breaker and current-limiting fuses are coordinated such that on overloads or fault currents of relatively low value, the overcurrent device of the breaker is operated to clear the fault. For high-magnitude short circuits above a predetermined value[crossover point], ensure that the current-limiting fuses operate to clear the fault. Ensure that the housing for the current-limiting fuses is an individual molding readily removable from the front and located at the load side of the circuit breaker. If the fuse housing is removed, ensure that a blown fuse is readily evident by means of a visible indicator. Ensure that the removal of the fuse housing causes the breaker contacts to open, and that it is not possible to close the breaker contacts with the fuse housing removed. Ensure that it is not possible to insert the fuse housing with a blown fuse or with one fuse missing. Ensure that the the blowing of any of the fuses causes the circuit breaker contacts to open.

][2.2.3 Drawout Breakers

Equip drawout breakers with disconnecting contacts, wheels, and interlocks for drawout application. Ensure that the main, auxiliary, and control disconnecting contacts are silver-plated, multifinger, positive-pressure, and self-aligning. Provide each drawout breaker with four-position operation. Clearly identify each position by an indicator on the circuit breaker front panel.

a. Connected Position: Primary and secondary contacts are fully engaged. Ensure that the breaker is tripped before racking into or out of position.

b. Test Position: Primary contacts are disconnected but the secondary contacts remain fully engaged. Ensure that the position allows complete test and operation of the breaker without energizing the primary circuit.

c. Disconnected Position: Primary and secondary contacts are disconnected.

d. Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker actuates the assembly that isolates the primary stabs.

][2.2.4 Electronic Trip Units

Equip[main and][distribution] breakers[as indicated] with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true RMS-sensing adjustable time-current circuit protection. The ampere rating of the current sensors are [as indicated][[_____] amperes][the same as the breaker frame rating]. The trip unit ampere rating is[as indicated][[_____] amperes].[Ground fault protection is[as indicated][zero-sequence sensing][residual-sensing].][Provide the electronic trip units with the following features[as indicated].]

[a. [Indicated breakers]Breakers have long-delay pickup and time settings, and LED indication of cause of circuit breaker trip.

][b. Main breakers have[short-delay pickup and time settings][and][, instantaneous settings][and][ground fault settings][as indicated].

][c. Distribution breakers have[short-delay pickup and time settings][, instantaneous settings][, and ground fault settings][as indicated].

][d. [Main]Breakers have a digital display for phase and ground current.

][e. [Main]Breakers have a digital display for watts(W), volt-amperes (VA), kilovolt-ampere hours (kVAh) volt-amperes reactive (VAr), kilovolt-ampere reactive hours (kVArh), and kilowatt hoursvars, VA, (kWh).

][f. [Main]Breakers have a digital display for phase voltage, and percentage total harmonic distortion (THD) voltage and current.

][g. [Main]Breakers have provisions for communication via a network twisted-pair cable for remote monitoring and control.

]][2.2.5 Electronic Trip Unit Central Monitor

Provide a microprocessor-based device designed to monitor and display parameters of the circuit breaker electronic trip units. Ensure that the central monitor has the following features:

a. Alphanumeric display

b. Indication of circuit breaker status: tripped, open, closed

c. Cause of circuit breaker trip

d. Phase, neutral, and ground current for each breaker

e. Energy parameters for each breaker

f. Provisions for communicating directly to a remote computer

][2.2.6 Instruments

Provide electrical indicating switchboard instruments, with 2-percent accuracy. Provide ac ammeters and voltmeters at least 2 inches square, with a 250-degree scale. Provide single-phase indicating instruments with flush-mounted transfer switches for reading three phases.

[2.2.6.1 AC Ammeters

Provide a [self-contained,][transformer-rated, 5-ampere input ac ammeter, for use with a [_____] to 5-ampere current transformer ratio,]0-to-[_____]-ampere scale range, 60 hertz.

][2.2.6.2 AC Voltmeters

Provide self-contained voltmeters.

][2.2.6.3 Instrument Control Switches

Provide rotary cam-operated instrument control switches with positive means of indicating contact positions. Ensure that switches have silver-to-silver contacts enclosed in a protective cover that can be removed to inspect the contacts.

]][2.2.7 Watthour and Digital Meters

[2.2.7.1 Digital Meters

Ensure that meters conform to IEEE C37.90.1 for surge-withstand requirements. Provide true RMS, plus/minus 1-percent accuracy, programmable, microprocessor-based meters enclosed in sealed cases with a simultaneous 3-line, 12-value LED display. Ensure that meters have 0.56-inch, minimum, LEDs.[Watthour meters have 0.56-inch, minimum, LEDs.] Ensure that the meters accept[input from standard 5A secondary instrument transformers][and][direct-voltage monitoring range to [300][600] volts, phase to phase]. Ensure the programming is via a front-panel display and a communication interface with a computer. Store password-secured programming in nonvolatile EEPROM memory. Ensure that digital communications are Modbus [ASCII][RTU] protocol via a [RS232C][RS485] serial port[and an independently addressable [RS232C][RS485] serial port]. Ensure that the meter calculates and stores average max/min demand values for all readings based on a user-selectable sliding-window averaging period. Ensure that the meter has programmable high/low set limits with two Form C dry-contact relays when exceeding alarm conditions.[Provide a meter with THD measurement to the thirty-first order.][Ensure that the historical-trend logging capability can to store up to [100,000] [_____] data points with intervals of 1 second to 180 minutes. Ensure that the unit can also store and time-stamp up to 100 programmable triggered conditions.][Ensure that event waveform recording is triggered by the RMS of two cycles of voltage or current exceeding programmable set points. Ensure that the meter stores waveforms for all six channels of voltage and current for a minimum of 10 cycles before the event and 50 cycles past the event.]

[a. Multifunction Meter: Meter simultaneously displays a selected phase-to-neutral voltage, phase-to-phase voltage, percent phase-to-neutral voltage THD, percentage phase-to-phase voltage THD; a selected phase current, neutral current, percent phase current THD, percentage neutral current; and selected total picofarad (PF), kW, kVA, kVAr, frequency (FREQ), kVAh, and kWh. Detected alarm conditions include over/under current, over/under voltage, over/under kVA, over/under frequency, over/under selected PF/kVAr, voltage phase reversal, voltage imbalance, reverse power, and over percentage THD. Ensure that the meter has a Form C KYZ pulse output relay.

][b. Power Meter: Meter simultaneously displays watts (W), VAr, and selected kVA/PF. Detected alarm conditions include over/under kVA, over/under PF, over/under VAr, and over/under reverse power.

][c. Voltmeter: Meter is selectable between simultaneous display of the three phases of phase-to-neutral voltages and simultaneous display of the three phases of the phase-to-phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, and over percentage THD.

][d. Ammeter: Meter simultaneously displays phase A, B, and C currents. Detected alarm conditions include over/under current and over percentage THD.

][e. Digital Watthour Meter: Meter has a single selectable display for W, total kWh and watt demand (Wd). The meter has a Form C KYZ pulse output relay.

]][2.2.7.2 Electronic Watthour Meter

Provide a switchboard-style electronic programmable watthour meter, semi-drawout, semiflush-mounted, as indicated. Meter is either programmed at the factory or programmed in the field. After field programming is complete, turn the field programming device over to the Contracting Officer.

a. Design: Provide a meter designed for use on a 3-phase, 4-wire, [208Y/120][480Y/277] volt system with three current transformers. Include the necessary KYZ pulse initiation hardware for the Energy Monitoring and Control System (EMCS)[as specified in[Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC]].

b. Coordination: Provide a meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Class: 20. Form: [9S][___]. Accuracy: plus/minus 1.0 percent. Finish: Class II.

d. Kilowatt hour Register: five-,digit electronic programmable.

e. Demand Register:

    (1) Meter reading multiplier: Indicate multiplier on the meter face.

    (2) Demand interval length: Program for [15][30][60] minutes with rolling demand up to six subintervals per interval.

f. Meter fusing: Provide a fuse block-mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

]]2.2.8 Current Transformers

Provide transformers that conform to IEEE C57.13. Ensure that transformers are single-ratio, 60 hertz, [_____] to 5-ampere ratio, [_____] rating factor, with a metering accuracy class of 0.3 through [_____].

[2.2.9 Transformer

Provide transformer section in [switchboard][switchgear] in accordance with [UL 891][UL 1558] and as indicated. Ensure that the transformer and section are suitable for the installation.[Test transformers greater than 10 kVA in accordance with UL 891.] Ensure that transformers conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

][2.2.10 Meter Fusing

Provide a fuse block-mounted in the metering compartment, containing one fuse per phase to protect the voltage input to voltage sensing meters. Size the fuses as recommended by the meter manufacturer.

][2.2.11 Heaters

Provide 120-volt heaters in each [switchboard][switchgear] section. Provide heaters that can control moisture condensation in the section, are a minimum 250 watts, and are controlled by a thermostat[and humidistat] located in the section. Provide an industrial, high-limit thermostat to maintain sections within the range of 60 to 90 degrees F.[Humidistat has a range of 30 to 60 percent relative humidity.] Obtain supply voltage for the heaters from a control power transformer within the [switchboard][switchgear]. If heater voltage is different from switchboard voltage, provide a transformer rated to carry 125 percent of heater full-load rating. Ensure that the transformer has a 220-degrees C insulation system with a temperature rise not exceeding 115 degrees C and conforms to IEEE C57.12.01.[Energize electric heaters in the switchboard assemblies while the equipment is in storage or in place before the heaters are placed in service. Provide a method to easily connect the heater to an external power source. Provide reliable, temporary, external power source if the commercial power at the rated voltage is not available on site.]

]2.2.12 Terminal Boards

Provide terminal boards with engraved plastic terminal strips and screw terminals for external wiring between components and for internal wiring between removable assemblies. Ensure that the terminal boards associated with current transformers are short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Ensure that the terminal board identification is identical in similar units. Color-code external wiring consistently for similar terminal boards.

2.2.13 Wire Marking

Mark the control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat-stamped with black block letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat-stamped with black block letters. Ensure that each sleeve contains a single letter or number, is elliptically shaped to securely grip the wire, and is keyed to align with the adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Ensure that each wire marker indicates the device or equipment, including the specific terminal number to which the remote end of the wire is attached.

2.2.14 Manufacturer's Nameplate

Ensure that each item of equipment has a nameplate bearing the manufacturer's name, address, model number, and serial number, securely affixed in a conspicuous place. The nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.2.15 Field-Fabricated Nameplates

Ensure that nameplates conform to ASTM D709. Provide laminated plastic nameplates for each[switchboard,][switchgear,] equipment enclosure, relay, switch, and device, as specified in this section or as indicated on the drawings. Ensure that each nameplate inscription identifies the function and, when applicable, the position. Construct the nameplates of melamine plastic, 0.125 inch thick, white with [black][_____] center core.[Provide a red laminated plastic label with a white center core where indicated.] Provide a matte finish with square corners. Accurately align lettering and engrave into the core. Ensure that nameplates measure at least 1 inch by 2.5 inches. Provide block lettering at least 0.25 inch high.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide schedules for equipment to be tested at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before the scheduled test date. Notify the Contracting Officer 15 calendar days before changes to the scheduled test date.

a. Test Instrument Calibration Requirements

(1) The manufacturer has a calibration program ensuring that all applicable test instruments are maintained within rated accuracy.

(2) The accuracy is directly traceable to the National Institute of Standards and Technology.

(3) The instrument calibration frequency schedule cannot exceed 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels are visible on all test equipment.

(5) The calibrating standard is of higher accuracy than that of the instrument tested.

(6) Records that indicate dates and test results of instruments calibrated or tested are kept up to date. For instruments calibrated by the manufacturer on a routine basis, in lieu of third-party calibration, the following are included:

(a) Up-to-date instrument calibration instructions and procedures for each test instrument

(b) Identification of instruments calibrated by a third party or laboratory to verify that the calibrating standard is met

2.3.2 [Switchboard][Switchgear] Design Tests

[NEMA PB 2 and UL 891][IEEE C37.20.1A and UL 1558].

2.3.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test

b. Enclosure tests

c. Dielectric test

[2.3.2.2 Additional Design Tests

In addition to normal design tests, perform the following tests on the actual equipment. Furnish reports that include results of design tests performed on the actual equipment.

a. Temperature rise tests

b. Continuous current

]2.3.3 [Switchboard][Switchgear] Production Tests

[NEMA PB 2 and UL 891][IEEE C37.20.1A and UL 1558]. Furnish reports that include results of production tests performed on the actual equipment for this project. These tests include the following:

a. 60-hertz dielectric tests

b. Mechanical operation tests

c. Electrical operation and control wiring tests

d. Ground fault sensing equipment test

2.4 COORDINATED POWER SYSTEM PROTECTION

Provide a power system study as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

PART 3 EXECUTION

3.1 INSTALLATION

Ensure that the electrical installations conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Grounding

Meet the requirements of NFPA 70 and IEEE C2, except that grounds and grounding systems have a resistance to solid earth ground not exceeding 5 ohms.

3.1.1.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at the equipment end of the ground conductors.

3.1.1.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG and not less than 24-inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed in order to obtain the specified ground resistance, the provision of the Contract covering "Changes" applies.

3.1.1.3 Connections

Make the joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, paragraph GROUNDING CONNECTIONS.

3.1.1.4 Grounding and Bonding Equipment

Ensure that the equipment conforms to UL 467, except as indicated or otherwise specified.

3.1.2 Installation of Equipment and Assemblies

Install and connect equipment furnished under this section as indicated on approved project or shop drawings and as specified herein.

3.1.2.1 [Switchboard

ANSI/NEMA PB 2.1.

]3.1.2.2 [Switchgear

IEEE C37.20.1A.

]3.1.2.3 [Meters and Instrument Transformers

ANSI C12.1.

]3.1.2.4 Field-Applied Painting

Where field painting of enclosures is necessary to correct damage to the manufacturer's factory-applied coatings, provide the manufacturer's recommended coatings and apply in accordance with the manufacturer's instructions.

3.1.2.5 Galvanizing Repair

Repair damage to galvanized coatings in conformance with ASTM A780/A780M, using zinc-rich paint, for galvanizing surfaces damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that the repair paint has been applied to.

3.1.2.6 Field-Fabricated Nameplate Mounting

Provide the number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.1.3 Foundation For Equipment And Assemblies

3.1.3.1 Exterior Location

Mount the [switchboard][switchgear] on a concrete slab. Unless otherwise indicated, ensure that the slab is at least 8 inches thick, reinforced with a 6 inch by 6 inch No. 6 mesh placed uniformly 4 inchesfrom the top of the slab. Place the slab on a 6 inch thick, well-compacted gravel base. Set the top of the concrete slab approximately 4 inches above the finished grade. Form the edges above grade to have a 0.5 inch chamfer. Ensure that the slab projects at least 8 inches beyond the equipment. Provide conduit turn-ups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in the slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above the slab surface. Ensure that concrete work is as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.1.3.2 Interior Location

Mount the [switchboard][switchgear] on the concrete slab. Unless otherwise indicated, ensure that the slab is at least 4 inches thick. Place the top of the concrete slab approximately 4 inches above the finished floor. Form edges above the floor to have a 0.5 inch chamfer. Size the slab to project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in the slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above the slab surface. Ensure that concrete work is as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2 FIELD QUALITY CONTROL

Submit a request for settings of breakers to the Contracting Officer after approval of the [switchboard][switchgear] and at least 30 days before their requirement.

3.2.1 Performance of Acceptance Checks and Tests

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

Perform tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

[3.2.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify appropriate anchorage, required area clearances, and correct alignment.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that[fuse and] circuit breaker sizes and types correspond to approved shop drawings.

[(7) Verify that current transformer ratios correspond to approved shop drawings.

] (8) Inspect all bolted electrical connections for high resistance using a low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by using the calibrated torque-wrench method or performing a thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Clean switchboard.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier[and shutter] installation[and operation].

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that vents are clear.

(16) Test the operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform overpotential tests.

(3) Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

[(6) Perform phasing check on double-ended switchboard to ensure correct bus phasing from each source.

][(7) Verify operation of switchboard heaters.

]][3.2.1.2 Switchgear

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify appropriate anchorage, required area clearances, and correct alignment.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that[fuse and] circuit breaker sizes and types correspond to approved shop drawings.

[(7) Verify that current transformer ratios correspond to approved shop drawings.

] (8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method or performing a thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Clean switchgear.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier[and shutter] installation[and operation].

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that vents are clear.

(16) Test the operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform overpotential tests.

(3) Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

[(6) Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

][(7) Verify operation of switchgear heaters.

]]3.2.1.3 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Inspect anchorage, alignment, and grounding. Inspect arc chutes. Inspect moving and stationary contacts for condition, wear, and

alignment.

(5) Verify that all maintenance devices are available for servicing and operating the breaker.

(6) Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

(7) Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

(8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by using the calibrated torque-wrench method or performing a thermographic survey.

(9) Verify cell fit and element alignment.

(10) Verify racking mechanism.

b. Electrical Tests

(1) Perform contact-resistance tests on each breaker.

(2) Perform insulation-resistance tests.

(3) Adjust breakers for final settings in accordance with Government-provided settings.

(4) Determine long-time minimum pickup current by primary current injection.

(5) Determine long-time delay by primary current injection.

[(6) Determine short-time pickup and delay by primary current injection.

][(7) Determine ground fault pickup and delay by primary current injection.

][(8) Determine instantaneous pickup value by primary current injection.

][(9) Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure the operation of shunt trip devices; check the operation of electrically operated breakers in their cubicle.

] (10) Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

(11) Verify operation of charging mechanism.

3.2.1.4 Circuit Breakers

[Low-Voltage - Insulated-Case][and][Low-Voltage Molded-Case with Solid-State Trips

] a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to verify smooth operation.

(4) Inspect case for cracks or other defects.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted connections or cable connections by using the calibrated torque-wrench method or performing a thermographic survey.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Perform breaker adjustments for final settings in accordance with Government-provided settings.

(4) Perform long-time-delay time-current characteristic tests.

[(5) Determine short-time pickup and delay by primary current injection.

][(6) Determine ground fault pickup and time delay by primary current injection.

][(7) Determine instantaneous pickup current by primary injection.

][(8) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

]3.2.1.5 Current Transformers (CTs)

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by using the calibrated torque-wrench method or performing a thermographic survey.

(6) Verify that all required grounding and shorting connections

provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.2.1.6 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to the manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.2.1.7 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform tests in conformance with IEEE 81. Measure ground impedance, using the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod, perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with the manufacturer's instructions to test each ground or group of grounds. Ensure that the instrument is equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and

grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (that is, pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.2.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Testing requires each item to perform its function not less than three times. Submit test results to the Contacting Officer. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer of the dates and times for checks, settings, and tests 5 working days in advance.

3.3 CLOSEOUT ACTIVITIES

3.3.1 [Switchboard][Switchgear] Operation and Maintenance Data

Submit operation and maintenance manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

3.3.2 Assembled Operation and Maintenance Manuals

Assemble and bind manuals securely in durable, hard-covered, water-resistant binders. Assemble and index the manuals in the following order with a table of contents

a. Manufacturer's O&M information required by paragraph SD-10 OPERATION AND MAINTENANCE DATA

b. Catalog data required by paragraph SD-03 PRODUCT DATA

c. Drawings required by paragraph SD-02 SHOP DRAWINGS

d. Prices for spare parts and supply list

[e. Information on metering

] f. Design test reports

g. Production test reports

[3.3.3 Spare Parts List

Furnish a list of spare parts.

] -- End of Section --

SECTION 26 24 16.00 40

PANELBOARDS
08/19

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA PB 1	(2011) Panelboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595	(Rev C; Notice 1) Colors Used in Government Procurement

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Jul 2020) UL Standard for Safety Panelboards
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1699	(2017; Reprint Feb 2022) UL Standard for Safety Arc-Fault Circuit-Interrupters

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

a. Detail Drawings and Outline Drawings shall be submitted for panelboards in accordance with paragraph entitled, "General Requirements," of this section.

SD-03 Product Data

Panelboards; G

Directory Card and Holder; G

SD-06 Test Reports

Acceptance Tests; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in

these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

Products manufactured more than 3 years prior to date of delivery to site are not to be used, unless specified otherwise.

1.3.3 Predictive Testing and Inspection Technology Requirements

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems installed by the Contractor have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

PART 2 PRODUCTS

2.1 PANELBOARDS

Provide panelboards in accordance with NEMA PB 1, UL 67, and UL 50. Ensure panelboards for use as service equipment are also in accordance with UL 869A. Ensure panelboards have current rating, number of phases, and number of wires as indicated or specified herein. Ensure panelboards are rated for 240-volt (maximum), single-phase 120/208-volt, three-phase 277/480-volt, three-phase, 60-hertz as indicated. Ensure each panelboard, as a complete unit, has a short-circuit current rating equal to or greater than the integrated equipment rating indicated, but in no case less than 10,000 amperes symmetrical.

Provide panelboards with bolt-on circuit breakers only. Use of plug-in style breaker is not permitted. Ensure panelboards are designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining required clearance. Provide main lugs or main circuit breakers mounted "above" or "below" branch breakers with current ratings as indicated. Use of sub-feed breakers is not acceptable unless specifically indicated otherwise. Where "space only" is indicated, make provisions for future installation of breakers.

Submit detail drawings and manufacturer's standard product data for panelboards. Detail drawings consist of fabrication and assembly drawings for all parts of the work in sufficient detail to verify conformity with all requirements. Ensure drawings for panelboards indicate details of bus layout, overall physical features, dimensions, ratings, service requirements, and weights of equipment.

2.2 COMPONENTS

2.2.1 Enclosure

Ensure panelboard enclosures are NEMA 250, Type as indicated and in accordance with UL 50 and NEMA PB 1.

Provide flush-mountedor surface mounted panelboard cabinets as indicated. Ensure cabinets are constructed of 12 gauge sheet steel and hot-dipped galvanized after fabrication. Ensure front of cabinet is form-flanged or fitted with structural shapes welded or riveted to the sheet steel for supporting the panelboard front. Provide panelboard cabinets fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch.

Provide door-in-door style cover where entire front is hinged on one side with a piano hinge for the full height and has keyed latch mechanism opposite the hinged side. Provide side gutters in enclosure measuring minimum 5.75 inches for routing of wiring. Where panelboards are installed flush with the walls, ensure that the hinged front can be opened without damage to the adjacent wall surfaces. Ensure circuit breaker access doors are equipped with pin-tumbler cylinder locks. Ensure all locks provided, including locks for hinged covers, are identically keyed and properly tagged. Provide two keys for each enclosure.

Finish panelboards with baked enamel. Finish color is ASTM D1535 No. 61 gray conforming to FED-STD-595.

2.2.2 Panelboard Buses

Providetinned copper buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems with a separate grounding bus in accordance with UL 67 bonded to the panelboard enclosure. Ensure grounding bus is a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment grounding conductors. In addition to equipment grounding bus, provide second "isolated" ground bus, where indicated. Provide three-phase, four-wire and single-phase, three-wire panelboards with an isolated full-capacity bus providing spaces for single-pole circuit breaker switches and spaces indicated as spare.

Provide bus bar connections to the branch circuit breakers that are the "distributed phase" or "phase sequence" type. Ensure single-phase, three-wire panelboard busing is such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Ensure that three-phase, four-wire panelboard busing is such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Ensure current-carrying parts of the bus assembly are plated.

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping.

2.2.3 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 and as specified in Section 26 05 71.00 40 LOW VOLTAGE OVERCORRECT PROTECTIVE DEVICES with frame a trip ratings as indicated.

Provide bolt-on type, molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering. Plug-in type, tandem, and half-size circuit breakers are not permitted.

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous thermal-magnetic tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than 250 ampere.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers or overcurrent protective devices to achieve indicated interrupt rating is not permitted.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

Provide shunt trips where indicated.

Ensure branch circuit breakers supplying convenience receptacle circuits have sensitive instantaneous trip settings of not more than 10 times the trip rating of the breaker to prevent repeated arcing shorts resulting from frayed appliance cords. Provide UL listed single-pole 15- and 20-ampere circuit breakers as "Switching Breakers" at 120 volts ac .

When multiple wires per phase are specified, furnish the circuit breakers with connectors made to accommodate multiple wires.

Ensure circuit breaker spaces called out on the drawings are complete with mounting hardware to permit ready installation of the circuit breakers.

2.2.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.2.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A ground-fault circuit interrupter. Tripping of a branch circuit breaker containing ground fault circuit interruption is not to disturb the feeder circuit to the panelboard.

2.2.3.3 Circuit Breakers for HVAC Equipment

Provide circuit breakers for HVAC equipment having motors (group or individual) marked for use with HACR type and UL listed as HACR type.

2.2.3.4 Arc-Fault Circuit Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated. Two pole arc-fault circuit-interrupters: rated 120/240 volts. The provision of (two) one pole circuit breakers for shared neutral circuits in lieu of (one) two pole circuit breaker is unacceptable. Provide with "push-to-test" button.

2.2.4 Directory Card and Holder

Provide a directory card on the inside of hinged fronts and doors in a metal frame, with spaces for circuit numbers and load supplied. Where hinged fronts or doors are not required, provide the directory card in a metal frame mounted on the left-hand side of the front trim. Ensure the directory card includes type written designations identifying each branch circuit with its respective and numbered circuit breaker.

2.2.5 Precautionary Label

To ensure persons are aware of immediate or potential hazard in the application, installation, use, or maintenance of panelboards, conspicuously mark each panelboard on the trim or dead front shield with the text (or equivalent) **DANGER** symbol. If the panel is supplied with a door, ensure the label is visible when the door is in the open position.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Provide panelboards in compliance with UL 67.

PART 3 EXECUTION

3.1 INSTALLATION

Install panelboards in accordance with the manufacturer's instructions. Fully align and mount panels so that the height of the top operating handle does not exceed 72inches above the finished floor.

Ensure directory-card information is typewritten in capital letters to indicate loads served by each circuit and is mounted in holders behind protective covering.

3.2 FIELD QUALITY CONTROL

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

Do not energize panelboards until the recorded test data has been submitted to and approved by the Contracting Officer.

Provide test equipment, labor, and personnel as required to perform the acceptance tests as specified. Record and submit test data. Include the location and identification of panelboards and megohm readings versus time.

Conduct continuity tests using a dc device with buzzer . Document results as pass-fail.

Conduct continuity and insulation tests on the panelboards after the installation has been completed and before the panelboard is energized. Document results as pass-fail.

Conduct insulation tests on 480-volt panelboards using a 1,000-volt insulation-resistance test set. Record readings every minute until three equal and consecutive readings have been obtained. Ensure resistance between phase conductors and between phase conductors and ground is not less than 50 megohms.

Conduct insulation tests on panelboards rated 300 volts or less using a 500-volt minimum insulation-resistance test set. Record readings after 1 minute and until the reading is constant for 15 seconds. Ensure resistance between phase conductors and between phase conductors and ground is not less than 25 megohms.

Conduct phase-rotation tests on all panelboards using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment in a clockwise direction, facing the source.

3.3 CLOSEOUT ACTIVITIES

Submit manufacturer's instructions for panelboards including special provisions required to install equipment components and system packages. Provide special notices details impedances, hazards and safety precautions.

-- End of Section --

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SECTION 26 27 13.10 30

ELECTRIC METERS
10/07, CHG 2: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

IEEE C37.90.1 (2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE C57.13 (2016) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-4-5 (2017) Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test

IEC 62053-22 (2020) Electricity Metering Equipment (A.C.) - Particular Requirements - Part 22: Static Meters for Active Energy (Classes 0,2 S and 0,5 S)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.18 (2006; R 2016) Protocol Specification for ANSI Type 2 Optical Port

ANSI C12.20 (2015; E 2018) Electricity Meters - 0.1, 0.2, and 0.5 Accuracy Classes

ANSI C62.61 (1993) American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA

20-11; TIA 20-12; TIA 20-13; TIA 20-14;
TIA 20-15; TIA 20-16; ERTA 20-4 2022)
National Electrical Code

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification and on the drawings are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

a. Provide the following in the maintenance manual:
   1. Condensed description of how the equipment operates.
   2. Block diagram indicating major assemblies.
   3. Troubleshooting information
   4. Preventive maintenance.
   5. Spare parts information.

b. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data."

SD-02 Shop Drawings

SD-03 Product Data

Power Meters; G

Current Transformers; G

Potential Transformer; G

Communications Module; G

Protocol Modules; G

Data Recorder; G

Modem; G

Include manufacturer's information for each component, device, and accessory provided with the meter, protocol module or communications module.

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-10 Operation and Maintenance Data

Power Meters; G

Communications Module; G

Protocol Modules; G

Data Recorder; G

Modem; G

SD-11 Closeout Submittals

System Function Verification; G

1.4 QUALITY ASSURANCE

1.4.1 Installation Drawings

Drawings indicate but are not limited to the following:

a. Elementary diagrams and wiring diagrams with terminals identified of advanced meter, current transformers, potential transformers, protocol modules, communications modules, Ethernet connections, telephone lines.

b. One-line diagram, including meters, switch(es), current transformers, potential transformers, protocol modules, communications modules, Ethernet connections, telephone outlets, and fuses. For each meter installation, provide a diagram identified by the building number.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Provide product that has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.4 Material and Equipment Manufacturing Data

Do not use products manufactured more than 2 years prior to date of delivery to site, unless specified otherwise.

1.5 WARRANTY

Provide equipment items supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6 SYSTEM DESCRIPTION

1.6.1 System Requirements

The metering and reading system, consisting of commercial, off-the-shelf meters, protocol modules, communications modules, and communication channels, will be used to record the electricity consumption and other values as described in the sections that follow and as shown on the drawings.

1.6.2 Selection Criteria

Metering components are part of a system that includes the physical meter, data recorder function and communications (modem) method. Include sufficient metering components to measure the electrical parameters identified and to store and communicate the values as required in the following sections for every building site identified. Verify that the metering system installed on any building site is compatible with the facility-wide communication and meter-reading protocol system. Contractor must connect the metering system to the facility-wide energy and utility monitoring and control system.

PART 2 PRODUCTS

2.1 POWER METERS

2.1.1 Physical and Common Requirements

a. Install metering system components according to the Metering System Schedule shown in this specification.

b. Power meter must be socket-mount design.

c. Power meter must be panel-mounted design. Furnish meters that are semi-flush, back-connected, dustproof, draw-out switchboard type. Provide cases with window removable covers capable of being sealed against tampering. Meters must be of a type that can be withdrawn through approved sliding contacts from fronts of panels or doors without opening current-transformer secondary circuits, disturbing external circuits, or requiring disconnection of any meter leads. Incorporate necessary test devices within each meter and provide means for testing either from an external source of electric power or from associated instrument transformers or bus voltage.

d. If existing meter base is usable, the meter base determines meter form factor. If a new meter is being installed, use meter and base form factor of 9S.

f. Provide meter consisting of a Class 20, transformer rated design.

g. Provide meter that is rated for use at temperature from -40 degrees Fahrenheit to +158 degrees Fahrenheit.

h. Meter must have NEMA 3R enclosure for surface mounting.

i. Surge withstand must conform to IEEE C37.90.1.

j. Provide meter with a standard 4-year warranty.

k. Provide meter in compliance with IEC 62053-22 (Part 21: Static Meter for

Active Energy, classes 0.2S and 0.5S), certified by a qualified third party test laboratory.

2.1.2 Voltage Requirements

a. Furnish meter that is capable of connection to the service voltage phases and magnitude being monitored. If the meter is not rated for the service voltage, provide suitable potential transformers to send an acceptable voltage to the meter.

b. Provide meter that is capable of connection to the service voltage indicated in the Metering System Schedule:

c. Provide meter that accepts independent voltage inputs from each phase and is auto-ranging over the full range of input voltages.

d. Optically isolate voltage input to 2500 volts DC from signal and communications outputs. Use components meeting or exceeding IEEE C37.90.1 (Surge Withstand Capability).

e. The Contractor is responsible for determining the actual voltage ratio of each potential transformer. Provide transformer conforming to IEEE C57.13 and the following requirements.

   1. Type: Dry type, of two-winding construction.

   2. Weather: Outdoor or Indoor rated for the application.

   3. Frequency: Nominal 60Hz, 50Hz for those bases that operate on 50Hz.

   4. Accuracy: Plus or minus 0.3% at 60Hz or 0.3% for those systems that operate at 50Hz.

2.1.3 Current Requirements

a. Accept independent current inputs from each phase. Install current transformer with a full load rating as shown in the schedule.

b. Provide single ratio current transformer with an Accuracy Class of 0.3 with a maximum error of +/- 0.3% at 5.0 amps.

c. Current transformer must have:

   1. Insulation Class: Provide 600 volt and below current transformers rated at 10 KV BIL. Provide current transformers for 2400 and 4160 volt service rated at 25 KV BIL.

   2. Frequency: Nominal 60Hz, 50Hz for bases that operate on 50Hz.

   3. Burden: Select burden class for the load.

   4. Phase Angle Range: 0 to 60 degrees.

d. Provide meter that accepts current input from standard instrument transformers (5A secondary current transformers.)

e. Current inputs must have a continuous rating in accordance with IEEE C57.13.

f. Provide multi-ratio current transformer where indicated with a top range equal to or greater than the actual load. The Contractor is responsible for determining the actual ratio of each transformer. Provide current transformer conforming to IEEE C57.13.

2.1.4 Electrical Measurements

Measure and report the following quantities:

a. Kilowatt-hours ("kWh" in Metering Systems Schedule) of consumption. Cumulative.

b. Kilowatts of demand ("kW" in Metering Systems Schedule). Peak average over a selectable demand interval between 5 and 60 minutes (typically 15 minutes).

c. Reactive power ("kVAR" in Metering Systems Schedule). Measured over the same interval as the peak kW reading.

d. Power factor ("PF" in Metering Systems Schedule). Measured over the same interval as the peak kW reading.

e. Time of use consumption ("TOU" in Metering Systems Schedule). Kilowatt-hours recorded separately for each period set by programming into the meter. Time periods must be capable of being changed without removal from service. The meter must internally record and store Time of Use data.

1. Four (4) minimum TOU Rates (Registers)

2. Twenty (20) Year Calendar

3. Two (2) minimum seasons per year

f. Interval recording ("IR" in Metering Systems Schedule). Record kilowatt-hours for each 15 minute interval and accumulate for 30 days. Memory for recording the interval readings must be internal to the meter and ANSI C12.19 compliant. Provide time-stamped readings for every measured parameter.

g. Meter readings must be true RMS.

2.1.5 Meter Accuracy

Provide the following accuracies. Measure accuracies as percent of reading at standard meter test points.

a. Provide power meter meeting ANSI C12.20 for Class 0.2 and IEC 62053-22 accuracy requirements.

2.1.6 An on the Meter Display, Output and Reading Capabilities

Include the following output signals.

a. The meter will have a face display plate and will display every electrical parameter indicated to be recorded. Do not require meters to indicate interval data collected in a data logger with a communications output feature. Display peak values, instantaneous and cumulative values.

b. Include optical output port capable of 9600 bps communication with a hand-held reading device. Provide optical device that is compatible with ANSI C12.18

c. Include output options for analog milliamp signals.

d. Provide meter with two channels of analog output, 0-1mA or 4-20mA, for positive watt/hour readings.

e. Include output option for pulse output. KYZ pulse output related to kWatts/HR.

f. Provide meter with two form C, dry contact relay outputs for alarm or control.

2.1.7 Installation Methods

a. Transformer mounted (XFMR)

1. Locate meter base outside on the secondary side of the pad-mounted transformer.

b. Stand-mounted adjacent to transformer ("STAND" in Metering Systems Schedule)

1. Mount meter base on a structural steel pole approximately 4 feet from the transformer pad. See detail on the drawings.

c. Building mounted ("BLDG" in Metering Systems Schedule)

1. Mount meter base on the side of the existing building near the service entrance. See detail on the drawings.

d. Panel mounted. ("PNL" in Metering Systems Schedule)

1. Mount meter where directed. See detail on the drawings.

e. Common features.

1. PTs (if required for proper voltage range) and physically connect CTs to the service entrance cables inside the service entrance disconnect enclosure.

2.1.8 Disconnecting Switches

a. Provide disconnecting wiring blocks between the current transformer and the meter. Build a shorting mechanism into the wiring block to allow the current transformer wiring to be changed without removing power to the transformer. Locate the wiring blocks where they are accessible without the necessity of disconnecting power to the transformer. For multi-ratio current transformers, provide a shorting block from each tap to the common lead.

b. Equip voltage-monitoring circuits with disconnect switches to isolate the meter base or socket from the voltage source.

2.1.9 Meter Programming

a. Provide power meter that is programmable by software supplied by the meter manufacturer.

b. Provide user-friendly software with Windows-compatible interface.

c. Operate software on Windows operating systems.

d. Provide software that allows the user to configure the meter, troubleshoot meter, query and display meter parameters and configuration data and stored values.

e. Provide meter firmware that is upgradeable through one of the communications ports without removing the unit from service.

2.2 COMMUNICATIONS

2.2.1 Communications Methods

2.2.1.1 Optical Port

Communicate with a hand-held reading device according to the following requirements.

a. Communications standards

1. ANSI C12.18

2. MV90 protocol

3. ANSI C12.20

b. Read operations

1. Current kWh values

2. Demand (kW) values since last reset

3. Last reset value

4. Meter status

5. Load profile

c. Write operations

1. Meter setup

2.2.1.2 Serial Port

Provide serial port for connection to modem module where required in this specification.

a. On-Board serial port types

1. RS232

2. \RS485

2.2.1.3 Ethernet

For those meters using the Ethernet, send logged information using open standard Internet Protocols.

a. On-board Ethernet port support

    1. HTTP

    2. SMTP

        (a) Modbus

b. Distribute stored data by

    1. FTP

    2. E-Mail

        (a) On-board web server

2.2.2 Communications Protocols and Methods

Use communications protocols and methods that are native to the meter. Provide communications module(s) as required to accomplish the following.

a. Include an IR port ("IR" in Metering Systems Schedule) for communication to external devices such as handheld readers that support a minimum speed of 9600 baud.

b. Include one or one digital communication port. Provide user configurable port with regard to speed, protocol, address, and other communications parameters that support a minimum communication speed of 9600 baud for the RS232 port.

c. Provide meter with a port that can be configured as a 10/100 Base-T Ethernet port ("BaseT" in Metering Systems Schedule)

    1. A communication module that converts serial RS232 or RS485 to Ethernet will be acceptable.

d. Auto Answer minimum 1200 baud internal modem ("A56K" in Metering Systems Schedule). Include automatic data buffering to provide faster, more reliable communications and the ability to automatically answer on a connected line.

e. Equip meter with one pulse output channel ("Pulse" in Metering Systems Schedule) that can be configured for operation as KYZ pulse output.

2.2.3 Communications Channels Surge Protection

Protect communications equipment against surges induced on its communications channels. Protect communication interfaces to all field equipment to meet the requirements of IEEE C37.90.1 or the requirements of IEC 61000-4-5, test level 4, while the equipment is operating. Do not use fuses for surge protection. For metallic cables and conductors which serve as communications channels between buildings, install surge protection at equipment rated for the application at each end, within 3 feet of the building cable entrance. Provide surge protectors meeting the requirements of the applicable extension of ANSI C62 (for example, ANSI C62.61).

2.3 METER DATA PROTOCOL

Provide power meters that have communicating data protocols native or provide in supplemental modules to communicate with the communications methods that follow.

2.3.1 Open Protocol

Support the following open protocols. Verify that the meter native protocol is consistent with the facility data recording and communication and data storage system. Provide additional converters and modules as required for a complete measurement, recording, communicating and data storage system.

a. Provide meter that is fully supported by MV-90 software system or existing AMR software that is MV-90 compatible.

b. For systems that use proprietary software, an alternative, competitive software system must be available.

Systems capable of using more than one brand of commercially available meters are expected. In addition, if proprietary meter reading software is used, meters are to be capable of being read by more than one manufacturer's software.

2.4 SPARE PARTS

2.4.1 Parts List

Provide spare parts as follows:

a. Power meter - two for each type used.

b. Current transformer - three for each type used.

c. Potential transformer - three for each type used.

d. Communications module - one for each type used.

e. Protocol module - one for each type used.

f. Other electronic and power components - one for each type used.

2.5 METERING SYSTEM SCHEDULE

Metering System Schedule is available at http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-

PART 3 EXECUTION

3.1 INSTALLATION

Perform electrical installations conforming to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.1.1 Existing Condition Survey

Perform a field survey, including inspection of all existing equipment, resulting clearances, and new equipment locations intended to be incorporated into the system, and furnish an existing conditions report to the Government. Identify those items that are non-workable as defined in the contract documents. The Contractor is responsible for repairs of modifications necessary to make the system perform as required.

3.1.2 Scheduling of Work and Outages

The Contract Clauses govern regarding permission for power outages, scheduling of work, coordination with Government personnel, and special working conditions.

3.2 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory-applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3 FIELD QUALITY CONTROL

3.3.1 Performance of Acceptance Checks and Tests

3.3.1.1 Meter Assembly

a. Visual and mechanical inspection

1. Compare equipment nameplate data with specification and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.

4. Verify grounding of metering enclosure.

5. Verify the presence of surge arresters.

6. Verify that the CT ratio and the PT ratio are properly included in the meter multiplier or the programming of the meter.

b. Electrical tests

1. Calibrate watthour meters according to manufacturer's published data.

2. Verify that correct multiplier has been placed on face or meter where applicable.

3. Prior to system acceptance, the Contractor will demonstrate and confirm the meter is properly wired and is displaying correct and accurate electrical information.

3.3.1.2 Current Transformers

a. Visual and mechanical inspection

1. Compare equipment nameplate data with specification and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.

5. Verify that required grounding and shorting connections provide good contact.

b. Electrical tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance test.

3. Perform a polarity test.

4. Perform a ratio-verification test.

3.3.1.3 Potential Transformers

a. Visual and mechanical inspection

1. PT's are rigidly mounted.

2. PT's are correct voltage.

3. Verify that adequate clearances exist between primary and secondary circuit.

b. Electrical tests

1. Perform a ratio-verification test.

3.3.2 Follow-Up System Function Verification

Upon completion of acceptance checks and tests, the show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, give the Contracting Officer 5 working days' advance notice of the dates and times of checking and testing.

3.3.3 Training

Conduct a training course for meter configuration, operation, and maintenance of the system as specified. Orient the training for all components and systems installed under this contract. Deliver training manuals for 6 trainees with two additional copies delivered for archiving at the project site. Furnish all audiovisual equipment and all other training materials and supplies. A training day is defined as eight hours of classroom instruction, including two 15-minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, assume that attendees have a high school education or equivalent, and are familiar with utility systems. Obtain approval of the planned training schedule from the Government at least 30 days prior to the training.

a. Training: Teach the course at the project site within thirty days after completion of the installation for a period of one to five day(s). A maximum of 6 personnel will attend the course. The training includes:

1. Physical layout of each piece of hardware.

2. Meter configuration, troubleshooting and diagnostics procedures.

3. Repair instructions.

4. Preventive maintenance procedures and schedules.

5. Testing and calibration procedures.

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SECTION 26 28 00.00 10

MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS
08/22

PART 1 GENERAL

1.1 SUMMARY

These specifications include the design, fabrication, assembly, wiring, testing, and delivery of the items of equipment and accessories and spare parts listed in the Schedule and shown on the drawings.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1 (2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M (2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

ASTM B187/B187M (2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

ASTM D877 (2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

ASTM D923 (2007) Standard Practice for Sampling Electrical Insulating Liquids

ASTM D924 (2008) Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids

ASTM D971 (2020) Standard Test Method for Interfacial Tension of Insulating Liquids Against Water by the Ring Method

ASTM D974	(2014; E 2016) Standard Test Method for Acid and Base Number by Color-Indicator Titration
ASTM D1500	(2012; R 2017) Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
ASTM D1524	(2015; R 2022) Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field
ASTM D1533	(2012) Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.04	(2018; Erta 2019; Corr 2021) Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V Corrigendum 1
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.4	(1984; R 2011) Registers - Mechanical Demand
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA PB 1	(2011) Panelboards

NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard
NEMA/ANSI C12.11	(2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8510.01	(2020; Change 1-2020) Risk Management Framework (RMF) for DoD Information Technology (IT)
DODI 8500.01	(2014) Cybersecurity

UNDERWRITERS LABORATORIES (UL)

UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Jul 2020) UL Standard for Safety Panelboards
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 845	(2021) UL Standard for Safety Motor Control Centers
UL 891	(2019) UL Standard for Safety Switchboards
UL 1063	(2017; Reprint Jun 2020) UL Standard for Safety Machine-Tool Wires and Cables

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

Shop Drawings; G

Motor Control Centers; G

Switchboards; G

Panelboards; G

SD-03 Product Data

Equipment; G

Factory Tests

Required Settings

Request For Settings

SD-06 Test Reports

Factory Tests

Acceptance Checks And Tests; G

SD-07 Certificates

Motor Control Centers

1.4 DELIVERY, STORAGE, AND HANDLING

Submit copies of such descriptive cuts and information as are required to demonstrate fully that all parts of the equipment will conform to the requirements and intent of the specifications, within 30 calendar days after date of award for approval. Include descriptive data showing typical construction of the types of equipment proposed, including the manufacturer's name, type of molded case circuit breakers or motor circuit protectors, performance capacities and other information pertaining to the equipment. Also sets of characteristic curves of the individual breaker trip element. Ship the equipment as completely assembled and wired as feasible so as to require a minimum of installation work. Properly match mark each shipping section to facilitate reassembly, and provide with removable lifting channels with eye bolts for attachment of crane slings to facilitate lifting and handling. Carefully pack and ship separately any relay or other device which cannot withstand the hazards of shipment when mounted in place on the equipment. Mark these devices with the number of the panel which they are to be mounted on and fully identified. Wrap all finished painted surfaces and metal work or otherwise protect from damage during shipment. Prepare all parts for shipment so that slings for handling may be attached readily while the parts are in a railway car or transport truck. Carefully package and clearly mark all spare parts and accessories.

1.5 MAINTENANCE

1.5.1 Accessories and Tools

Furnish a complete set of accessories and special tools unique to equipment provided and required for erecting, handling, dismantling, testing and maintaining the apparatus.

1.5.2 Extra Materials

Furnish spare parts as specified below. All spare parts must be of the same material and workmanship, must meet the same requirements, and must be interchangeable with the corresponding original parts furnished.

SPARE PARTS	
Amount	Description
2 of each type and size	Fuses
1	Circuit breaker auxiliary switch
2 for each size ac contactor	Operating coils
1 for each size dc contactor	Operating coil
2 Complete sets for each size ac contactor	3-pole stationary and moving contact assemblies
1 Complete set for each size dc contactor	2-pole stationary and moving contact assemblies
3 of each type and rating	Contactor overload relays, each relay with a complete set of contact blocks
1 Spare set for each heater rating provided	Heater elements
2 for each type	Indicating lamp assemblies
1 of each type and rating	Control transformer
1 of each type and rating	Control relay
1 of each type	Contactor auxiliary contact
4 One quart containers	Finish paint for indoor equipment
2 One quart containers	Paint used for the exterior surfaces of outdoor equipment
4	Keys for motor control center door loc
1 for each type and rating	Circuit Breaker

SPARE PARTS	
Amount	Description
1 for each type and rating	Motor Circuit Protector

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are standard products of a manufacturer regularly engaged in their manufacture and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening and that conform to the requirements of these specifications. Provide high quality materials, free from defects and imperfections, of recent manufacture, and of the classification and grades designated. All materials, supplies, and articles not manufactured by the Contractor must be the products of other recognized reputable manufacturers.

2.1.1 Rules

Provide equipment conforming to the requirements of NFPA 70 unless more stringent requirements are indicated herein or shown. NEMA rated and UL listed equipment has been specified when available. Provide equipment meeting NEMA and UL construction and rating requirements as specified. No equivalent will be acceptable. Immediately notify the Contracting Officer of any requirements of the specifications or Contractor proposed materials or assemblies that do not comply with UL or NEMA. International Electrotechnical Commission (IEC) rated equipment will not be considered an acceptable alternative to specified NEMA ratings.

2.1.2 Coordination

The general arrangement of the motor control centers, switchboards and panelboards is shown on the contract drawings. Any modifications of the equipment arrangement or device requirements as indicated will be subject to the approval of the Contracting Officer. If any conflicts occur necessitating departures from the drawings, submit details of and reasons for departures for approval prior to implementing any change. Completely assemble all equipment at the factory. The motor control centers and switchboards may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.

2.2 NAMEPLATES

Provide nameplates made of laminated sheet plastic or of anodized aluminum approximately 1/8 inch thick, engraved to provide white letters on a black background. Fasten the nameplates to the panels in proper positions with anodized round-head screws. Lettering must be minimum 1/2 inch high. Provide nameplate designations in accordance with lists on the drawings, and as a minimum provide nameplates for the following equipment:

a. Motor Control Centers

b. Individual items of equipment mounted in the Motor Control Centers

c. Switchboards

d. Individually-mounted circuit breakers in Switchboard

e. Group-mounted circuit breakers in Switchboard

f. Panelboards

g. Individually-mounted circuit breakers in Panelboard

Provide equipment of the withdrawal type with nameplates mounted on the removable equipment in locations visible when the equipment is in place.

2.3 CONNECTIONS

Furnish all bolts, studs, machine screws, nuts, and tapped holes in accordance with ASME B1.1. Provide sizes and threads of all conduit and fittings, tubing and fittings, and connecting equipment in accordance with ASME B1.20.1. Provide ferrous fasteners that have rust-resistant finish and equip all bolts and screws with approved locking devices. Manufacturer's standard threads and construction may be used on small items which, in the opinion of the Contracting Officer, are integrally replaceable, except that threads for external connections to these items must meet the above requirements.

2.4 MOLDED CASE CIRCUIT BREAKERS

Provide molded case circuit breakers conforming to the applicable requirements of UL 489 and UL 489. Provide circuit breakers that are manually-operated, that are the quick-make, quick-break, common trip type, and that are of the automatic-trip type unless otherwise specified or indicated on the drawings. Operate all poles of each breaker simultaneously by means of a common handle. Provide operating handles that clearly indicate whether the breakers are in "On," "Off," or "Tripped" position and have provisions for padlocking in the "Off" position. Provide personnel safety line terminal shields for each breaker. Furnish circuit breakers that are products of only one manufacturer, and are interchangeable when of the same frame size. Where indicated on the drawings, provide circuit breakers with shunt trip devices.

2.4.1 Trip Units

Except as otherwise noted, provide combination thermal and instantaneous magnetic or solid state trip units for the circuit breakers, of frame sizes and the trip unit ratings as shown on the drawings. The Government reserves the right to change the indicated trip ratings, within frame limits, of the trip devices at the time the shop drawings are submitted for approval. Submit copies of outline drawings of all equipment to be furnished under this contract, together with weights and overall dimensions, within 30 calendar days after date of award , for the approval of the Contracting Officer. Provide interchangeable breaker trip units and instantaneous magnetic trip units that are adjustable on frame sizes larger than 150 amperes. Set nonadjustable instantaneous magnetic trip units at approximately 10 times the continuous current ratings of the circuit breakers.

2.4.2 480-Volt AC Circuits

Furnish circuit breakers for 480-volt or 277/480-volt ac circuits that are rated 600 volts ac, andthat have an UL listed minimum interrupting capacity of 14,000 symmetrical amperes at 600 volts ac.

2.4.3 120/240-Volt AC Circuits

Circuit breakers for 120-volt ac circuits rated less than 120/240 or 240 volts ac are not permitted, and must have a UL listed minimum interrupting capacity of 10,000 symmetrical amperes.

2.4.4 125-Volt DC Circuits

Circuit breakers for 125-volt dc circuits must be two-pole rated 125/250 or 250 volts dc, and must have an UL listed minimum interrupting capacity of 10,000 amperes dc.

2.5 WIRING

Provide control wire consisting of stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44 or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards. Provide hinge wire consisting of Class K stranding. Current transformer secondary leads smaller than No. 10 AWG is not permitted. The minimum size of control wire is be No. 14 AWG. Furnish power wiring for 480-volt circuits and below that is the same type as control wiring and a minimum size of No. 12 AWG. Give special attention to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.6 CONTROL SWITCHES

2.6.1 General

All control switches must be of the rotary switchboard type with handles on the front and the operating contact mechanisms on the rear of the panels. Provide each switch with ample contact stages to perform the functions of the control system and provide with at least two spare contacts. Provide self-aligning contacts that operate with a wiping action. Provide a positive means of maintaining high pressure on closed contacts. Compression springs or pivotal joints must not carry current. All control switches must be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches must be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. Provide switches capable of continuously carrying 20 amperes without exceeding a temperature rise of 30 degrees C. The single-break inductive load interrupting rating of switches must not be less than 1.5 amperes for 125 volts DC or 10 amperes for 115 volts AC.

2.6.2 Switch Features

a. Provide control and instrument switches that are suitable for the intended use and that have the features shown on the schematic diagrams and switch development drawings. Provide switches that have handles as shown or approved and are black in color unless otherwise specified.

b. Control switches for electrically-operated circuit breakers must be 3-position momentary-contact type with spring return to neutral position, and must have modern-black, heavy duty pistol grip handles. Provide circuit breaker control switches that have mechanical operation indicators to show the last manual operation of the switches and slip contacts.

c. Provide control switches for instrument and meter transfer switches and for selector switches that are the maintained contact type with the required number of positions and that have round notched or knurled handles. Connect ammeter and voltmeter switches to read all three phase ammeter switches. Do not open the secondary circuits of the current transformer at any time.

c. Provide each control switch with an escutcheon clearly marked to show each operating position. Engrave the switch identifications on the escutcheon plates or on separate nameplates. The escutcheon and nameplate markings are subject to approval.

2.7 TERMINAL BLOCKS

Furnish control circuit terminal blocks for control wiring that are molded or fabricated type with barriers, rated not less than 600 volts. Provide terminals that are removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals must be no less than No. 10 in size and have sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement is subject to the approval of the Contracting Officer and provide no less than four (4) spare terminals or 10 percent, whichever is greater, on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. Submit data showing that the proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.7.1 Types of Terminal Blocks

2.7.1.1 Short-Circuiting Type

Furnish short-circuiting type terminal blocks for all current transformer secondary leads and have provision for shorting together all leads from each current transformer without first opening any circuit. Provide terminal blocks meeting the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

2.7.1.2 Load Type

Provide load terminal blocks rated no less than 600 volts and of adequate capacity for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits except those for feeder tap units. Provide terminals that are either the stud type with contact nuts and locking nuts or the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Place the circuit designation or wire number on or near the terminal in permanent contrasting color for each connected terminal.

2.7.2 Marking Strips

Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations. Make wire numbers with permanent ink. Use reversible marking strips to permit marking both sides, or furnish two marking strips with each block. Marking strips must accommodate the two sets of wire numbers. For each device to which a connection is made, assign a device designation in accordance with NEMA ICS 1 and mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations. Show the general arrangement and overall dimensions of the motor control centers, switchboards, and panelboards. Show space requirements, details of any floor supports to be embedded in concrete and provisions for conduits for external cables. Prints of drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

2.8 SPACE HEATERS

Provide space heaters where indicated on the drawings and control using an adjustable 50 to 90 degrees F thermostat, magnetic contactor, and a molded-case circuit breaker and a 480-120 volt single-phase transformer, where required. Provide space heaters that are 250-watt, 240 volt strip elements operated at 120 volts and are supplied from the motor control center bus . Furnish contactors that are open type, electrically-held, rated 30 amperes, 2-pole, with 120-volt ac coils.

2.9 MOTOR CONTROL CENTERS

Design each motor control center for operation on 480-volts ac, 3-phase, 60-Hz system, and equipment conforming to all the applicable requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 4and NEMA ICS 6. List and label vertical sections and individual units under UL 845 where ever possible. In lieu of the UL listing, certification from any nationally recognized, adequately equipped, testing agency that the individual units and vertical sections have been tested and conform to the UL requirements of that agency will be acceptable when approved by the Contracting Officer.

a. Certification of factory test reports. Certification must be signed by official authorized to certify on behalf of the manufacturer, attesting that the motor control center meets the specified requirements. The statement must be dated after the award of this contract, must state the Contractor's name and address, must name the project and location, and must list the specific requirements which are being certified.

b. Furnish motor control center that is NEMA Class II, Type B or C as indicated in the bid item list, motor control centers in accordance with NEMA ICS 2. Submit copies of electrical equipment drawings, within 30 calendar days after date of award , for the approval of the Contracting Officer. The NEMA Class II motor control center drawings must include a connection diagram with wire designations and schematic diagrams to illustrate operation of associated motor unit controls.

c. Submit an individual wiring diagram for each motor control center. Wiring diagrams must be in a form showing physical arrangement of the control center with interconnecting wiring shown by lines or by terminal designations (wireless). Provide a single-line diagram, equipment list and nameplate schedule for each switchboard and panelboard.

2.9.1 Enclosures

Provide motor control center consisting of the required number of vertical sections of 90 inches nominal height, bolted together, with steel channel sills and suitable for mounting against a wall. Provide vertical section that is 20 inches deep and buses, control wiring, control transformers, small power transformers, terminal blocks, line terminals, cable supports, and clamps that are accessible from the front. Provide NEMA Type 1 gasketed 12 3R enclosure. Fabricate the control centers from smooth select steel sheets shaped and reinforced to form rigid free-standing structures. Metal thickness for enclosures less than specified in NEMA ICS 6 are not acceptable. Fabricate and bolt vertical edges of sections exposed to view so that the joints will not pass a 1/16 inch gage. Design each structure for the addition of future sections required. Isolate individual compartments from adjacent compartments.

2.9.1.1 Unit Compartments

Each operating unit must contain equipment as shown on the drawings, mounted in an individual cell. The unit assembly, except main circuit breakers, panelboards and auxiliary control devices, must be drawout type removed from the front, without rear access or disturbing other units in the control center assembly. Provide drawout type unit assemblies that have positive guide rail system to ensure alignment of connection to vertical bus. Provide units that are mechanically interlocked with the door to prevent removal while in the energized position. Each removable unit must have provision for padlocking in a position in which it is disconnected from the vertical bus although not removed from the stationary structure. Provide all ventilating openings with corrosion-resistant insect-proof screens on the inside. Provide bus closing plugs for all unused openings in vertical bus barriers.

2.9.1.2 Motor Control Center Doors and Covers

Provide each unit compartment, including blank compartments for future use, with either a flange-formed or a rolled-edge door. Mount each door on fully-concealed or continuous full-length piano-type hinges and provide with positive fasteners. Prevent door sag by proper alignment of hinges made of sufficiently strong material. Provide interlocked door fastenings to prevent opening when the equipment is energized. Provide external operating handle that clearly indicates whether the equipment is in an "ON", "OFF" or "TRIPPED" position.

2.9.1.3 Horizontal Wireways

Structure must have a minimum 12 inches high wireway at the top and a 6 inches minimum wireway at the bottom. Run both horizontal wireways the length of the structure Provide a master terminal block compartment with full length wireway space at the where indicated in all Type C assemblies. Provide cover plates on the side of the assembly to permit extension of the horizontal bus and wireway when vertical sections are added.

2.9.1.4 Vertical Wireways

Provide vertical wireways in all vertical sections accepting multiple plug-in components. Connect vertical wireways with horizontal wireways at the top and bottom and are a minimum 4 inches wide. Provide barriers in sections containing both ac and dc vertical buses. Provide doors on each vertical wireway. The exposed surface of any door must not deviate more than 1/16 inch from a true plane.

2.9.1.5 Sills

Furnish channel iron foundations, complete with bolts and drilled holes for grouting and anchoring to the floor, for the complete length (front and rear) of each motor control center assembly. Design the channels for flat mounting and a maximum channel depth of 1-1/2 inches. Provide additional channel or substantial metal trim flush with the end panels to completely enclose the bases across the ends of the equipment assemblies.

2.9.1.6 NEMA 3R Enclosures

The motor control center must be non-walk in NEMA Type 3R rainproof enclosure as shown on the drawings. Provide outside enclosure consisting of smooth select steel sheets on a structural steel frame. Provide full-length single or double doors with top and bottom bolts and a center latch operated by means of a keyed handle. Provide steel sheets and doors that are no less than No. 10 gage thick and doors that have bent angle or channel edges with all corner seams welded and ground smooth. Assemble the motor control center within the enclosure with adequate gaskets and structure to assure a measure of vandal resistance. Provide ventilating openings and an effective insulating air space of approximately 2 inches below the roof of the structure which slopes from front to back for adequate drainage. The outside edges of the control center base must permit easy sealing at the concrete surface with mastic compound. Furnish a 200-watt outdoor lighting fixture with globe and guard to light the front of the assembly. Provide watertight lighting connections. Furnish a weatherproof switch installation on the front or side of the enclosure so that the light can be switched prior to opening the assembly doors. Provide "ac" rated, 15 amperes, 120/277 volts exterior manual switch. Provide two duplex receptacle units within the outer weatherproof enclosure. Wire the lighting fixture and receptacles to the 120-volt ac panelboard located in the control center, and run external wiring in rigid galvanized steel conduit.

2.9.1.7 Shutters

Provide drawout units that have shutters which close when the unit is withdrawn to isolate the vertical bus.

2.9.2 Buses

Furnish buses that are copper and furnish all bolted splices and connections between buses and for extensions or taps for equipment that are tin or silver-plated . Provide copper bars and shapes for bus conductors conforming to the applicable requirements of ASTM B187/B187M . Bolt all splices for field assembly with at least two bolts and employ the use of "Belleville" washers in the connection. Base the bus ratings on a 65 degree Celsius maximum temperature rise in accordance with UL 845 requirements. Bus must have a short-circuit current rating as required or indicated for the application. Support all bus work on wet process porcelain insulators, glass polyester, or suitable molded material.

2.9.2.1 Horizontal Bus

Provide each control center assembly with a three-phase main horizontal bus, with a continuous current rating as required or indicated for the application. Drill the ends of horizontal buses for future extensions. Fully insulate the main horizontal bus.

2.9.2.2 Vertical Bus

Provide each vertical section with a three-phase vertical bus with a continuous current rating as required or indicated for the application connected to the horizontal bus by brazing, welding, or bolting. Where the incoming feeder breakers are located at the bottom of a control center, rate the vertical bus in that section the same as the main horizontal bus. Extend vertical buses from the horizontal bus to the bottom of the lowest available unit mounting space. Isolate the vertical bus from wireways and equipment in compartments.

2.9.2.3 Ground Bus

Provide a full width copper ground bus at the bottom of the motor control center line-up. Provide a full clamp-type solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable at each end of the bus for connection to the station grounding system.

2.9.2.4 Neutral Bus

Furnish a continuous fully rated neutral bus through the control center. Lugs of appropriate capacity will be furnished.

2.9.3 Combination Starters

Furnish combination motor controller units containing motor circuit protectors, auxiliary and pilot devices and a magnetic contactor with thermal overload relays. Provide ratings of motor circuit protectors, air circuit breakers, contactors, motor controllers and other devices as shown on the drawings. All combination motor controller units must have short circuit ratings as required or indicated for the application. Where control push-buttons, indicating lamps, "Hand-Off-Automatic" switches, and similar control devices are associated with a unit, mount them on the unit compartment door. Door-mounted components must not interfere with access within the compartments. Provide molded case circuit breakers for use in combination starters meeting the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS. Motor circuit protectors are only part of the combination starters as required by NFPA 70 and conform to all requirements of paragraph MOLDED CASE CIRCUIT BREAKERS, except provide trip units that have provision for locking the selected trip setting.

2.9.3.1 Magnetic Contactors

Provide magnetic contactors of the NEMA sizes indicated on the drawings. Conform to the requirements of NEMA ICS 2 for contactors with continuous current ratings for the duty indicated. Provide contactors for motor control that are rated for full-voltage starting (Class A controllers). Provide contactors that are suitable for at least 200,000 complete operations under rated load without more than routine maintenance. Minimize the interruption arc and flame by suitable arc chutes or other means so that no damage will be done to other portions of the device. The arc chutes, if provided, must be easily removable without removing or dismantling other parts. The contacts must be easily removable. All current-carrying contact surfaces must be silver-surfaced or of other approved material to prevent the formation of high resistance oxides.

Operate the contactor without chatter or perceptible hum while energized. Provide coils that are suitable for continuous operation. Provide alternating-current contactors that are three-pole, except where otherwise noted, and insulated for 600 volts ac and of the electrically- operated, magnetically-held type. Provide direct-current contactors that are two-pole, suitable for controlling circuits operating at 125 volts dc, insulated for 250 volts dc, electrically-operated, magnetically-held type and adequate for full-voltage motor starting service.

2.9.3.2 Reduced Voltage Starters

Provide autotransformers rated for medium duty and have taps according to NEMA ICS 2. For thermal over load protection, the autotransformer must have normally closed thermostat wired in series with the normally closed thermal overload contact of the starter. Make initial connection to the 65 percent tap. Provide solid state soft-start starters consisting of three phase SCR controlled for stepless reduced voltage starting of induction motors. Current transformers must provide feedback signal to regulate torque during start up and to prevent overload conditions while motor is running. Furnish starter with starting current of 300 percent of full load amps for thirty seconds, bypass/isolation contactor, and three phase thermal overload relay.

2.9.3.3 Auxiliary Contacts

Provide each controller with a minimum of three auxiliary contacts which can be easily changed from normally open to normally closed. Where indicated on the drawings, provide a fourth auxiliary contact and red and green indicating lights.

2.9.3.4 Overload Relays

Except as otherwise indicated, provide three NEMA Class 20 thermal or solid state overload relays with external manual reset for each controller. Prior to shipment of the control centers, the Contracting Officer will furnish the ratings of the heater elements to be installed in the relays by the Contractor.

2.9.3.5 Individual Control Transformers

Where 120 volt ac control of contactors is indicated or required, provide individual control transformer on the line side of the unit disconnect. Provide control transformers rated 480-120 volts and conforming to the requirements for control transformers in UL 508. Provide control transformers that have adequate volt-ampere capacity for the control functions indicated. Install transformers with primary fuses. Except as otherwise indicated on the drawings, provide each control transformer with a fuse in one secondary lead and ground the other secondary lead.

2.9.3.6 Voltage Fault Protection

Where shown, provide starters with protection against voltage faults, phase unbalance, phase loss, phase reversal, undervoltage and overvoltage. Upon sensing one of these faults, the protector must de-energize the starter. Use a combination of voltage and phase-angle sensing to detect phase loss even when regenerated voltages are present. Connect the protector to the load side of the motor circuit disconnect. Provide an adjustable line voltage trip level, adjustable trip delay, automatic reset and manual reset by an external normally closed push-button, and Double Pull Double Throw

(DPDT) output contacts. Protector operation must have repeatability of +1 percent of set point, maximum, and a dead band of 2 percent maximum. Provide green indicator to show normal status and red indicator to show tripped status. Indicators will be visible through the compartment door. Cover protector with a clear unbreakable cover when LED's are used. Provide nameplates when lamps are used and group with other indicating lights.

2.9.4 Molded Case Circuit Breakers in Unit Compartments

Provide molded case circuit breakers for installation in unit compartments meeting the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS above.

2.9.5 Panelboards for Motor Control Centers

Provide panelboards meeting the requirements of paragraph PANELBOARDS.

2.9.6 Distribution Transformers

Furnish dry type transformers for power and lighting loads with voltage and kVA ratings as indicated on the drawings. Provide transformers conforming to the requirements for general-purpose transformers in NEMA ST 20. Protect each transformer on the primary side with a molded case circuit breaker as indicated on the drawings.

2.9.7 Ground Detector Indicator

Provide ground-detector indicator (GDI) rated 120-volts; has three lamps, one per phase, three 480-120 volt transformers connected delta-wye, adjustable loading resistor for balancing capacitive charging current, and push-to test-switch. Provide visual indication of a single ground-fault on any phase (A, B, or C) of a three-phase, three-wire ungrounded power system. When no phase is grounded, all lamps must glow at partial brightness, giving long lamp life, the push-to test switch must not affect the brightness of any lamp. When a single ground-fault occurs on any phase, the lamp that corresponds to the faulted phase must be dark and the other two lamps must glow at full brightness. The push-to-test switch must cause all lamps to return to partial brightness, showing the GDI is functioning properly.

2.9.8 Wiring for Motor Control Centers

All wiring must meet the requirements of paragraph WIRING above. Provide heavy-duty clamp type terminals for terminating all power cables entering the control centers.

2.9.8.1 Contractor's Wiring

Form Contractor's wiring into groups, suitably bound together, properly support and run straight horizontally or vertically. There must be no splices in the wiring. The manufacturer's standard pressure-type wire terminations for connections to internal devices will be acceptable. Add terminal blocks for wiring to devices having leads instead of terminals. Use ring tongue indented terminals on all wires terminated on control terminal blocks for external or interpanel connections and at shipping splits. Provide contact nuts and either locking nuts or lockwashers for all stud terminals.

2.9.8.2 External Connections

Power and control cables will enter the control centers at the where shown on the drawings.

2.9.8.3 Terminal Blocks

Furnish terminal blocks meeting the requirements of paragraph TERMINAL BLOCKS above. In no case must the terminals provided for circuit breakers or contactors accommodate less than the number or size of conductors shown on the drawings. Give special attention to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.9.9 Control Transformers

Mount control transformers for several starter units in a separate compartment and connect its primary windings to the main bus through a molded case circuit breaker of suitable rating. Provide control transformers that are rated 480-120 volts and conforming to the requirements for control transformers in UL 508. Provide control transformers with adequate volt-ampere capacity for the control functions indicated and an additional 10 percent capacity. Install transformers without primary fuses. Except as otherwise indicated on the drawings, each unit compartment must provide a fuse for control power in one secondary lead and must have the other secondary lead grounded. Equip the unit disconnect with a normally open contact to isolate the control circuit from the source when the controller disconnect is open.

2.9.10 Accessories and Control Devices

Provide control accessories that are suitable for mounting on the front of, or inside, the control centers as indicated on the drawings. Provide control accessories meeting the applicable requirements of NEMA ICS 2. Mount relays and other equipment so that mechanical vibration will not cause false operation.

2.9.10.1 Control Stations

Provide push-button stations and selector switches in conformance to NEMA ICS 2, of the heavy-duty, oil-tight type, rated 600 volts ac, and with a contact rating designation of A600. Provide switches with escutcheon plates clearly marked to show operating positions. Provide sufficient contact blocks to make up the electrically separate contacts required for lead-lag selector switches.

2.9.10.2 LED Indicating Lights

Furnish red and green LED's where shown on the drawings, indicating contact "open" and "closed" position. Make LED's accessible and replaceable from the front of the control center through a finished opening in the compartment door. Provide LED assemblies that are the heavy duty oiltight, watertight, and dusttight type.

2.9.10.3 Control Relays

Provide control relays that are electrically operated, magnetically held, self-reset, open type, suitable for mounting inside the starter compartments, and are 120-volt ac. Provide contacts as indicated on the drawings and have a contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2.

2.9.10.4 Timing Relays

Provide pneumatic type timers that are suitable for mounting inside the control center and rated 120 volts ac, 60 Hz. Provide instantaneous and time delay contacts as indicated on the drawings, and have a contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2. Provide means for manual adjustment over a range as indicated on the drawings.

2.9.10.5 Alternators

Alternators 120-volt, 60 Hz, single-phase, open type, suitable for mounting inside of control center as indicated. Alternators must automatically cycle two motor starters in such a manner that No. 1 will lead and No. 2 will lag during the first cycle, and during the second cycle No. 2 will lead and No. 1 will lag, and the third cycle will repeat the first cycle. The duration of a cycle will be determined by an adjustable time delay. Provide contacts with a minimum contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2.

2.9.10.6 Elapsed-Time Meters

Furnish hour-indicating time meters that have 6- digit registers with counter numbers at least 1/4 inch high. Use white numbers on black backgrounds to provide hour indication with the last digit in contrasting colors to indicate tenths of an hour. Provide enclosure that is 3-1/2 inches square and dust resistant. Provide operating voltage of 120 volts ac. Provide nonreset type.

2.9.11 Feeder Tap Units

Provide feeder tap units as indicated on the drawings.

2.9.12 Metering Section

Provide metering section with instruments as indicated on the drawings.

2.9.12.1 Instrument Transformers

Use transformers for metering meeting the requirements of NEMA/ANSI C12.11 and IEEE C57.13. Protect voltage transformers with removable primary and secondary fuses. Install fuses in each ungrounded lead and locate adjacent to the transformers in an easily accessible place. If cable connections to current transformer primary are required, furnish terminals of an approved solderless type and proper size. If current transformers are connected to buses, furnish proper connections, complete with bolts, nuts, washers and other accessories.

2.9.12.2 Ammeters

Provide switchboard type ammeter where indicated on the drawings. Ammeter shall be complete with selector switch having off position and positions to read each phase current. Provide meters that are long scale 6.8 inches), semiflush rectangular, indicating type mounted at eye level.

2.9.12.3 Voltmeters

Provide switchboard type voltmeter where indicated on the drawings. Voltmeter, range 0 to 600 volts, complete with selector switch having off position and positions to read each phase to phase voltage. Provide meters that are long scale 6.8 inches, semiflush rectangular, indicating type mounted at eye level.

2.9.12.4 Watthour Meters

Furnish watthour meters conforming to ANSI C12.1 and NEMA/ANSI C12.10, except numbered terminal wiring sequence and case size may be the manufacturer's standard. Provide watthour meters of the drawout switchboard type having a 15-minute, cumulative form, demand register meeting NEMA C12.4 and provide with no less than two and one-half stators. Provide watthour demand meters that have factory installed electronic pulse initiators meeting the requirements of ANSI C12.1.

2.9.12.5 Switches

Furnish rotary switchboard type metering switches with handles on the front and operating contact mechanisms on the rear of the panels. Provide control switches suitable for operation on 600-volt AC or 250-volt DC circuits. Provide switches that are capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. Provide maintained-contact type selector switches with the required number of positions, and that have round notched, or knurled handles. Ammeter switches must not open the secondary circuits of current transformers at any time. Provide instrument switches for potential selection with oval handles.

2.10 SWITCHBOARDS

Provide dead-front switchboards conforming to NEMA PB 2 and label under UL 891. Provide completely enclosed self-supporting metal structures with the required number of vertical panel sections, buses, molded-case circuit breakers, and other devices as shown on the drawings. Provide switchboards that are fully rated for a short-circuit current as required or indicated for the application.

2.10.1 Enclosure

Provide NEMA type switchboard enclosure, built with selected smooth sheet steel panels of no less than No. 14 gage, as required or indicated for the application . Exposed panels on the front and ends must have bent angle or channel edges with all corner seams welded and ground smooth. Do not drill or weld the front outside surfaces for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front. Make the front panels in sections flanged on four sides and attach to the framework by screws and arrange for ready removal for inspection or maintenance. Provide rear access to the bus and device connections. Provide ventilating openings as required and preferably of the grille type. Provide all ventilating openings with corrosion-resistant insect-proof screens on the inside. Provide each switchboard with a channel iron base at front, rear, and sides, with exposed ends covered by welded steel plates. Provide grout holes. Bolt the switchboard sections to the base. Mount switchboards as shown on the drawings and furnish mounting materials as indicated. Treat all interior and exterior steel parts to inhibit corrosion and paint as specified in paragraph PAINTING.

2.10.2 Bus

Provide buses that are copper and all bolted splices and connections between buses and for extensions or taps for equipment that are tin or silver-plated throughout. Provide copper bars and shapes for bus conductors conforming to the applicable requirements of ASTM B187/B187M . Bolt all splices for field assembly with at least two bolts and employ the use of "Belleville" washers in the connection. Horizontal and vertical power buses have minimum current ratings as shown on the drawings. Insulate the buses for no less than 600 volts. Braze, pressure-weld or bolt shop splices and tap connections. Bolt all splices for field assembly. Mount the buses on insulating supports of wet process porcelain, glass polyester, or suitable molded material, and brace to withstand no less than 14,000 symmetrical amperes ac.

2.10.3 Grounding Bus

Mount a copper ground bus, rated no less than 300 amps, extending the entire length of the assembled structure, near the bottom of enclosure. Provide a full clamp-type solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable at each end of the bus for connection to the station grounding system.

2.10.4 Components

Equip each switchboard with molded-case circuit breakers conforming to paragraph MOLDED CASE CIRCUIT BREAKERS and with frame sizes, trip ratings, and terminal connectors for attachment of outgoing power cables as shown on the drawings. Stationary mount the circuit breakers individually, as shown on the drawings, that are operable and removable from the front. Where shown on the drawings, enclose circuit breakers in individual compartments. Provide the group-mounted circuit breakers complete with bus work in an integrated assembly on the switchboard and conform to the applicable requirements of paragraph PANELBOARDS.

2.11 PANELBOARDS

Provide panelboards consisting of assemblies of molded-case circuit breakers with buses and terminal lugs for the control and protection of branch circuits to motors, heating devices and other equipment operating at 480 volts ac or less. Provide UL 67 labeled panelboards. "Loadcenter" type panels are not acceptable. Design panelboards for installation in surface-mounted or flush-mounted cabinets accessible from the front only, as shown on the drawings. Provide panelboards that are fully rated for a short-circuit current of 14,000 symmetrical amperes RMS ac.

2.11.1 Enclosure

Furnish enclosures meeting the requirements of UL 50. Fabricate all cabinets from sheet steel of no less than No 10 gage if flush-mounted or mounted outdoors, and no less than No 12 gage if surface-mounted indoors, with full seam-welded box ends. Hot-dip galvanize cabinets mounted outdoors or flush-mounted after fabrication. Paint cabinets in accordance with paragraph PAINTING. Provide outdoor cabinets of NEMA 3R raintight and conduit hubs welded to the cabinet or a removable steel plate 1/4 inch thick in the bottom for field drilling for conduit connections. Form-flange edges of cabinets or fit with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. Fabricate all cabinets so that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch. Provide holes in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 1/2 inch clear space between the back of the cabinet and the wall surface. Mount flush doors on hinges that expose only the hinge roll to view when the door is closed. Fit each door with a combined catch and lock, except provide doors over 24 inches long with a three-point latch having a knob with a T-handle, and a cylinder lock. Provide two keys with each lock, and key all locks alike. Provide finished-head cap screws for mounting the panelboard fronts on the cabinets. Provide enclosure nameplates in accordance with paragraph NAMEPLATES. Provide directory holders, containing a neatly typed or printed directory under a transparent cover, on the inside of panelboard doors.

2.11.2 Buses

Provide dead-front type panelboards with buses and circuit breakers mounted on a plate or base for installation as a unit in a cabinet. Provide buses that are copper . Provide copper bars and shapes for bus conductors conforming to the applicable requirements of ASTM B187/B187M. Provide sizes of buses and the details of panelboard construction meeting or exceeding the requirements of NEMA PB 1. Make suitable provisions for mounting the bus within panelboards and adjusting their positions in the cabinets. Provide terminal lugs required to accommodate the conductor sizes shown on the drawing for all branch circuits larger than No. 10 AWG. Provide a grounding bus with a lug suitable for 1/0 AWG wire for each panelboard.

2.11.3 Components

Equip each branch circuit, and the main buses where so specified or shown on the drawings, with molded-case circuit breakers having overcurrent trip ratings as shown on the drawings. Provide circuit breakers designed for bolted connection to buses in a panelboard assembly, and meeting the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS. Circuit breakers of the same frame size and rating must be interchangeable.

2.12 FACTORY TESTS

Each item of equipment supplied under this contract must be given the manufacturer's routine factory tests and tests as specified below, to insure successful operation of all parts of the assemblies. The Contracting Officer will witness all tests required herein unless waived in writing, and no equipment will be shipped until it has been approved for shipment by the Contracting Officer.

a. Submit copies of manufacturer's routine factory test procedures and production line tests for all motor control centers and switchboards, within a minimum of 14 days prior to the proposed date of tests. Notify the Contracting Officer a minimum of 14 days prior to the proposed date of the tests so that arrangements can be made for the Contracting Officer to be present at the tests.

b. Use factory test equipment and the test methods conforming to the applicable NEMA Standards, and are subject to the approval of the Contracting Officer. Submit complete reproducible copies of the factory inspection results and complete reproducible copies of the factory test results in booklet form, including all plotted data curves, all test conditions, a listing of test equipment complete with calibration certifications, and all measurements taken.

c. Report must be signed and dated by the Contractor's and Contracting Officer's Representatives. Reports of all witnessed tests must be signed by witnessing representatives of the Contractor and Contracting Officer. The Contractor is responsible for the cost of performing all tests and include in the prices bid in the schedule for equipment.

2.12.1 Motor Control Centers Tests

2.12.1.1 Dielectric Tests

Completely assemble each motor control center and perform dielectric tests in accordance with NEMA ICS 1.

2.12.1.2 Operational Tests

Check the correctness of operation of each air circuit breaker or motor circuit protector and magnetic contactor and of all control devices, accessories and indicating lamps. Make these checks rated voltage with power supplies to the main buses. Also check all magnetic contactors for proper operation with power at 90 percent of rated voltage.

2.12.1.3 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Contractor may submit design tests demonstrating that satisfactory short-circuit tests, as specified in NEMA ICS 2, have been made on a motor control center of similar type of construction and having the same available short circuit current at the motor terminals, including any motor contributions, as the motor control centers specified to be furnished under these specifications.

2.12.2 Switchboards Tests

2.12.2.1 Production Tests

Completely assemble each switchboard and give applicable production tests for assembled switchboard as specified in NEMA PB 2.

2.12.2.2 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Contractor may submit design tests demonstrating that satisfactory short-circuit tests have been made on a switchboard of similar type of construction and of the same short-circuit rating as the switchboards specified to be furnished under these specifications.

2.12.3 Panelboards Tests

Assemble each panelboard with cabinet and front to the extent necessary to check the fit and provisions for installing all parts in the field. Give each panelboard a dielectric test in accordance with NEMA PB 1. Operate all circuit breakers to check mechanical adjustments. Check all doors and locks for door clearances and fits and the performance of lock and latches.

2.13 PAINTING

Clean interior and exterior steel surfaces of equipment enclosures thoroughly and then apply a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces must be free from holes, seams, dents, weld marks, loose scale or other imperfections. Apply no less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice to exterior surfaces. Prime exterior, filld where necessary, and give no less than two coats baked enamel with semigloss finish. Equipment located indoors must be ANSI Light Gray, and equipment located outdoors must be ANSI Light Grey. Perform all touch-up work with manufacturer's coatings as supplied under paragraph SPARE PARTS.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems with a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Motor Control Centers

NEMA ICS 1.

NEMA ICS 2.

3.3.2 Switchboards

NEMA PB 1.

3.3.3 Panelboards

NEMA PB 2.

3.3.4 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.5 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.6 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount Motor Control Centers on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inch No. 6 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

d. Provide edges above grade 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

f. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

g. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

h. Cut off and bush conduits 3 inches above slab surface.

i. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount Motor Control Centers on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 4 inches thick.

b. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

c. Provide edges above grade 1/2 inch chamfer.

d. Provide slab of adequate size to project at least 8 inches beyond the equipment.

e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

g. Cut off and bush conduits 3 inches above slab surface.

h. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Submit Required Settings of breakers to the Contracting Officer after approval of the Motor Control Center and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.5.1.1 Motor Control Center

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Compare equipment nameplate data with drawings and specifications.

3. Inspect anchorage, alignment, grounding, and required area clearances.

4. Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

5. Verify that fuse and circuit breaker sizes and types correspond to drawings and coordination study as well as to the circuit breaker address for microprocessor-communication packages.

6. Verify that current and voltage transformer ratios correspond to drawings.

7. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or

performing thermographic survey.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

10. Confirm correct application of manufacturer's recommended lubricants.

11. Inspect insulators for evidence of physical damage or contaminated surfaces.

12. Verify correct barrier and shutter installation and operation.

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that filters are in place and vents are clear.

16. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

17. Inspect control power transformers.

b. Electrical Tests

1. Perform insulation-resistance tests on each bus section.

2. Perform dielectric withstand voltage tests.

3. Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

4. Perform control wiring performance test.

5. Perform primary current injection tests on the entire current circuit in each section of assembly.

6. Perform phasing check on double-ended motor control center to ensure correct bus phasing from each source.

7. Verify operation of motor control center heaters.

3.5.1.2 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Inspect arc chutes.

6. Inspect moving and stationary contacts for condition, wear, and alignment.

7. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

8. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Verify cell fit and element alignment.

11. Verify racking mechanism.

12. Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests

1. Perform contact-resistance tests on each breaker.

2. Perform insulation-resistance tests.

3. Adjust Breaker(s) for final settings in accordance with Government provided settings.

4. Determine long-time minimum pickup current by primary current injection.

5. Determine long-time delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

10. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

11. Verify operation of charging mechanism.

3.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance tests.

3. Perform polarity tests.

4. Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify tightness of electrical connections.

b. Electrical Tests

1. Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

2. Calibrate watthour meters according to manufacturer's published data.

3. Verify all instrument multipliers.

4. Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

1. IEEE 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

2. Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.1.6 Switches, Air, Low-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify the unit is clean.

5. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

6. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and coordination study.

7. Verify that each fuse has adequate mechanical support and contact integrity.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Verify operation and sequencing of interlocking systems.

10. Verify correct phase barrier installation.

11. Verify correct operation of all indicating and control devices.

12. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, in accordance with Section 7.5.1.1.A.8.1 of NETA ATS.

2. Measure contact resistance across each switchblade and fuseholder.

3. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

4. Measure fuse resistance.

5. Verify cubicle space heater operation.

6. Perform ground fault test in accordance with Section 7.14 of NETA ATS.

7. Perform tests on other protective devices in accordance with Section 7.9 of NETA ATS.

3.5.1.7 Switches, Air, Medium-Voltage, Metal-Enclosed

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify the unit is clean.

5. Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.

6. Verify that fuse sizes and types are in accordance with drawings, short-circuit study, and coordination study.

7. Verify that expulsion-limiting devices are in place on all fuses having expulsion-type elements.

8. Verify that each fuseholder has adequate mechanical support and contact integrity.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Verify operation and sequencing of interlocking systems.

11. Verify correct phase barrier installation.

12. Verify correct operation of all indicating and control devices.

13. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.5.1.2.A.9.1 of

NETA ATS.

2. Measure contact resistance across each switchblade assembly and fuseholder.

3. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

4. Perform a dielectric withstand voltage test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.2 of NETA ATS.

5. Measure fuse resistance.

6. Verify cubicle space heater operation.

7. Perform online partial-discharge survey in accordance with Section 11 of NETA ATS.

3.5.1.8 Circuit Breakers

3.5.1.8.1 Circuit Breakers, Air, Insulated-Case/Molded-Case

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage and alignment.

4. Verify the unit is clean.

5. Operate the circuit breaker to insure smooth operation.

6. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

7. Inspect operating mechanism, contacts, and arc chutes in unsealed nits.

8. Perform adjustments for final protective device settings in accordance with the coordination study.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.1.A.6.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's

published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and time delay by primary current injection.

8. Determine instantaneous pickup by primary current injection.

9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage tests on shunt trip and close coils in accordance withmanufacturer's published data.

11. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

12. Verify operation of charging mechanism.

3.5.1.8.2 Circuit Breakers, Low-Voltage Power

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Verify the arc chutes are intact.

7. Inspect moving and stationary contacts for condition and alignment.

8. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

9. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.

10. Inspect all bolted electrical connections for high resistance

using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey

11. Verify cell fit and element alignment.

12. Verify racking mechanism operation.

13. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

14. Perform adjustments for final protective device settings in accordance with coordination study provided by end user.

15. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.2.A.10.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.20 of NETA ATS.

11. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.

12. Verify operation of charging mechanism.

3.5.1.8.3 Circuit Breakers, Air, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Verify the arc chutes are intact.

7. Inspect moving and stationary contacts for condition and alignment.

8. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that contact sequence is in accordance with manufacturer's published data. In the absence of manufacturer's data, use IEEE C37.04.

9. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer's published data.

10. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey

11. Verify cell fit and element alignment.

12. Verify racking mechanism operation.

13. Inspect puffer operation.

14. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

15. Perform contact-timing test.

16. Perform mechanism-motion analysis.

17. Perform trip/close coil current signature analysis.

18. Record as-found and as-left operation-counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. See Section 7.6.1.3.A.10.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be on minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow manufacturer’s recommendation.

5. With breaker in the test position, make the following tests:

(a) Trip and close breaker with the control switch.

(b) Trip breaker by operating each of its protective relays.

(c) Verify mechanism charge, trip-free, and antipump functions.

6. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.20 of NETA ATS.

7. Perform power-factor or dissipation-factor tests with breaker in both the open and closed positions.

8. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/ capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

9. Perform a dielectric withstand voltage test on each phase with the circuit breaker closed and the poles not under test grounded. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.19 of NETA ATS.

10. Measure blowout coil circuit resistance.

11. Verify operation of heaters.

12. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.8.4 Circuit Breakers, Oil, Medium- and High-Voltage

a. Visual and Mechanical Inspection

1. Visual and Mechanical Inspection

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify correct oil level in all tanks and bushings.

6. Verify that breather vents are clear.

7. Verify the unit is clean.

8. Inspect hydraulic system and air compressor in accordance with manufacturer's published data.

9. Test alarms and pressure-limit switches for pneumatic and hydraulic operators as recommended by the manufacturer.

10. Perform mechanical operation tests on the operating mechanism in accordance with manufacturer's published data.

11. While performing internal inspection:

(a) Remove oil. Lower tanks or remove manhole covers as necessary. Inspect bottom of tank for broken parts and debris.

(b) Inspect lift rod and toggle assemblies, contacts, interrupters, bumpers, dashpots, bushing current transformers, tank liners, and gaskets.

(c) Verify that contact sequence is in accordance with manufacturer's published data. In the absence of manufacturer's data, use IEEE C37.04.

(d) Fill tank(s) with filtered oil.

12. Inspect bolted electrical connections for high resistance using one or more of the following methods:

(a) Use of low-resistance ohmmeter in accordance with Section 7.6.2.B.1 of NETA ATS.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.12 of NETA ATS.

(c) Perform thermographic survey in accordance with Section 9 of NETA ATS.

14. Verify racking mechanism operation.

15. Perform contact-timing test.

16. Perform mechanism-motion analysis.

17. Perform trip/close coil current signature analysis.

18. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

19. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.2.A.12.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit-breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a static contact/pole resistance test.

4. Perform a dynamic contact/pole resistance test.

5. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

6. Remove a sample of insulating liquid in accordance with ASTM D923. Sample will be tested in accordance with the referenced standard.

(a) Dielectric breakdown voltage: ASTM D877

(b) Color: ASTM D1500

(c) Power factor: ASTM D924

(d) Interfacial tension: ASTM D971

(e) Visual condition: ASTM D1524

(f) Neutralization number (acidity): ASTM D974

(g) Water content: ASTM D1533

7. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.20 of NETA ATS.

8. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, antipump function.

9. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.

10. Perform power-factor or dissipation-factor tests on each pole with breaker open and each phase with breaker closed. Determine tank loss index.

11. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer's published data.

12. Perform a dielectric withstand voltage test in accordance with manufacturer's published data.

13. Verify operation of heaters.

14. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.8.5 Circuit Breakers, Vacuum, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer's published data.

7. Measure critical distances such as contact gap as recommended by manufacturer.

8. Inspect bolted electrical connections for high resistance using one or more of the following methods:

(a) Use of low-resistance ohmmeter in accordance with Section 7.6.3.B.1 of NETA ATS.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.12 of NETA ATS.

(c) Perform thermographic survey in accordance with Section 9 of NETA ATS.

9. Verify cell fit and element alignment.

10. Verify racking mechanism operation.

11. Verify appropriate lubrication on moving, current-carrying parts and on moving and sliding surfaces.

12. Perform contact-timing test.

13. Perform trip/close coil current signature analysis.

14. Perform mechanism motion analysis.

15. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.3.A.8.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.

4. Perform a contact/pole-resistance test.

5. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.20 of NETA ATS.

6. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, and antipump function.

7. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.

8. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed.

9. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

10. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.

11. Perform vacuum bottle integrity (dielectric withstand voltage) test across each vacuum bottle with the breaker in the open position in strict accordance with manufacturer’s published data.

12. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.19 of NETA ATS.

13. Verify operation of heaters.

14. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.8.6 Circuit Breakers, SF6

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. When provisions are made for sampling, remove a sample of SF6 gas and test in accordance with Table 100.13 of NETA ATS. Do not break seal or distort “sealed-for-life” interrupters.

7. Inspect operating mechanism and/or hydraulic or pneumatic system and SF6 gas-insulated system in accordance with manufacturer’s published data.

8. Test for SF6 gas leaks in accordance with manufacturer’s published data.

9. Verify correct operation of alarms and pressure-limit switches for pneumatic, hydraulic, and SF6 gas pressure in accordance with manufacturer’s published data.

10. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that contact sequence is in accordance with manufacturer’s published data. In the absence of manufacturer’s data, refer to IEEE C37.04.

11. Perform all mechanical operation tests on the operating mechanism in accordance with the manufacturer’s published data.

12. Inspect all bolted electrical connections for high resistance using one or more of the following methods:

(a) Use of a low-resistance ohmmeter in accordance with Section 7.6.4.B.1 of NETA ATS.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.12 of NETA ATS.

(c) Perform a thermographic survey in accordance with Section 9 of NETA ATS.

13. Verify the appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

14. Perform contact-timing test.

15. Perform trip/close coil signature analysis.

16. Perform mechanism motion analysis.

17. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.4.A.12.1 of

NETA ATS.

2. Perform insulation-resistance tests in accordance with Table 100.1 of NETA ATS from each pole-to-ground with breaker closed and across open poles at each phase. For single-tank breakers, perform insulation resistance tests in accordance with Table 100.1 from pole-to-pole.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components or for control devices that cannot tolerate the voltage, follow manufacturer's recommendation.

5. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data.

6. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, and antipump function. Reset all trip logs and indicators.

7. Trip circuit breaker by operation of each protective device.

8. Perform power-factor or dissipation-factor tests on each pole with the breaker open and on each phase with the breaker closed.

9. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer's published data.

10. Perform a dielectric withstand voltage test in accordance with manufacturer's publisheddata.

11. Verify operation of heaters.

12. Test instrument transformers in accordance with Section 7.10 from NETA ATS.

3.5.1.9 Motor Control, Motor Starters, Low-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify the unit is clean.

5. Inspect contactors.

(a) Verify mechanical operation.

(b) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.

6. Motor-Running Protection

(a) Verify overload element rating/motor protection settings are correct for application.

(b) If motor-running protection is provided by fuses, verify correct fuse rating.

7. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

8. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.1.A.7.1 from NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with starter closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data or Table 100.1 from NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

4. Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, use Section 7.9 from NETA ATS.

5. Test circuit breakers in accordance with Section 7.6.1.1 from NETA ATS.

6. Perform operational al tests by initiating control devices.

3.5.1.10 Motor Control, Motor Starters, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify the unit is clean.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or

performing thermographic survey.

6. Test electrical and mechanical interlock systems for correct operation and sequencing.

7. Verify correct barrier and shutter installation and operation.

8. Exercise active components and confirm correct operation of indicating devices.

9. Inspect contactors.

(a) Verify mechanical operation.

(b) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer’s published data.

10. Verify overload protection rating is correct for its application. Set adjustable or programmable devices according to the protective device coordination study.

11. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.2.A.5.1 from NETA ATS.

2. Perform insulation-resistance tests on contactor(s) for one minute, phase-to-ground and phase-to-phase with the contactor closed, and across each open contact. Test voltage will be in accordance with manufacturer’s published data, or Table 100.1 from NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.

4. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.

5. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.9 from NETA ATS.

6. Perform vacuum bottle integrity test (dielectric withstand voltage) across each vacuum bottle with the contacts in the open position in strict accordance with manufacturer’s published data.

7. Perform contact resistance tests.

8. Measure blowout coil circuit resistance.

9. Measure resistance of power fuses.

10. Energize contactor using an auxiliary source. Adjust armature to

minimize operating vibration.

11. Test control power transformers in accordance with Section 7.1.B.8 from NETA ATS.

12. Test starting transformers, in accordance with Section 7.2.1 from NETA ATS.

13. Test starting reactors, in accordance with 7.20.3 from NETA ATS.

14. Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, test in accordance with Section 7.9 from NETA ATS.

15. Standard Commissioning Specifications for Electrical Power Equipment & Systems.

16. Verify operation of cubicle space heater.

17. Test instrument transformers in accordance with Section 7.10 from NETA ATS.

18. Test metering devices in accordance with Section 7.11 from NETA ATS.

3.5.1.11 Cybersecurity Installation Certification

Furnish a certification that control systems are installed in accordance with DODI 8500.01, DOD 8510.01, and as required by individual Service Implementation Policy.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

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SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE 399	(1997) Brown Book IEEE Recommended Practice for Power Systems Analysis

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis

Protective Device Coordination Study

System Coordinator

1.3 QUALITY ASSURANCE

1.3.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis must be accomplished by a registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems. Submit verification of experience and license number, of a registered Professional Engineer as specified above. Provide experience data consisting of at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers.

PART 2 PRODUCTS

2.1 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. Include a load flow analysis, a fault current analysis, and a protective device coordination study. Submit the study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government is not responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. The studies must be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.1.1 Single Line Diagram

Prepare a single line diagram to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point must have a unique identifier. If a fault-impedance diagram is provided, show impedance data. Show location of switches, breakers, and circuit interrupting devices on the diagram together with available fault data, and the device interrupting rating.

2.1.2 Fault Current Analysis

2.1.2.1 Method

Perform the fault current analysis in accordance with methods described in IEEE 242, and IEEE 399.

2.1.2.2 Data

Utilize actual data in fault calculations. Bus characteristics and transformer impedance must be those proposed. Document data in the report.

2.1.2.3 Fault Current Availability

Provide balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values at each voltage transformation point and at each power distribution bus. Show the maximum and minimum values of fault available at each location in tabular form on the diagram or in the report.

2.1.3 Coordination Study

Demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. Include a description of the coordination of the protective devices in this project. Provide a written narrative describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Provide recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction). Provide composite coordination plots on log-log graph paper.

2.1.4 Study report

a. Include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. Include descriptive and technical data for existing devices and new protective devices proposed. Include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. Document [utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings;] [and] [existing power system data including time-current characteristic curves and protective device ratings and settings].

d. The report must contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. Include recommended ratings and settings of all protective devices in tabulated form.

e. Provide the calculation performed for the analyses, including computer analysis programs utilized. Provide the name of the software package, developer, and version number.

PART 3 EXECUTION

Not Used

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SECTION 26 29 01.00 10

ELECTRIC MOTORS, 3-PHASE VERTICAL INDUCTION TYPE
11/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9 (2015) Load Ratings and Fatigue Life for Ball Bearings

ABMA 11 (2014) Load Ratings and Fatigue Life for Roller Bearings

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM B344 (2020) Standard Specification for Drawn or Rolled Nickel-Chromium and Nickel-Chromium-Iron Alloys for Electrical Heating Elements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

1.2 SUMMARY

The work under this section includes providing all labor, equipment, and material and performing all operations required to design, manufacture, assemble, test, and package and deliver the vertical induction motors for driving pumps specified under Section 35 45 01 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER TYPE.

a. Supply motors complete with all accessories, spare parts, tools, and manufacturer's data and instructions as specified herein.

b. Submit 6 copies of complete instructions for the proper installation, inspection, and maintenance of the machines provided for this particular service. Submit to the Contracting Officer not later than the date the equipment is shipped from the manufacturer's plant. Include a cross-sectional drawing indicating the major component parts of the motor and the procedure for disassembly.

c. Submit 6 copies of a complete list of renewal parts with prices for each different rating of motor. Include the list along with the instruction manual.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Motors; G

SD-03 Product Data

Insulated Windings; G

Duty Cycle; G

Motors; G

Government Study

Spare Parts

SD-06 Test Reports

Starting Capabilities

Factory Tests

SD-07 Certificates

Power Factor and Efficiency

Factory Tests

SD-10 Operation and Maintenance Data

Instructions; G

1.4 QUALITY ASSURANCE

1.4.1 Corrosion Prevention and Finish Painting

The equipment provided under these specifications will be subjected to severe moisture conditions and must be designed to render it resistant to corrosion from such exposure. The general requirements to be followed to mitigate corrosion are specified below. Any additional special treatment or requirement considered necessary for any individual items is specified under the respective item. However, other corrosion-resisting treatments that are the equivalent of those specified herein may, with the approval of the Contracting Officer, be used.

1.4.1.1 Fastenings and Fittings

Where practicable, provide corrosion-resistant screws, bolts, nuts, pins, studs, springs, washers, and other similar fittings or treat in an approved manner to render them resistant to corrosion.

1.4.1.2 Corrosion-Resisting Materials

Corrosion-resisting steel, copper, brass, bronze, copper-nickel, and nickel-copper alloys are acceptable corrosion-resisting materials.

1.4.1.3 Corrosion-Resisting Treatments

Perform hot-dip galvanizing in accordance with ASTM A123/A123M or ASTM A153/A153M as applicable. Other corrosion-resisting treatments may be used if approved by the Contracting Officer.

1.4.1.4 Frames

Clean motor frames, end bells, covers, conduit boxes, and any other parts, if of steel, and if they will be coated during the process of insulating the windings, of rust, grease, millscale, and dirt, and then treated and rinsed in accordance with manufacturer's standard process. If any of the above-listed parts are not coated during the process of insulating the windings then, in addition to the above, give one coat of primer and then two coats of manufacturer's standard moisture-resistant coating, processed as required.

1.4.1.5 Cores

Thoroughly clean the assembled motor core and then immediately prime by applying a minimum of two coats of a moisture-resisting and oil-resisting insulating compound. Give a minimum of one coat to air gap surfaces.

1.4.1.6 Shafts

Clean exposed surfaces of motor shafts of rust, grease, and dirt and, except for bearing surfaces, give one coat of a zinc molybdate or equivalent primer and two coats of a moisture-proof coating, cure each as required. Shafts of a corrosion-resisting steel may be used in lieu of the above treatment.

1.4.1.7 Finish Painting

Finish paint all equipment in accordance with the standard practice or recommendation of the manufacturer, as approved by the Contracting Officer.

1.4.2 Government Study

Submit 6 copies of the specified data. Supply to the Government, for completion of its Motor Torque and Accelerating Time Studies (MTATS), the following data:

a. Complete equivalent circuit data referred to the stator with friction, windage, and stray load losses.

b. Current, power factor, and torque versus speed (0-100 percent, inclusive, in 1 percent increments up to 95 percent and in 0.1 percent increments above 95 percent) and load (0-125 percent, inclusive, in 25 percent increments) as a function of line voltage (from 80 percent to

110 percent, inclusive, in 5 percent increments), for rated and 90 percent of rated voltage at starter. Only tabulated data will be required.

c. Load inertia, Wk2 of motor rotating parts, pound-foots.

PART 2 PRODUCTS

2.1 NAMEPLATES

Include rated voltage, rated full-load amperes, rated horsepower, service factor, number of phases, RPM at rated load, frequency, code letter, locked-rotor amperes, duty rating, insulation system designation, and maximum ambient design temperature.

2.2 MOTORS

Supply motors under these specifications that are the vertical shaft type as required by the pump manufacturer, normal or low starting torque, low starting current, squirrel-cage induction type, designed for full voltage starting, of drip-proof construction, and conforming to the applicable requirements of NEMA MG 1, except as hereinafter specified.

a. Submit 6 copies of equipment foundation dimensions; outline drawings with weights, nameplate data, and details showing method of mounting and anchoring the motor. Obtain Contracting Officer's approval in writing prior to the commencement of manufacture of motors.

b. Six copies of complete descriptive specification of each type and size motor provided, with necessary cuts, photographs, and drawings to clearly indicate the construction of the motor, the materials and treatments used to prevent corrosion of parts, bearing construction, and type of insulation used on all windings.

c. Include all information required for selection of protective and control equipment and for operational setting, such as, but not limited to, normal and maximum operation temperature for windings and bearings, overload trip setting for motor at pump maximum head condition and starting times for starting at rated and 90 percent starter voltage.

2.2.1 Rating

Wind each motor for 3-phase, 60-Hz, alternating current, and for the respective operating voltage.

Design motor for operation in a 105 degrees Fambient temperature and all temperature rises must be above this ambient temperature. A rated horsepower of the motor less than 110 percent of the determined maximum load requirement of the pump is not acceptable. Provide motors that have a service factor of 1.0 or apply using a service factor of 1.0 if standard service factor is greater than 1.0. For the temperature rise above the ambient temperature for continuous rated full-load conditions and for the class of insulation used, do not exceed the values given in NEMA MG 1, paragraph 12.42 or paragraph 20.8.

2.2.2 Operating Characteristics

2.2.2.1 Torques

Provide sufficient starting torque to start the pump to which the motor will be connected under the maximum conditions specified, do not use starting torque less than 60 percent of full-load torque. Breakdown torque less than 200 percent of full-load torque is not permitted.

2.2.2.2 Locked-Rotor Current

Do not exceed 600 percent of normal full-load running current.

2.2.2.3 Starting Capabilities

Provide large motors, on the basis of the load torque characteristics and the load inertia Wk2 listed in NEMA MG 1, paragraphs 20.41 and 20.42, that are, as a minimum, capable of making the starts required in NEMA MG 1, paragraph 20.43. Provide smaller motors conforming to the requirements in NEMA MG 1, paragraph 12.50. Submit 6 copies of certified test reports, when available, of tests previously performed on motors of each type and size specified or calculated data to substantiate the motor's capability to conform to the specified requirements.

2.2.2.4 Duty Cycle

Submit an analysis to verify that the motor, when operated in accordance with the duty cycle specified, will not undergo injurious temperature rise. If the duty cycle cannot be met with a standard NEMA design motor, the motor manufacturer must provide a description of proposed modifications to provide such compliance. Each motor, when operating at rated voltage and frequency and on the basis of the connected pump load inertia Wk2 and the speed-torque characteristics of the load during starting conditions as furnished by the pump manufacturer, must be capable of performing on a continuous basis the following motor duty cycle without injurious temperature rise: Provide a starting information nameplate setting forth the starting capabilities on each motor. Also include the minimum time at standstill and the minimum running time prior to an additional start on the nameplate.

2.2.2.5 Balance

Do not exceed the specified values for balance of each motor when measured in accordance with NEMA MG 1, paragraph 12.06 or paragraph 20.53. Provide motors that meet the provisions of Section 35 45 01 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE paragraph .

2.2.2.6 Noise

Operate all motors at a noise level less than 85 decibels A-weighted mean sound pressure level (dBA). The specified noise limit applies for a reference distance of one meter for free-field conditions.

2.2.2.7 Power Factor and Efficiency

The power factor and efficiency at full load, 3/4 full load, and 1/2 full load must not be less than premium grade per NEMA MG1. Motors will be rejected if factory tests specified in paragraph FACTORY TESTS do not demonstrate that these values will be met or exceeded. Submit certification of guaranteed value of power factor and efficiency for full load, 3/4 full load, and 1/2 full load.

2.2.3 Frames and Brackets

Provide cast iron, cast steel, or welded steel frames and end brackets. Build the mounting ring, unless otherwise approved, integral with the frame or lower end bracket and arranged for direct mounting on the pump, or station floor, or as required by the installation conditions. Treat against corrosion as specified in paragraph GENERAL REQUIREMENTS.

2.2.3.1 Stator Frame

Provide rigid stator frame that is sufficiently strong to support the weight of the upper bearing bracket load, the weight of the stator core and windings, and to sustain the operating torques without perceptible distortion. Support the stator frame, if not direct mounted on the pump, on a motor base or drive pedestal which in turn will be supported on sole plates or other suitable structure installed in the concrete foundation constructed as part of the pumping station structure. Provide the motor base or drive pedestal with bolts and dowels for fastening to the sole plates or supporting structure for preserving the alignment.

2.2.3.2 Supporting Bracket

Provide upper bracket supporting the thrust bearing and upper guide bearings of sufficient strength and rigidity to support the weight of the entire rotating element of the motor, together with the pump impeller and shaft, and the hydraulic thrust of the pump impeller.

2.2.3.3 Overspeed Alternate

Design each motor to withstand indefinitely, without injury, the maximum overspeed to which the motor will be subjected when the pump to which it is connected is acting as a hydraulic turbine under the maximum head with the pump discharge pipe open.

2.2.3.4 Antireverse Device Alternate

Install a self-actuated backstop device or antireversing ratchet, to prevent reverse rotation of the pump due to loss of power or failure of the electric prime mover, as an integral part of the motor. Submit the design of the device to the Contracting Officer for approval. If the device requires a lubrication system, provide an oil reservoir independent of the one used for the thrust bearing and complete with visible oil level gauge and 120-volt a.c. rated high and low level contacts. Terminate all electrical leads in the accessory terminal box specified in paragraph MOTOR TERMINALS AND BOXES. Provide lubricant for the antireverse device containing a corrosion inhibitor whose type and grade is shown on a special nameplate attached to the frame adjacent to the lubricating filling device.

2.2.3.5 Eyebolts

Provide eyebolts, lugs, or other approved means for assembling, dismantling, and removing the motor, if required, from above using an overhead crane. Provide all lifting devices required for use in conjunction with the crane with the motor.

2.2.4 Cores

Build up the cores for the stators and rotors of separately punched thin laminations of low-hysteresis loss, nonaging, annealed, electrical silicon steel, assembled under heavy pressure, and clamped in such a manner as to insure that the assembled core is tight at the top of the teeth of the laminated core. Properly insulate laminations from each other. Only use laminations free from burrs, and take care to remove all burrs or projecting laminations from the slots of the assembled cores. Key, dovetail, or otherwise secure cores to the shaft or frame in an approved manner. Treat against corrosion as specified in paragraph GENERAL REQUIREMENTS.

2.2.5 Insulated Windings

Furnish motors that have a nonhygroscopic, sealed, fungus-resisting insulation of a type designed and constructed to withstand severe moisture conditions, and insofar as practicable, to operate after long periods of idleness without previous drying out. Provide sealed windings and connections defined in NEMA MG 1 paragraph 1.27.2. Submit a detailed description of and specification for the manufacturing process, submit the materials and the insulating varnish or compound used in insulating the windings to the Contracting Officer for approval before manufacture of the motors is commenced. If, in the opinion of the Contracting Officer, the insulation proposed is not of the quality specified and if the methods of manufacture are not considered to be in accordance with best modern practice, the motors will not be accepted. Submit 6 copies of motor design curves and 6 copies of motor speed-torque curves, as specified. Completely assemble insulated windings, unless otherwise approved, in the motor core before impregnating with the insulating compound. Furnish 100 percent solid resin compound.

a. Impregnate the windings with the insulating compound by vacuum impregnation method followed by baking. Repeat the procedure as often as necessary to fill in and seal over the interstices of the winding, but in no case must the number of dips and bakes be less than two dips and bakes when the vacuum method of impregnation is used. Provide completed stator that is capable of passing the submerged or sprayed water test, as applicable, required by NEMA MG 1 paragraph 20.49.

b. Random wound coils may be used on motors supplied in NEMA frame size 445 TP and smaller. The components of the insulation system and the conductor insulation of the coils must be Class F insulation with a 110 percent continuous overload factor as defined in NEMA MG 1 paragraph 1.66. After winding, encapsulate the completely wound stator with an insulating resin as defined in NEMA MG 1 paragraph 1.27.1.

c. Use form wound coils on motors supplied in NEMA frames larger than 445 TP. Provide components of the insulation system and coil insulation of the rectangular conductors conforming to Class F insulation with a 110 percent continuous overload factor as defined in NEMA MG 1, paragraph 1.66. The completed stator windings and connections must be of the sealed type as defined in NEMA MG 1paragraph 1.27.2.

d. Process insulation to ground on the coil. Slot tubes or cells are not acceptable. Provide insulation of adequate thickness and breakdown strength throughout the length of the coil. Use mica in the slot portion of adequate thickness to withstand the dielectric tests specified in paragraph FACTORY TESTS. Provide uniform form wound coils such that the stator windings on motors of equal ratings are alike, in shape and size, and are interchangeable.

e. Submit motor design (characteristic) curves or tabulated data (test or calculated), indicating the speed, power factor, efficiency, current, and kilowatt input, all plotted or tabulated against torque or percent load as abscissa. Give the base value whether ANSI or IEEE standard system is used. Also provide the maximum allowable reverse rotation speed for the motor.

f. Submit pump and motor speed-torque curves for the pump starting operation. Plot the motor speed-torque curves for the following values of voltage at the motor terminals]. Plot the pump torque curve for starting and accelerating against maximum head. Furnish computations to demonstrate that the motor furnished will carry the pump load under all the foregoing conditions.

g. Fully brace coils of all windings so that vibration is virtually eliminated during repeated starts as required by the duty cycle specified as well as during normal operation. If a tied system is used, no tie is dependent upon the integrity of any other tie within the system.

2.2.6 Thermal Protection

For motors rated 500 hp or greater, provide resistance temperature detectors (two per phase) in accordance with NEMA MG 1, paragraph 20.63. Provide detectors that have a copper resistance element having a resistance of 10 ohms at 76 degrees F. Terminate leads on the terminal blocks specified in paragraph MOTOR TERMINALS AND BOXES. For motors rated less than 500 hp, embed positive-temperature-coefficient thermistors (one per phase) in the windings. Provide thermistors with all necessary additional equipment, as required, that open a normally closed contact when the critical temperature is reached. Terminate all outgoing wiring on the terminal blocks specified in paragraph MOTOR TERMINALS AND BOXES.

2.2.7 Winding Heaters

Wrap heaters around the winding end turns. Designate for operation on 120 volts, 1-phase, 60 Hz, alternating current and of sufficient capacity or wattage that, when energized, they will hold the temperature of the motor windings approximately 10 degrees C above the ambient temperature. Design for continuous operation and to withstand at least 10 percent overvoltage continuously. Maintain uniform rate of heat dissipation throughout the effective length of the heater. Install heaters around the winding end turns consisting of the required turns of heating cable wrapped around the end turns and secured in place before the winding is impregnated.

2.2.7.1 Heating Element

Provide heating element conforming to the requirements of ASTM B344 for an 80 percent nickel and 20 percent chromium alloy.

2.2.7.2 Sheath

Provide sheath consisting of a corrosion-resisting, nonoxidizing metal and a wall thickness not less than 0.025 inch.

2.2.7.3 Insulation

Provide insulation consisting of a granular mineral refractory material, highly resistant to heat, and has a minimum specific resistance of 1,000 megohms per inch cubed at 1,000 degrees F. Provide insulation for the heating cable (winding wraparound type) type heaters that is suitable for a conductor temperature of 356 degrees F.

2.2.7.4 Terminals

Provide watertight terminals of the heater, including the leads, and provide with leads suitable for making connections to the drip-proof terminal box provided in paragraph MOTOR TERMINALS AND BOXES.

2.2.8 Shafts

Make shafts of high grade steel, finished all over, and of ample size to drive the pumps under maximum load conditions. Provide hollow or solid shafts as required by the pump manufacturer. See paragraph GENERAL REQUIREMENTS for treatment against corrosion.

2.2.9 Bearings

2.2.9.1 Loading

Bearings must be capable of withstanding all stresses incidental to the normal operation of the unit and the maximum speed of the pumping unit when operating in the reverse direction.

2.2.9.2 Thrust Bearings

Thrust bearings must be of the antifriction type of either the ball or roller type. Do not use tandem or series bearing assemblies. Provide antifriction bearings conforming to the requirements of ABMA 9 an d ABMA 11.

2.2.9.3 Guide Bearings

Guide bearings must be of the sleeve or antifriction type of either the ball or roller type or a combination of sleeve and antifriction bearings.

2.2.9.4 Lubrication

Provide either oil or grease lubricated bearings and use lubricant containing a corrosion inhibitor. Show type and grade of lubricant used on a special nameplate attached to the frame of the motor adjacent to the bearing lubricant filling device. In addition to the quantity of lubricant required to fill the system initially, provide spare lubricant in sufficient quantity to purge and refill the system.

2.2.9.5 Housings

Design and assemble bearing housings that will permit ready removal of the bearings, prevent escape of lubricant and entrance of foreign matter, and protected by the lubricant when the motor is idle. Except for prelubricated antifriction bearings of an approved type, provide suitable means to apply and drain the lubricant. Provide oil-lubricated bearing housings with oil-level indicator gauges that will be readily visible.

2.2.9.6 Cooling

Provide self-cooling bearings unless otherwise specifically approved by the Contracting Officer. If the use of cooling is approved, employ means that, unless otherwise approved by the Contracting Officer, require no auxiliary pumping equipment; and provide suitable means to indicate the bearing temperature, actuate an alarm when the bearing temperature is above normal, and actuate a device to shut down the motor when the maximum safe operating temperature of the bearing is reached. Provide copper cooling coils of copper tubing and design for the operating pressure used to circulate the cooling water.

2.2.9.7 Rating

Rate antifriction bearings on the basis of a minimum life factor of 8,800 hours, based on the life expectancy of 90 percent of the group, unless otherwise approved by the Contracting Officer.

2.2.9.8 Shaft Currents

Insulate bearings or otherwise protect against the damaging effects of shaft currents.

2.3 SURGE PROTECTION

2.3.1 Surge Capacitors

Provide a three-pole capacitor unit, equipped with built-in discharge resistors and using a non-polychlorinated biphenyl (PCB) insulating medium, in the main terminal box. Provide removable bus links for motor testing. Treat these links to resist corrosion, design to maintain a positive contact, and have low contact resistance.

2.3.2 Surge Arresters

Provide surge arresters of the station type with porcelain tops in the main terminal box. Provide metal-oxide arresters rated as required for maximum continuous operating voltage (MCOV) line-to-ground. Provide removable bus links for motor testing. Treat these links to resist corrosion, design to maintain a positive contact, and have low contact resistance.

2.3.3 Space Heater

If recommended by the surge protection manufacturer, provide a space heater of adequate capacity and rated 120 volts. Provide space heaters that have a maximum watt density of 20 watts per square inch.

2.4 MOTOR TERMINALS AND BOXES

2.4.1 Stator Terminal Box

Supply drip-proof cast iron or steel conduit terminal boxes, treated as specified for frames in paragraph GENERAL REQUIREMENTS, for housing the stator lead connections surge capacitors and surge arresters and that have adequate space to facilitate the installation and maintenance of cables and equipment. Furnish boxes that have a bolted cover providing unrestricted access, are mounted on the motor frame, and have an auxiliary floor supporting structure, when required, supplied by the motor manufacturer. Enter conduit from the bottom. Design boxes to permit removal of motor supply leads when the motor is removed. Provide a "HIGH VOLTAGE" warning sign on the cover of the box.

2.4.2 Stator Terminals

Apply a treatment equal to that of the motor winding to insulated terminal leads. Bring leads out of the stator frame and provide with terminal lugs for connection to the motor supply wiring.

2.4.3 Grounding

Provide a ground bus and means for external connection to the station grounding system in the stator terminal box when surge protection is provided.

2.4.4 Accessory Leads and Boxes

Bring terminal leads for motor winding space heaters, surge protection equipment space heater, resistance temperature detectors thermistors and any other auxiliary equipment into conveniently located terminal boxes provided with terminal blocks for extension by others. Provide drip-proof terminal boxes and treat as specified for frames in paragraph GENERAL REQUIREMENTS. Provide auxiliary wiring consisting of stranded copper conductors with 600-volt flame-retardant insulation, except temperature detector leads may be in accordance with the manufacturer's standard practice. Properly identify all wiring and terminals.

2.5 WRENCHES, TOOLS, AND SPECIAL EQUIPMENT

Provide all nonstandard and special equipment required for dismantling, reassembly, and general maintenance of the motor units. Provide one complete set of lifting attachments such as detachable eyebolts or special slings for handling various parts with a hoist.

2.6 FACTORY TESTS

Give a complete test of one motor of each rating type, selected at random by the Contracting Officer. Give the remainder of the motors check test.

a. Submit 6 copies of test reports recording all data obtained during the tests specified to the Contracting Officer for each motor used. Include performance curves indicating the results of subparagraph COMPLETE TEST below.

b. Submit 6 certified copies of the results of a "Complete Test" for duplicate equipment. It will be accepted in lieu of the "Complete Test" as specified in subparagraph COMPLETE TEST below for equipment of the respective rating and type.

c. No substitute will be accepted for the "Check Test." Give the base value whether ANSI or IEEE standard system is used. All complete tests must be witnessed by the Contracting Officer .

2.6.1 Complete Test

Include the following:

2.6.1.1 Excitation Test

Including a plot of volts as abscissa versus amperes and watts as ordinates.

2.6.1.2 Impedance Test

Including a plot of volts as abscissa versus amperes and watts as ordinates.

2.6.1.3 Performance Test

Including a plot of torque or percent load as abscissa versus efficiency, power factor, amperes, watts, and RPM or percent slip as ordinates.

2.6.1.4 Speed-Torque Test

Prony brake or other equivalent method. Including a plot of torque in foot-pounds as abscissa versus speed in RPM as ordinate.

2.6.1.5 Temperature Test

Made on completion of paragraph c above. (If screens are provided over openings, test will be made with screens removed and by thermometer).

2.6.1.6 Insulation Resistance-Temperature Test

Take following heat run, readings being taken at approximately 10 degrees C intervals. Determine temperature by the resistance method. Plot test result values on semilogarithmic graphs, the insulation resistance values as logarithmic ordinates and the temperature values as uniform abscissas. For comparison purposes, plot a curve indicating the safe operating value of insulation resistance on the same sheet with the insulation resistance-temperature test curve.

2.6.1.7 Cold and Hot Resistance Measurement

2.6.1.8 Dielectric Test

2.6.1.9 Sound Level Test

In accordance with NEMA MG 1 paragraph 20-50.

2.6.1.10 Vibration Measurement

In accordance with NEMA MG 1 paragraph 20.54.

2.6.1.11 Conformance Tests

In accordance with NEMA MG 1 paragraph 20.47.

2.6.2 Check Test

Include the following:

2.6.2.1 Routine Test

Test in accordance with NEMA MG 1 paragraph 12.51 or NEMA MG 1 paragraph 20.47.

2.6.2.2 Cold Resistance Measurement

2.6.2.3 Insulation Resistance and Winding Temperature

Insulation resistance and winding temperature at time the insulation resistance was measured.

2.6.2.4 Conformance Test

In accordance with NEMA MG 1 paragraph 20.47.

2.6.2.5 Vibration

Vibration measurement in accordance with NEMA MG 1 paragraph 12.07 or NEMA MG 1 paragraph 20.54.

2.6.3 Form Wound Coil Test

Test all form wound coils, either before or after they are placed in the slots, for short circuits between turns of the individual coils by applying a high frequency voltage of not less than 75 percent of the voltage for which the machine is insulated, or by applying a surge test voltage of equivalent value to the terminals of each coil. Equivalent surge voltage must be a wave whose peak value is equal to 1.06 times the voltage for which the motor is insulated.

2.6.4 Winding Space Heater Test

Test each winding space heater unit at the factory for successful operation and dielectric strength.

PART 3 EXECUTION

NOT USED

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SECTION 26 29 23

ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS
02/20, CHG 1: 05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

EN 61800-3	(2017) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-3-12	(2012) Electromagnetic Compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and </=75 A per phase

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 3.1	(2019) Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 7	(2020) Adjustable-Speed Drives

NEMA ICS 7.2	(2015) Application Guide for AC Adjustable Speed Drive Systems
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 61800-5-1	(2016) Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15 and EN 61800-3 rules and regulations, must be certified to comply with the requirements for class A computing devices and labeled.

1.3.1.2 Electromechanical and Electrical Components

Ensure electrical and electromechanical components of the Adjustable Speed Drive (ASD) do not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519, IEC 61000-3-12 Control panel must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified must be protected against surges induced on control and sensor wiring installed outdoors and as shown. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Diagrams; G

Interconnecting Diagrams; G

Installation Drawings; G

As-Built Drawings; G

SD-03 Product Data

Adjustable Speed Drives; G

Wires and Cables

Equipment Schedule

SD-06 Test Reports

ASD Test

Performance Verification Tests

Endurance Test

SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

ASD Test Plan; G

Standard Products

SD-10 Operation and Maintenance Data

Adjustable Speed Drives, Data Package 4

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.5.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.5.3 Installation Drawings

Show floor plan of each site, with ASD's and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes. Submit drawings for government approval prior to equipment construction or integration. Immediately record modifications to original drawings made during installation for inclusion into the as-built drawings.

1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule must provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule must include the total quantity of each item of equipment supplied and data indicating compatibility with motors being driven. For complete assemblies, such as ASD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.5.5 Installation Instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.5.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6 DELIVERY AND STORAGE

Store delivered equipment to protect from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 WARRANTY

The complete system must be warranted by the manufacturer for a period of one year . Repair or replace any component failing to perform its function as specified and documented at no additional cost to the Government. Items repaired or replaced must be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.8 MAINTENANCE

1.8.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

1.8.2 Operation and Maintenance Data

Provide in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Provide additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.8.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Contractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Contractor.

1.8.4 Technical Support

Provide the ASDs with manufacturer's technical telephone support in

English, readily available during normal working hours.

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

Provide adjustable speed drive to control the speed of induction motor(s). The ASD must include the following minimum functions, features and ratings.

a. Input circuit breaker per UL 489 with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.

b. A converter stage per UL 61800-5-1 must change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard NEMA MG 1 Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.

d. The ASD shall be capable of supplying 110 percent of rated full load current for one minute at maximum ambient temperature.

e. The ASD must be designed to operate from a required voltage, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in NEMA ICS 7.2-2015 paragraph 5.2.5.

g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

j. The controller efficiency at any speed must not be less than 96 percent.

k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.

l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:

(1) Short circuit at controller output

(2) Ground fault at controller output

(3) Open circuit at controller output

(4) Input undervoltage

(5) Input overvoltage

(6) Loss of input phase

(7) AC line switching transients

(8) Instantaneous overload

(9) Sustained overload exceeding 115 percent of controller rated current

(10) Over temperature

(11) Phase reversal

m. Solid state motor overload protection must be included such that current exceeding an adjustable threshold must activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.

n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA MG 1 Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The ASD must be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required.

p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.

q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The ASD must have a minimum of three user selectable bandwidths.

r. Provide preperly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.

s. Each individual ASD must meet the following Total Harmonic Distortion (THD) requirements at the input terminals to the factory assembly of the ASD or at the load disconnecting means serving the ASD and filter assembly. These measurements should be taken with the drive set at 90 percent frequency (rpms) and the motor under a minimum of 50 percent demand.

(1) The Voltage THD should not exceed 2.0 percent THD.

(2) The Current THD should not exceed 15.0 percent THD.

(3) If the standard factory ASD does not meet or exceed these requirements the factory must install appropriate equipment (Harmonic Traps, Filters, different Drive technology, etc.) to mitigate the distortion to assure performance of the VFD is within the limits.

(4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment in the field. If the requirements listed above are met, IEEE 519 will also be met.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, with a heater if located outdoors. An HMCP device shall provide the disconnecting means. The operating handle shall protrude through the door, but the disconnect shall not be mounted on the door. The handle shall indicate ON, OFF, and tripped conditions. The handle shall have provisions to accommodate a minimum of three padlocks in the OFF position. Interlocks shall prevent unauthorized opening or closing of the ASD door with the disconnect handle in the ON position. The door handle interlock should have provisions to be defeated by qualified maintenance personnel.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures must conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed test plan must be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests must conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. Inform the Government at least 14 working days prior to the dates of testing. Perform the ASD test engaging a qualified testing agency's field supervisor currently certified by NETA to supervise on-site testing.

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Government 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The contractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contracting Officer. Provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.4.1.1 Instructions to Government Personnel

Provide the services of competent instructors with minimum two-year field experience with the operation and maintenance of similar ASDs who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors must be thoroughly familiar with the subject matter they are to teach. The number of training days of instruction furnished must be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals must be turned over to the Government at the end of last training session.

3.4.1.2 Operating Personnel Training Program

Provide one 2-hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. Alarm formats

e. Failure recovery procedures

f. Troubleshooting

3.4.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Government. Provide a one-day training session to train four engineering personnel in the functional operations of the system. This training must include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

-- End of Section --

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SECTION 26 32 15.00

ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B31.1	(2020) Power Piping
ASME B31.3	(2020) Process Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for

	High-Temperature Service
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM B395/B395M	(2018) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM D975	(2020) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995) Performance Standard for Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1	(2000; R 2011) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation
IEEE 43	(2013) Recommended Practice for Testing Insulation Resistance of Rotating Machinery
IEEE 48	(2020) Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 100	(2000; Archived) The Authoritative

Dictionary of IEEE Standards Terms

IEEE 115 (2019) Guide for Test Procedures for Synchronous Machines: Part I Acceptance and Performance Testing; Part II Test Procedures and Parameter Determination for Dynamic Analysis

IEEE 120 (1989; R 2007) Master Test Guide for Electrical Measurements in Power Circuits

IEEE 404 (2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V

IEEE 484 (2019) Recommended Practice for Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications

IEEE 485 (2020) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

IEEE 519 (2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

IEEE C57.13 (2016) Standard Requirements for Instrument Transformers

IEEE C57.13.1 (2006; R 2012) Guide for Field Testing of Relaying Current Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60034-2A (1974; ED 1.0) Rotating Electrical Machines Part 2: Methods for Determining Losses and Efficiency of Rotating Electrical Machinery from Tests (Excluding Machines for Traction Vehicles) Measurement of Losses by the Calorimetric Method

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3046 (2002, 2006, 2009, 2001) Reciprocating Internal Combustion Engines - Performance--Part 1, 3, 4, 5, 6

ISO 8528	(1993; R 2018) Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets--Part 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
NEMA/ANSI C12.11	(2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2021; TIA 20-1; TIA 20-2) Flammable and Combustible Liquids Code
NFPA 37	(2021) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 54	(2021) National Fuel Gas Code

NFPA 58	(2020; TIA 20-1; TIA 20-2; TIA 20-3) Liquefied Petroleum Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 99	(2021; TIA 20-1) Health Care Facilities Code
NFPA 110	(2022) Standard for Emergency and Standby Power Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J537	(2016) Storage Batteries

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-461	(2015; Rev G) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 60	Standards of Performance for New Stationary Sources

UNDERWRITERS LABORATORIES (UL)

UL 142	(2006; Reprint Jan 2021) UL Standard for Safety Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 429	(2013; Reprint Mar 2021) Electrically Operated Valves
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2019) UL Standard for Safety Switchboards
UL 1236	(2015; Reprint Feb 2021) UL Standard for Safety Battery Chargers for Charging Engine-Starter Batteries

UL 1437	(2006) Electrical Analog Instruments - Panel Board Types

1.2 RELATED MATERIALS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING apply to this section, except as modified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Engine-Generator Set and Auxiliary Equipment; G

Auxiliary Systems; G

Detailed Drawings; G

Acceptance; G

SD-03 Product Data

Harmonic Requirements; G

Engine-Generator Set Efficiencies; G

Emissions; G

filters; G

special tools; G

Remote Alarm Annunciator; G

Engine-Generator Parameter Schedule

Heat Exchanger

Generator

Manufacturer's Catalog

Site Welding

Spare Parts

Onsite Training

Vibration-Isolation

Posted Data and Instructions; G

Instructions; G

Experience

Field Engineer

General Installation

Exciter

SD-05 Design Data

Performance Criteria

Sound Limitations; G

Integral Main Fuel Storage Tank

Day Tank

Power Factor

Heat Exchanger

Time-Delay on Alarms

Cooling System

Vibration Isolation

Battery Charger

Capacity Calculations for Engine-Generator Set; G

Brake Mean Effective Pressure (BMEP) Calculations; G

Torsional Vibration Stress Analysis Computations; G

Capacity Calculations for Batteries; G

Turbocharger Load Calculations; G

SD-06 Test Reports

Performance Tests

Factory Inspection and Tests

Factory Tests

Onsite Inspection and Tests; G

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Maintenance Procedures; G

Operation and Maintenance Manuals; G

Inspections; G

Functional Acceptance Test Procedure; G

SD-07 Certificates

Cooling System

Vibration Isolation

Prototype Test

Reliability and Durability

Fuel System Certification; G

Start-Up Engineer; G

Instructor's Qualification Resume; G

Engine Emission Limits; G

Sound Limitations

Site Visit

Current Balance

Materials and Equipment

Factory Inspection and Tests

SD-09 Manufacturer's Field Reports

Engine Tests; G

Generator Tests; G

Assembled Engine-Generator Set Tests; G

SD-10 Operation and Maintenance Data

Preliminary Assembled Operation and Maintenance Manuals; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

SD-11 Closeout Submittals

Posted Data and Instructions; G

Training Plan; G

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation must also conform to the code.

1.4.2 Site Welding

Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING. For all other welding, qualify procedures and welders in accordance with ASME BPVC SEC IX.

a. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1.

b. Submit a copy of qualifying procedures and a list of names and identification symbols of qualified welders and welding operators.

c. Submit a letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their identification symbols.

d. Perform welder qualification tests for each welder whose qualifications are not in compliance with the referenced standards. Notify the Contracting Officer 24 hours in advance of qualification tests which must be performed at the work site, if practical.

e. The welder or welding operator must apply the personally assigned symbol near each weld made as a permanent record.

1.4.3 Vibration Limitation

Limit the maximum engine-generator set vibration in the horizontal, vertical, and axial directions to 6 mils (peak-peak RMS), with an overall velocity limit of 0.95 inches/second RMS, at rated speed for all loads through 110 percent of rated speed. The engine-generator set must be provided with vibration isolation in accordance with the manufacturer's standard recommendation. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

1.4.4 Torsional Analysis

Submit torsional analysis including prototype testing or calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus/minus 10 percent.

1.4.5 Performance Data

Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Also submit a description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

1.4.6 Seismic Requirements

Seismic requirements must be in accordance with UFC 3-301-01 and Sections

13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT, 23 05 48.19 SEISMIC BRACING FOR HVAC and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT .

1.4.7 Experience

Each component manufacturer must have a minimum of 3 years' experience in the manufacture, assembly and sale of components used with stationary engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler must have a minimum of 3 years' experience in the manufacture, assembly and sale of stationary engine-generator sets for commercial and industrial use. Submit a statement showing and verifying these requirements.

1.4.8 Field Engineer

The engine-generator set manufacturer or assembler must furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer must have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer.

1.4.9 Detailed Drawings

Submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Starting system.

c. Fuel system.

d. Cooling system.

e. Exhaust system.

f. Electric wiring of relays, breakers, programmable controllers, and switches including single line and wiring diagrams.

g. Lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, including wiring schematics.

j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.

k. Panel layouts.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set rigging points and lifting instructions.

1.4.10 Auxiliary Systems Engine-Generator Set and Auxiliary Equipment Drawing Requirements

Submit drawings pertaining to the engine-generator set and auxiliary equipment, including but not limited to the following:

a. Certified outline, general arrangement (setting plan), and anchor bolt details. Show total weight and center of gravity of assembled equipment on the steel sub-base.

b. Detailed elementary, schematic wiring, and interconnection diagrams of the engine starting system, jacket coolant heating system, engine protective devices, engine alarm devices, engine speed governor system, generator and excitation system, and other integral devices.

c. Detailed elementary, schematic wiring; and interconnection diagrams of the fuel system, starting battery system, engine-generator control panel, generator circuit breaker, and remote alarm annunciator.

d. Dimensional drawings or catalog cuts of exhaust silencers, radiator, fuel day tanks, fuel oil cooler, valves and pumps, intake filters, vibration isolators, and other auxiliary equipment not integral with the engine-generator set.

1.4.11 Auxiliary Systems Drawing Requirements

Submit drawings showing floor plan arrangement of exhaust, air intake, fuel oil cooler, and jacket coolant water systems including arrangement of piping and pipe sizes.

1.4.12 Vibration Isolation System Certification

Submit certification from the manufacturer that the vibration isolation system will reduce the vibration to the limits specified in the paragraph VIBRATION ISOLATION.

1.4.13 Fuel System Certification

When the fuel system requires a fuel oil cooler as described in the paragraph FUEL OIL COOLER, submit certification from the engine manufacturer that the fuel system design is satisfactory.

1.5 DELIVERY, STORAGE, AND HANDLING

Properly protect materials and equipment, in accordance with the manufacturers recommended storage procedures,before, during, and after installation. Protect stored items from the weather and contamination. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

Deliver equipment on pallets or blocking wrapped in heavy-duty plastic, sealed to protect parts and assemblies from moisture and dirt. Protect and prepare batteries for shipment as recommended by the battery manufacturer. Store auxiliary equipment at the site in covered enclosures, protected from atmospheric moisture, dirt, and ground water.

1.6 EXTRA MATERIALS

Provide two sets of special tools and two sets of filters required for maintenance. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. One handset must be provided for each electronic governor when required to indicate and/or change governor response settings. Furnish 4 liters one gallon of identical paint used on engine-generator set in manufacturer's sealed container with each engine-generator set.

Wrenches and tools specifically designed and required to work on the new equipment, which are not commercially available as standard mechanic's tools, must be furnished to the Contracting Officer.

Provide proposed operating instructions for the engine-generator set and auxiliary equipment laminated between matte-surface thermoplastic sheets and suitable for placement adjacent to corresponding equipment. After approval, install operating instructions where directed.

1.7 MAINTENANCE SERVICES

Submit the operation and maintenance manuals and have them approved prior to commencing onsite tests.

1.7.1 Operation Manual

Provide three copies of the manufacturers standard operation manual . Sections must be separated by heavy plastic dividers with tabs which identify the material in the section. Fold drawings with the title block visible, and placed in 8-1/2 by 11 inch plastic pockets with reinforced holes. The manual must include:

a. Step-by-step procedures for system startup, operation, and shutdown;

b. Drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems with their controls, alarms, and safety systems;

c. Procedures for interface and interaction with related systems to include automatic transfer switches and load shedding systems.

1.7.2 Maintenance Manual

Provide three copies of the manufacturers standard maintenance manual . Separate each section by a heavy plastic divider with tabs. Fold drawings with the title block visible, and placed in plastic pockets with reinforced holes. The manual must include:

a. Procedures for each routine maintenance item.Procedures for troubleshooting.Factory-service, take-down overhaul, and repair service manuals, with parts lists.

b. The manufacturer's recommended maintenance schedule.

c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components.

d. A list of spare parts for each piece of equipment and a complete list of materials and supplies needed for operation.

1.7.3 Assembled Operation and Maintenance Manuals

The contents of the assembled operation and maintenance manuals must include the manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA and the manufacturer's O&M information specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

a. Manuals must be in separate books or volumes, assembled and bound securely in durable, hard covered, water resistant binder, and indexed by major assembly and components in sequential order.

b. A table of contents (index) must be made part of the assembled O&M. The manual must be assembled in the order noted in table of contents.

c. The cover sheet or binder on each volume of the manuals must be identified and marked with the words, "Operation and Maintenance Manual."

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set must satisfy the requirements specified in the Engine-Generator Parameter Schedule. Submit certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

b. Provide each engine-generator set consisting of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and all other necessary ancillary equipment which may be mounted separately. Assemble sets having a capacity of 750 kW or smaller and attach to the base prior to shipping. Sets over 750 kW capacity may be shipped in sections. Provide set components that are environmentally suitable for the locations shown and that are the manufacturer's standard product offered in catalogs for commercial or industrial use. Provide a generator strip heater for moisture control when the generator is not operating. Identify any nonstandard products or components and the reason for their use.

2.1.1 Rated Output Capacity

Provide each engine-generator-set with power equal to the sum of service load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity must also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

The engine must meet the specified maximum BMEP requirements at rated speed as calculated in accordance with the calculations in the engine-generator parameter schedule. The engine capacity must be based on the following:

a. Engine burning diesel fuel conforming to ASTM D975, Grade 2-D, or at an ambient temperature of 85 degrees F. For stationary engines operated in the United States, diesel fuel requirements are found in 40 CFR 60 Subpart IIII.

b. Engine cooled by a radiator fan mechanically driven by the engine or remote with a motor driven fan.

c. Engine cooled by coolant mixture of water and ethylene glycol, 50 percent by volume of each.

2.1.1.1 Engine Emission Limits

Engine must be certified by the manufacturer to meet applicable EPA emission standards found in 40 CFR 60 Subpart IIII. In addition, engine must meet any applicable state or local emission requirements (ex: California SCAQMD).

2.1.1.2 Performance Class

The voltage and frequency behavior of the generator set must be in accordance with ISO 8528 operating limit values for performance Classas required.

2.1.2 Power Ratings

Power ratings must be in accordance with EGSA 101P.

2.1.3 Transient Response

The engine-generator set governor and voltage regulator must cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set must respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

2.1.4 Reliability and Durability

Each standby engine-generator set must have both an engine and a generator capable of delivering the specified power on a standby basis with an anticipated mean time between overhauls of no less than 5,000 hours operating with a load factor of 70 percent. Cite two like engines and two like generators that have performed satisfactorily in a stationary power plant, independent and separate from the physical location of the manufacturer's and assembler's facilities, for standby without any failure to start, including all periodic exercise. Provide like engines and generators that have had no failures resulting in downtime for repairs in excess of 72 hours during two consecutive years of service. Provide engines that are the same model, speed, bore, stroke, number and configuration of cylinders, and rated output capacity. Provide generators that are the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

Submit a reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e. engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.

2.1.5 Parallel Operation

Configure each engine-generator set specified for parallel operation for automatic parallel operation. Each set must be capable of parallel operation with one or more sets on an isolated bus .

2.1.6 Load Sharing

Configure each engine-generator set specified for parallel operation to automatically load share with other sets by proportional loading. Proportional loading must load each set to within 5 percent of its fair share. A set's fair share is its nameplate-rated capacity times the total load, divided by the sum of all nameplate-rated capacities of on-line sets. Incorporate both the real and reactive components of the load.

2.1.7 Engine-Generator Set Enclosure

Provide engine-generator set enclosures that are corrosion resistant and fully weather resistant. The enclosure must contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Provide access doors to controls and equipment requiring periodic maintenance or adjustment. Provide removable panels for access to components requiring periodic replacement. The enclosure must be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure must reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

2.1.8 Vibration Isolation

Provide an engine-generator set with a vibration isolation system in accordance with the manufacturer's standard recommendation. Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor plus description of seismic qualification of the engine-generator mounting, base, and vibration isolation. Submit torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus 10 percent. Design and qualify vibration isolation systems as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

2.1.9 Harmonic Requirements

Non-linear loads to be served by each engine-generator set are as indicated. The maximum linear load demand (kVA at PF) when non-linear loads will also be in use is as indicated.

2.1.10 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

2.2 NAMEPLATES

Provide the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment for each major component of this specification. Provide plates and tags sized so that inscription is readily legible to operating or maintenance personnel and securely mounted to or attached in proximity of their identified controls or equipment. Lettering must be normal block lettering, a minimum of 0.25 inch high. As a minimum, provide nameplates for:

Engines	Relays
Generators	Transformers (CT & PT)
Regulators	Day tanks
Pumps and pump motors	Governors
Generator Breaker	Air Starting System
Economizers	Heat exchangers (other than base mounted)

Where the following equipment is not provided as a standard component by the engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Switchboards	Exhaust mufflers
Switchgear	Silencers
Battery	Exciters

2.2.1 Materials

Construct ID plates and tags of 16 gage minimum thickness bronze or stainless steel sheet metal engraved or stamped with inscription. Construct plates and tags not exposed to the weather or high operational temperature of the engine of laminated plastic, 0.125 inch thick, matte white finish with black center core, with lettering accurately aligned and engraved into the core.

2.2.2 Control Devices and Operation Indicators

Provide ID plates or tags for control devices and operation indicators, including valves, off-on switches, visual alarm annunciators, gages and thermometers, that are required for operation and maintenance of provided mechanical systems. Plates or tags must be minimum of 0.5 inch high and 2 inches long and must indicate component system and component function.

2.2.3 Equipment

Provide ID plates of a minimum size of high and 5 inches long on provided equipment indicating the following information:

a. Manufacturer's name, address, type and model number, serial number, and certificate of compliance with applicable EPA mission standards;

b. Contract number and accepted date;

c. Capacity or size;

d. System in which installed; and

e. System which it controls.

2.3 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices such that proper operation of the equipment is not impaired.

2.4 MATERIALS AND EQUIPMENT

Submit certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

2.4.1 Circuit Breakers, Low Voltage

UL 489.

2.4.2 Filter Elements

Provide the manufacturer's standard fuel-oil, lubricating-oil, and combustion-air filter elements.

2.4.3 Instrument Transformers

NEMA/ANSI C12.11.

2.4.4 Revenue Metering

IEEE C57.13.

2.4.5 Pipe (Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A53/A53M, or ASTM A106/A106M steel pipe. Pipe smaller than 2 inches must be Schedule 80. Pipe 2 inches and larger must be Schedule 40.

2.4.5.1 Flanges and Flanged Fittings

ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

2.4.5.2 Pipe Welding Fittings

ASTM A234/A234M, Grade WPB or WPC, Class 150 or ASME B16.11, 3000 lb.

2.4.5.3 Threaded Fittings

ASME B16.3, Class 150.

2.4.5.4 Valves

MSS SP-80, Class 150.

2.4.5.5 Gaskets

Manufacturer's standard.

2.4.6 Pipe Hangers

MSS SP-58.

2.4.7 Electrical Enclosures

NEMA ICS 6.

2.4.7.1 Switchboards

NEMA PB 2.

2.4.7.2 Panelboards

NEMA PB 1.

2.4.8 Electric Motors

Provide electric motors that conform to the requirements of NEMA MG 1. Motors must have sealed ball bearings and a maximum speed of 1800 rpm. Motors used indoors must have drip-proof frames; enclose those that are used outside. Alternating current motors larger than 1/2 Hp must be of the squirrel-cage induction type for operation on 208 volts or higher, 60 Hz, and three-phase power. Alternating current motors 1/2 Hp or smaller, must be suitable for operation on 120 volts, 60 Hz, and single-phase power. Direct current motors must be suitable for operation on as required volts.

2.4.9 Motor Controllers

Provide motor controllers and starters that conform to the requirements of NFPA 70 and NEMA ICS 2.

2.5 ENGINE

Each engine must operate on No. 2-D diesel fuel conforming to ASTM D975, must be designed for stationary applications and must be complete with ancillaries. The engine must be a standard production model shown in the manufacturer's catalog describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance. The engine must be naturally aspirated, supercharged, or turbocharged. The engine must be 2- or 4-stroke-cycle and compression-ignition type. The engine must be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. The engine must have a minimum of two cylinders. Opposed-piston type engines must have more than four cylinders. Each block must have a coolant drain port. Equip each engine with an over-speed sensor.

ISO 3046. Diesel engines must be four-cycle naturally aspirated, or turbocharged, or turbocharged and intercooled; vertical in-line or vertical Vee type; designed for stationary service. Engines must be capable of immediate acceleration from rest to normal speed without intermediate idle/warm up period or pre-lubrication to provide essential electrical power. Two-cycle engines are not acceptable.

2.5.1 Sub-base Mounting

Mount each engine-generator set on a structural steel sub-base sized to support the engine, generator, and necessary accessories, auxiliaries and control equipment to produce a complete self-contained unit as standard with the manufacturer. Design the structural sub-base to properly support the equipment and maintain proper alignment of the engine-generator set in the specified seismic zone. In addition, provide sub-base with both lifting rings and jacking pads properly located to facilitate shipping and installation of the unit. Factory align engine and generator on the sub-base and securely bolt into place in accordance with the manufacturer's standard practice. Crankshaft must have rigid coupling for connection to the generator.

2.5.2 Assembly

Completely shop assemble each engine-generator set on its structural steel sub-base. Paint entire unit with manufacturer's standard paints and colors. After factory tests and before shipping, thoroughly clean and retouch painting as necessary to provide complete protection.

2.5.3 Turbocharger

If required by the manufacturer to meet the engine-generator set rating, provide turbine type driven by exhaust gas from engine cylinders, and direct connected to the blower supplying air to the engine intake manifold.

2.5.4 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.5.5 Crankcase Protection

2.5.6 Miscellaneous Engine Accessories

Provide the following engine accessories where the manufacturer's standard design permits:

a. Piping on engine to inlet and outlet connections, including nonstandard companion flanges.

b. Structural steel sub-base and vibration isolators, foundation bolts, nuts, and pipe sleeves.

c. Level jack screws or shims, as required.

d. Rails, chocks, and shims for installation of sub-base on the foundation.

e. Removable guard, around fan. Support guard, on engine sub-base, to suit manufacturer's standard.

2.5.7 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.6 FUEL SYSTEM

Provide fuel system conforming to the requirements of NFPA 30 and NFPA 37 and containing the following elements.

2.6.1 Pumps

Fuel transfer pumps may be mounted on the day tank. Pumps must be horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively.

2.6.1.1 Main Pump

Provide engines with an engine driven pump. The pump must supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. Base the fuel flow rate on meeting the load requirements and all necessary recirculation.

2.6.1.2 Auxiliary Fuel Pump

Provide auxiliary fuel pumps to maintain the required engine fuel pressure, if either required by the installation or indicated on the drawings. The auxiliary pump must be driven by a dc electric motor powered by the starting/station batteries. Automatically actuate the auxiliary pump by a pressure-detecting device.

2.6.2 Fuel Filter

Provide a minimum of one full-flow fuel filter for each engine. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark the inlet and outlet connections of the filter.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.6.3 Relief/Bypass Valve

Provide a relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.6.4 Integral Main Fuel Storage Tank

Provide each engine with an integral main fuel tank. Each tank must be factory installed and provided as an integral part of the generator manufacturer's product. Provide each tank with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. Provide a fuel return line cooler as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank must be below the flash point of the fuel. Mount the tank within the enclosure for each engine-generator set provided with weatherproof enclosures. The fuel fill line must be accessible without opening the enclosure.

a. All Tanks: UL 142. Provide integral in skid or free standing double wall (110 percent containment) fuel tanks with a minimum capacity of 72 hours of engine-generator set operation at full-rated load . Epoxy coat day tanks inside and prime and paint outside. Construct tanks of not less than 3/16 inch steel plate with welded joints and necessary stiffeners on exterior of tank. Provide a braced structural steel framework support. Weld tank top tight. Provide 4 1/2 inch square inspection port with a 2 inch NPT fill connection and spill box. Provide proper normal and emergency venting for the primary tank and emergency venting only for the secondary tank / containment basin in accordance with UL 142 requirements.

b. Float Switches for Day Tanks: Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level float switches to close on rise of liquid level, and low level float switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts must be suitable for the station battery voltage.

   (1) Critical low level float switch which must activate at 5 percent of normal liquid level must shut engine off.

   (2) Low-low level float switch which must activate alarm at 30 percent of normal liquid level.

   (3) Low level float switch which must open the fuel oil solenoid valve and start the remote fuel transfer pump at 75 percent of normal liquid level.

   (4) High level float switch which must close the fuel oil solenoid valve and stop the fuel transfer pump at 90 percent of normal liquid level.

   (5) Critical high level float switch which must activate alarm at 95 percent of normal liquid level.

c. Leak Detector Switch for All Tanks: Actuates when fuel is detected in containment basin, stops fuel transfer pump, and closes the fuel oil solenoid valve.

d. Control Panel for All Tanks: Provide NEMA ICS 6, Type as required, enclosed control panel for each day tank. Control panel must include the following accessories.

(1) Power available LED (green).

(2) Critical low fuel alarm contacts for shut down of engine.

(3) Low-low level fuel alarm LED.

(4) Low-low level fuel alarm contracts for remote annunciator.

(5) Critical high level fuel alarm LED.

(6) Leak detecting alarm LED.

(7) Alarm horn.

e. Tank Gages for All Tanks: Provide buoyant force type gages for fuel tanks with dial indicator not less than 4 inches in size and arranged for top mounting. Calibrate each reading dial or scale for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

f. Integral Base Tanks Used as Primary Tank: Provide a 2 inch opening at the tank fill port, fitted an overfill prevention valve (OPV). Additionally, the fill opening must be perpendicular to the tank in order to allow operation of the OPV. Integral base tank must be sized and configured such that the filling and venting nozzles are outside the generator cabinet for ease of accessibility, inspection, and maintenance. Level gage must be in the line of sight from the fill port.

g. Integral Base Tanks Located Inside Buildings. The tank vents must discharge outside the building in accordance with NFPA 30 and NFPA 37. The fill pipe must terminate outside the building. The fill pipe connection point must be housed in a sealed spill box. High level alarms or level gauges used as overfill protection mechanisms must annunciate at the fill connection point. Provide an overfill prevention valve (OPV) at the tank with a check valve mounted on the fill line in the spill box. The fill connection point must be labeled with tank contents and capacity.

h. External tanks (all non-integral base tanks) are specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.6.4.1 Fuel Transfer Pumps

Fuel transfer pumps may be mounted on the day tank. Pumps must be duplex, horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively.

2.6.4.2 Capacity

Each tank must have capacity to supply fuel to the engine for an uninterrupted 72-hour period at 100 percent rated load without being refilled.

2.6.4.3 Local Fuel Fill

Each local fuel fill port on the day tank must have a screw-on cap.

2.6.4.4 Fuel Level Controls

Provide tanks with a float-switch assembly to perform the following functions:

a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.6.4.5 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors must have an internal or external factory installed valve located as near as possible to the shell of the tank. The valve must close when the engine is not operating. Provide integral day tanks with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection must be welded pipe.

2.6.5 Day Tank

Provide engine with integral day tank. Submit calculations for the capacity of each day tank, including allowances for recirculated fuel, usable tank capacity, and duration of fuel supply. Provide connections for fuel supply line, , . Mount the day tank within the enclosure for each engine-generator set with weatherproof enclosures. The fuel fill line must be accessible without opening the enclosure.

2.6.5.1 Capacity, Prime

Provide day tank with the capacity to supply fuel to the engine for an uninterrupted 72-hour period at 100 percent rated load without being refilled, plus any fuel which may be returned to the main fuel storage tank. Submit calculations for the capacity of each day tank, including allowances for recirculated fuel, usable tank capacity, and duration of fuel supply. The calculation of the capacity of each day tank must incorporate the requirement to stop the supply of fuel into the day tank at a "High" level mark of 90 percent of the ultimate volume of the tank.

2.6.5.2 Capacity, Standby

Provide day tank with the capacity to supply fuel to the engine for an uninterrupted 72-hour period at 100 percent rated load without being refilled, plus any fuel which may be returned to the main fuel storage tank. Submit calculations for the capacity of each day tank, including allowances for recirculated fuel, usable tank capacity, and duration of fuel supply. The calculation of the capacity of each day tank must incorporate the requirement to stop the supply of fuel into the day tank at 90 percent of the ultimate volume of the tank.

2.6.5.3 Drain Line

Each day tank drain line must be accessible and equipped with a shutoff valve. Arrange self-supporting day tanks to allow drainage into a 12 inch tall bucket.

2.6.5.4 Local Fuel Fill

Each local fuel fill port on the day tank must have a screw-on cap.

2.6.5.5 Fuel Level Controls

Provide day tank with a float-switch assembly to perform the following functions:

a. Start the supply of fuel into the day tank when the fuel level is at the "Low" level mark, 75 percent of the rated tank capacity.

b. Stop the supply of fuel into the day tank when the fuel level is at 90 percent of the rated tank capacity.

c. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

d. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

e. Activate the automatic fuel supply shut-off valve located on the fill line of the day tank and shut down the fuel pump which supplies fuel to the day tank at 95 percent of the rated tank capacity. Stop the flow of fuel before any fuel can be forced into the fuel overflow line.

2.6.5.6 Fuel Oil Solenoid Valve

UL 429. Provide electric solenoid type control valve for each day tank. Solenoid must be rated for starting battery voltage. Valve body must have a minimum working pressure rating of 150 psig at 200 degrees F. Valve must be capable of passing 0 to 10 gpm of fuel oil. Valves must be two-way, direct acting, normally closed (open when energized, closed when de-energized), with stainless steel body and resilient seat material. Solenoid enclosures must be NEMA ICS 6, Type 1. Body connections must be same size as connecting piping. Valve must be in line before the fuel pump.

2.6.5.7 Arrangement

Arrange self-supporting day tanks so that the fuel level in the day tank remains above the suction port of the engine driven fuel pump or be provided with a transfer pump to provide fuel to the engine driven pump. Arrange the overflow connection and fuel supply line so that the highest possible fuel level is below the fuel injectors. The fuel supply line from the day tank to the manufacturer's standard engine connection must be welded pipe.

2.6.6 Fuel Supply System

Provide the fuel supply from the main storage of fuel to the day tank as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.6.7 Strainer

Simplex or Duplex strainers must comply with Section 33 52 10 SERVICE

PIPING, FUEL SYSTEMS.

2.6.8 Fuel Oil Meters

Fuel oil meter must comply with Section 33 52 10 SERVICE PIPING, FUEL SYSTEMS.

2.6.9 Fuel Oil Cooler

Provide an air cooled fuel oil cooler if the temperature of the fuel returned to the tank from the engine will cause overheating of the tank fuel above the maximum fuel temperature allowed by the engine manufacturer when operating at maximum rated generator power output and low fuel level in the tank. The fuel oil cooler must be furnished by the engine manufacturer for the application and the installation must be complete including piping and power requirements.

2.7 LUBRICATION

Provide engine with a separate lube-oil system conforming to NFPA 30 and NFPA 37. Pressurize each system by engine-driven pumps. Regulate system pressure as recommended by the engine manufacturer. Provide a pressure relief valve on the crankcase for closed systems. Vent the crankcase in accordance with the manufacturer's recommendation. Do not vent the crankcase to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, must be piped to vent to the outside. The system must be readily accessible for service such as draining, refilling, etc. Each system must permit addition of oil and have oil-level indication with the set operating. The system must utilize an oil cooler as recommended by the engine manufacturer.

2.7.1 Lube-Oil Filter

Provide one full-flow filter for each pump. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark inlet and outlet connections.

2.7.2 Lube-Oil Sensors

Equip each engine with lube-oil pressure sensors located downstream of the filters and provide signals for required indication and alarms. Submit two complete sets of filters, required for maintenance, supplied in a suitable storage box. Provide these filters in addition to filters replaced after testing.

2.7.3 Precirculation Pump

Provide a motor-driven precirculation pump powered by the station battery, complete with motor starter, if recommended by the engine manufacturer.

2.8 COOLING SYSTEM

Provide each engine with its own cooling system to operate automatically while its engine is running. The cooling system coolant must use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine must not exceed that recommended below. Submit a letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

a. The maximum allowable inlet temperature of the coolant fluid or .

b. The minimum allowable inlet temperature of the coolant fluid through the engine or cooling air across the engine.

c. The maximum allowable temperature rise in the coolant fluid through the engine or cooling air across the engine.

d. The minimum allowable inlet fuel temperature.

2.8.1 Coolant Pumps

Provide centrifugal coolant pumps. Each engine must have an engine-driven primary pump. Provide secondary pumps that are electric motor driven and have automatic controllers. Control raw-water circulating pump by manual-off-automatic controllers and must be electric motor driven.

2.8.2 Heat Exchanger

Provide heat exchanger with the size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted for the maximum summer outdoor design temperature and site elevation. Submit manufacturer's data to quantify heat rejected to the space with the engine generator set at rated capacity. Provide heat exchangers that are corrosion resistant, suitable for service in ambient conditions of application.

2.8.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosion resistant film, provided that corrective measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Provide internal surfaces that are compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Provide heat exchangers that are pressure type incorporating a pressure valve, vacuum valve and a cap. Design caps for pressure relief prior to removal. Provide heat exchanger and cooling system that is capable of withstanding a minimum pressure of 7 psi and protect with a strong grille or screen guard. Provide heat exchanger with at least two tapped holes; equip one tapped hole with a drain cock, and plug the rest.

Provide for each engine-generator set, as standard with the manufacturer.

a. Design Conditions: Each radiator unit must have ample capacity to remove not less than the total Btu per hour of heat rejected by its respective engine at 100 percent full-rated load to the jacket water, fuel oil, and lubricating oil system, and intercooler. Radiator capacity must be rated at optimum temperature of coolant leaving the engine and intercooler as recommended by the engine manufacturer with an ambient dry bulb air temperature outside the enclosure of as required minimum at the site elevation specified in the paragraph SITE CONDITIONS, and with the coolant mixture specified in the paragraph ENGINE CAPACITY. Pressure drop through the radiator must not exceed 6 psi when circulating the maximum required coolant flow. Radiator air velocity must be a maximum of 1500 feet per minute.

b. Engine Mounted Radiator Construction: Radiator fan must direct airflow from the engine outward through the radiator. Fan must be V-belt driven directly from the engine crankshaft. Radiator fan must have sufficient capacity to meet design conditions against a static restriction as required. Fan static capacity must be adjusted to suit the ductwork furnished. Cooling section must have a tube and fin-type core consisting of copper or copper base alloy tubes with nonferrous fins. Select engine-driven fans for quiet vibration-free operation. Make provision for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with the manufacturer. Provide suitable guards for each fan and drive.

c. Coolant solution must be a mixture of clean water and ethylene glycol, 50 percent by volume each. Provide an anti-freeze solution tester suitable for the mixture.

Field installed jacket coolant water piping must conform to the following:

a. Piping: Provide seamless steel pipe, Schedule 40, conforming to ASTM A53/A53M, Grade A.

b. Fittings and Flanges: Fittings, 1 1/2 inches or smaller, must be malleable iron conforming to ASME B16.3 for Class 300 threaded type. Fittings, 2 inches and larger, must be steel butt welding conforming to ASME B16.9. Utilize either ASME B16.1 or Class A of ASTM A126 for Class 125 cast-iron flanged fittings. Flanges must be Class 150 slip-on forged steel welding flanges in accordance with ASME B16.5, with material in accordance with ASTM A181/A181M, Grade I. Provide flat face flanges for connecting to Class 125 standard cast-iron valves, fittings, and equipment connections.

c. Valves

(1) Gate Valves: For valves, 1 1/2 inches and smaller, provide double disk, rising stem, inside screw, union bonnet type, Class 125 bronze material conforming to MSS SP-80. For valves, 2 inches and larger, provide double-disk, parallel seat type, hydraulic-rated, Class 125, outside screw and yoke type with flanged ends and bronze trim conforming to MSS SP-70. Provide stem packing of material compatible with the system coolant.

(2) Globe Valves: For valves, 1 1/2 inches and smaller, provide rising stem, inside screw, union bonnet type, Class 125 bronze valves conforming to MSS SP-80. For valves, 2 inches and larger, provide Class 125 cast iron, flanged ends, bronze trim globe valves conforming to MSS SP-85. Valves must have renewable composition or cast iron discs compatible with the system coolant.

(3) Check Valves: MSS SP-71 or MSS SP-80, swing check type.

d. Hangers and Supports: MSS SP-58.

e. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Place sleeves during construction. Unless indicated otherwise, pipe sleeves must comply with following requirements: Sleeves in outside walls below and above grade, in floor, or in roof slabs, must be standard weight zinc coated steel pipe. Sleeves in partitions must be zinc coated sheet steel having a nominal weight of not less than 0.90 pound per square foot. Space between piping insulation and the sleeve must be not less than 0.25 inch. Sleeves must be held securely in proper position and location during construction. Sleeves must be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs must extend 2 inches above the finished floor. Space between the pipe and the sleeve must be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.

2.8.2.2 Shell and U-Tube Type Heat Exchanger

Provide multiple pass shell, U-tube type heat exchanger. Exchanger must operate with low temperature water in the shell and high temperature water in the tubes. Provide exchangers that are constructed in accordance with ASME BPVC SEC VIII D1 and certified with ASME stamp secured to the unit. Provide U-tube bundles that are completely removable for cleaning and tube replacement and free to expand with the shell. Construct shells of seamless steel pipe or welded steel. Tubes must be cupronickel or inhibited admiralty, constructed in accordance with ASTM B395/B395M, suitable for the temperatures and pressures specified. Tubes less than 3/4 inch unless otherwise indicated are not acceptable. Design shell side and tube side for 150 psig working pressure and factory tested at 300 psig. Locate high and low temperature water and pressure relief connections in accordance with the manufacturers standard practice. Water connections larger than 3 inches must be ASME Class 150 flanged. Water pressure loss through clean tubes must be as recommended by the engine manufacturer. Minimum water velocity through tubes must be 1 fps and assure turbulent flow. Provide one or more pressure relief valves for each heat exchanger in accordance with ASME BPVC SEC VIII D1. The aggregate relieving capacity of the relief valves must be not less than that required by the above code. Install discharge from the valves indicated. Install the relief valves on the heat exchanger shell. Install a drain connection with 3/4 inch hose bib at the lowest point in the system near the heat exchanger. Install additional drain connection with threaded cap or plug wherever required for thorough draining of the system.

2.8.3 Expansion Tank

The cooling system must include an air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The tank must be suitable for operating temperature of 250 degrees F and a working pressure of 125 psi. Provide welded steel tank , tested and stamped in accordance with ASME BPVC SEC VIII D1 for the stated working pressure. Do not use a bladder type tank. Support the tank by steel legs or bases for vertical or steel saddles for horizontal installation.

2.8.4 Thermostatic Control Valve

Provide a modulating type, thermostatic control valve in the coolant system to maintain the coolant temperature range submitted in paragraph SUBMITTALS.

2.8.5 Ductwork

Provide ductwork as specified in Section Section 23 30 00 HVAC AIR DISTRIBUTION except use a flexible connection to connect the duct to the engine radiator. Material for the connection must be wire-reinforced glass. Provide airtight connection.

2.8.6 Temperature Sensors

Equip each engine with coolant temperature sensors. Provide temperature sensors with signals for pre-high and high indication and alarms.

2.9 SOUND LIMITATIONS

Submit sound power level data for the packaged unit operating at 100 percent load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification. Submit certification from the manufacturer stating that the sound emissions meet the specification. Do not exceed the following sound pressure levels in any of the indicated frequencies when measured in a free field at a radial distance of 22.9 feet 7 meters at 45 degrees apart in all directions when operating at 100 percent load.

Frequency Band (Hz)	Maximum Acceptable Sound Level (Decibels)
31	84
63	84
125	96
250	105
500	110
1,000	111
2,000	110
4,000	109
8,000	105

2.10 AIR INTAKE EQUIPMENT

Locate filters and silencers in locations that are convenient for servicing. Provide high-frequency filter type silencers and locate in the air intake system as recommended by the engine manufacturer. Provide silencer to reduce the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Provide copper or rubber expansion elements in air-intake lines.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.11 EXHAUST SYSTEM

Provide a separate and complete system for each engine. Support piping to minimize vibration. Where a V-type engine is provided, use a V-type connector, with necessary flexible sections and hardware, to connect the engine exhaust outlets.

2.11.1 Flexible Sections and Expansion Joints

Provide a flexible section at each engine and an expansion joint at each muffler. Provide flexible sections and expansion joints that have flanged connections. Provide flexible sections made of convoluted seamless tube without joints or packing. Provide bellows type expansion joints. Provide stainless steel expansion and flexible elements suitable for engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Provide expansion and flexible elements that are capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.11.2 Exhaust Muffler

Provide a chamber type exhaust muffler. Provide welded steel muffler designed for outside inside vertical horizontal mounting. Provide eyebolts, lugs, flanges, or other items as necessary for support in the location and position indicated. Do not exceed the engine manufacturer's recommended pressure drop. Outside mufflers must be zinc coated or painted with high temperature 400 degrees F resisting paint. The muffler and exhaust piping together must reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. Provide muffler with a drain valve, nipple, and cap at the low-point of the muffler.

A critical class silencer must be provided for each engine which will reduce the exhaust sound spectrum by the following listed values at a 75 foot radius from the outlet, with generator set loaded to rated capacity and clear weather. Inlet and outlet connections must be flanged.

Octave Band Center Frequency (Hertz)								
Minimum Silencer Attenuation Decibels	63	125	250	500	1000	2000	4000	8000
Critical Class	15	32	37	36	30	36	37	37

2.11.3 Exhaust Piping

Slope horizontal sections of exhaust piping downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction must be long radius. Insulate exhaust piping, mufflers and silencers installed inside any building in accordance with paragraph THERMAL INSULATION and covered to protect personnel. Provide vertical exhaust piping with a hinged, gravity-operated, self-closing, rain cover.

Field installed exhaust piping must conform to the following:

a. Exhaust Piping: Provide flanges for connections to engines, exhaust mufflers, and flexible connections. Provide steel pipe conforming to ASTM A53/A53M for each engine complete with necessary fittings, flanges, gaskets, bolts, and nuts. Exhaust piping must be Schedule 40 pipe for 12 inches and smaller, standard weight for sizes 14 inches through 24 inches, and 0.25 inch wall thickness for sizes larger than 24 inches. Flanges must be Class 150 slip-on forged steel welding flanges in accordance with ASME B16.5, with material in accordance with ASTM A181/A181M, Grade I. Fittings must be butt welding conforming to ASTM A234/A234M, with wall thickness same as adjoining piping. Fittings must be of same material and wall thickness as pipe. Built-up miter welded fittings may be used. Miter angles of each individual section must not exceed 22.5 degrees total and not more than 11.25 degrees relative to the axis of the pipe at any one cut. Gaskets for exhaust piping must be of high temperature asbestos-free material suitable for the service and must be ASME B16.21, composition ring, 0.0625 inch thick. Bolting material for exhaust flanges must be alloy-steel bolt-studs conforming to ASTM A193/A193M, Grade B7 bolts and alloy-steel nuts conforming to ASTM A194/A194M, Grade 7. Bolts must be of sufficient length to obtain full bearing on the nuts and must project not more than two full threads beyond the nut. Provide stainless steel counterbalance type rain caps at termination of each exhaust pipe.

b. Expansion (Flexible) Joints: Provide sections of multiple corrugated stainless steel expansion joints with liners in the engine exhaust piping for each engine to absorb expansion strains and vibration transmitted to the piping. Flexible joints must be suitable for operation at 200 degrees F above normal exhaust gas temperature at 100 percent load, 10,000 cycles, minimum. Joints must be flanged and located between engine exhaust manifold and exhaust piping, must be the same size as exhaust piping size, and must be designed and constructed for engine exhaust service.

c. Hangers and Supports: MSS SP-58.

d. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Sleeves must be placed during construction. Unless indicated otherwise, pipe sleeves must comply with following requirements: sleeves in outside walls below and above grade, in floor, or in roof slabs, must be standard weight zinc coated steel pipe. Sleeves in partitions must be zinc coated sheet steel having a nominal weight of not less than 0.90 pound per square foot. Space between piping insulation and the sleeve must not be less than 0.25 inch. Sleeves must be held securely in proper position and location during construction. Sleeves must be sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs must extend 2 inches above the finished floor. Space between the pipe and the sleeve must be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.

e. Piping Insulation: Provide exhaust piping insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.12 PYROMETER

Provide a pyrometer, with calibrated leads to show the temperature of the combined exhaust. For a supercharged engine, provide additional points, thermocouples and leads to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length less than 6 inches is not acceptable. Provide double pole selector switch with an "off" position, one set of points for each thermocouple, and suitable indicating dial. Calibrate the pyrometer, thermocouples, leads and compensating devices to show true exhaust temperature within plus or minus 1 percent above the highest temperature encountered at 110 percent load conditions.

2.13 EMISSIONS

The finished installation must comply with Federal, state, and local regulations and restrictions regarding the limits of emissions. Submit certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification must include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HAPs).

2.14 STARTING SYSTEM

Provide starting system for standby engine generator sets used in emergency applications in accordance with NFPA 99 and NFPA 110.

2.14.1 Controls

Provide an engine control switch with functions including: run/start (manual), off/reset, and, automatic mode. Provide start-stop logic for adjustable cycle cranking and cool-down operation. Arrange the logic for fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Provide electrical starting systems with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.14.2 Capacity

Provide starting system with sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system must provide a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period must have a maximum duration of 15 seconds. Starting must be accomplished using an adequately sized dc starter system with a positive shift solenoid to engage the starter motor and to crank the engine continuously for 60 seconds without overheating.

2.14.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground. Starting motors must be in accordance with SAE ARP892.

2.14.3.1 Battery

Provide a starting battery system including the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Provide battery in accordance with SAE J537. Size critical system components (rack, protection, etc.) to withstand the seismic acceleration forces specified. Provide nickel-cadmium battery with sufficient capacity, at the minimum outdoor and maximum outdoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

2.14.3.2 Battery Charger

Provide a current-limiting battery charger, conforming to UL 1236, that automatically recharges the batteries. Submit battery charger sizing calculations. The charger must be capable of an equalize charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition. Provide an ammeter to indicate charging rate. Provide a voltmeter to indicate charging voltage. Provide a timer for the equalize charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

Provide 120 volt ac, enclosed, automatic equalizing, dual-rate, solid-state, constant voltage type battery charger with automatic ac line compensation. DC output must be voltage regulated and current limited. Charger must have two ranges, float and equalize, and must provide continuous taper charging. The charger must have a continuous output rating of not less than 10 amperes and must be sized to recharge the engine starting batteries in a minimum of 8 hours while providing the control power needs of the engine-generator set. Enclosure must be NEMA ICS 6, Type as required. The following accessories must be included:

a. DC ammeter

b. DC voltmeter

c. Equalize light

d. AC on light

e. Low voltage light

f. High voltage light

g. Equalize test button/switch

h. AC circuit breaker

i. Low dc voltage alarm relay

j. High dc voltage alarm relay

k. Current failure relay

l. AC power failure relay

2.14.4 Storage Batteries

Provide storage batteries of suitable rating and capacity to supply and maintain power for the remote alarm annunciator for a period of 90 minutes minimum without the voltage applied falling below 87.5 percent of normal. Provide a 120 volt ac automatic battery charger.

2.14.5 Pneumatic

Provide a pneumatic starting system. Provide compressed air system as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE, for a working pressure as required.

2.14.5.1 Air Driven Motors

Provide air driven motors complete with solenoid valve, strainer, and lubricator.

2.14.5.2 Cylinder Injection

Perform starting by admitting compressed air into two or more engine cylinders through a timing valve, or through a distributor into a sufficient number of cylinders to assure successful starting regardless of piston positions.

2.14.6 Starting Aids

Provide one or more of other following methods to assist engine starting.

2.14.6.1 Glow Plugs

Design glow plugs to provide sufficient heat for combustion of fuel within the cylinders to guarantee starting at an ambient temperature of -25 degrees F.

2.14.6.2 Jacket-Coolant Heaters

Mount a thermostatically controlled electric heater in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 120 volts ac. Include necessary equipment, piping, controls, wiring, and accessories.

2.14.6.2.1 Prime Rated Sets

The control temperature must be the higher of the manufacturer's recommended temperature or the minimum coolant inlet temperature of the engine recommended in paragraph SUBMITTALS.

2.14.6.2.2 Standby Rated Sets

The control temperature must be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.14.6.3 Lubricating-Oil Heaters

Mount a thermostatically controlled electric heater in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 120 volts ac.

2.14.7 Exerciser

Provide exerciser in accordance with Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.15 GOVERNOR

Provide a forward acting type engine speed governor system. Steady-state frequency band and frequency regulation (droop) must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

Provide engine with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. Configure the governor for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of 0 to 100 percent or rated capacity. Submit two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. Provide a suitable tool box for tools. Provide one handset for each electronic governor when required to indicate and/or change governor response settings.

2.16 GENERATOR

Provide synchronous type, one or two bearing, generator conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data. Provide Class H insulation.

a. Select NEMA MG 1, Part 16, standby duty, and temperature rise of 130 degrees C for engine-generator sets which are expected to operate for less than 300 hours per year. Select NEMA MG 1, Part 22, continuous duty, and temperature rise of 105 degrees C for engine-generator sets expected to operate 300 hours or greater per year or rated 300 kW and above.

b. Select 2/3 pitch design option for engine-generator sets rated 300 kW and above.

c. Select 10-12 lead re-connectable for engine-generator sets rated 300 kW to 800 kW.

d. For applications requiring high SCR loading or in harsh environments laden with salts and chemicals, select vacuum pressure impregnation (VPI) insulated coils. When engine-generator sets are rated 800 kW and larger, also select form wound coils.

e. Provide salient-pole type, ac, brushless-excited, revolving field, air-cooled, self-ventilated, coupled type, synchronous generator conforming to NEMA MG 1. Generator must be rated for standby duty at 100 percent of the power rating of the engine-generator set as specified in paragraph ENGINE-GENERATOR SET RATINGS AND PERFORMANCE. Temperature rise of each of the various parts of the generator must not exceed 105 degrees C as measured by resistance, based on a maximum ambient temperature of 40 degrees C. Winding insulation must be Class H.

f. Stator: Stator windings must be as required.

g. Rotor: The rotor must have connected amortisseur windings.

h. Generator Space Heater: Provide 120 volt ac heaters. Heater capacity must be as recommended by the generator manufacturer to aid in keeping the generator insulation dry.

i. Grounding: Provide non-corrosive steel grounding pads located at two opposite mounting legs.

j. Filters: Provide manufacturer's standard generator cooling air filter assembly.

k. Design generator to protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 110 percent for prime applications and 100 percent for standby applications.

l. Provide generator ancillary equipment meeting the short circuit requirements of NEMA MG 1. Select drip-proof guarded option for generators without weatherproof enclosures.

m. Submit manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:

(1) Direct-Axis sub-transient reactance (per unit).

(2) The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

2.16.1 Current Balance

At 100 percent rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases must not exceed 2 percent of the largest current on either of the 2 phases. Submit certification stating that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.16.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated output capacity, the difference in line-to-neutral voltage among the 3 phases must not exceed 1 percent of the average line-to-neutral voltage. For a single phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases must not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement must be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.16.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity must not exceed 10 percent. The RMS of all harmonics must be less than 5.0 percent and that of any one harmonic less than 3.0 percent of the fundamental at rated output capacity. Design and configure engine-generator to meet the total harmonic distortion limits of IEEE 519.

2.17 EXCITER

Provide brushless generator exciter. Provide semiconductor rectifiers that have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at 104 degrees F ambient. The exciter and regulator in combination must maintain generator-output voltage within the limits specified.

Provide a brushless excitation system consisting of an exciter and rotating rectifier assembly , and permanent magnet generator integral with the generator and a voltage regulator. Insulation class for parts integral with the generator must be as specified in paragraph GENERATOR. System must provide a minimum short circuit of 300 percent rated engine-generator set current for at least 10 seconds. Steady state voltage regulation must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

a. Exciter and Rotating Rectifier Assembly: Rectifiers must be provided with surge voltage protection.

b. Permanent Magnet Generator: Provide a voltage spike suppression device for permanent magnet generator (PMG) excitation systems.

c. Voltage Regulator: Voltage regulator must be solid state or digital, automatic, three-phase sensing, volts per hertz type regulator. Regulator must receive its input power from a PMG. Voltage variation for any 40 degree C change over the operating temperature range must be less than plus or minus 1.0 percent. Operating temperature must be minus 40 degree C to plus 70 degree C. Voltage adjust range must be plus to minus 5.0 percent of nominal. Inherent regulator features must include over excitation shutdown.

2.17.1 Electromagnetic Interference (EMI) Suppression

Provide as an integral part of the generator and excitation system, EMI suppression complying with MIL-STD-461.

2.18 VOLTAGE REGULATOR

Provide a solid-state voltage regulator, separate from the exciter, for each generator. Maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Configure regulator for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110 percent of the rated voltage over the steady state load range of 0 to 100 percent of rated output capacity. Regulation drift exceeding plus or minus 0.5 percent for an ambient temperature change of 68 degrees F is not acceptable. Reactive droop compensation or reactive differential compensation must load share the reactive load proportionally between sets during parallel operation. Provide voltage regulator with a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.19 GENERATOR ISOLATION AND PROTECTION

Provide necessary devices for electrical protection and isolation of each engine-generator set and its ancillary equipment. The generator circuit breaker (IEEE Device 52) ratings must be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings to match the generator capacity. Provide operated as indicated generator circuit breaker. Mount a set of surge capacitors at the generator terminals. Provide monitoring and control devices as specified in paragraph GENERATOR PANEL.

The generator circuit breaker must comply with UL 489 requirements for molded case, adjustable thermal magnetic trip type circuit breaker. The circuit breaker continuous current rating must be adequate for the power rating of the engine-generator set and the circuit breaker must be rated to withstand the short circuit current provided by the generator set. Provide circuit breaker in a NEMA ICS 6, Type as required enclosure mounted on the engine-generator set.

2.19.1 Switchboards

Provide free-standing, metal-enclosed, general purpose, 3-phase, 4-wire, 600 volt rated, with neutral bus and continuous ground bus, switchboards conforming to NEMA PB 2 and UL 891. Neutral bus and ground bus capacity must be full capacity. Provide panelboards conforming to NEMA PB 1. Provide enclosure designs, construction, materials and coatings suitable for the application and environment. Bus continuous current rating must be as indicated. Current withstand (short circuit rating) must be equal to the breaker interrupting rating . Provide copper buses.

2.19.2 Devices

Provide switches, circuit breakers, switchgear, fuses, relays, and other protective devices as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects must conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical connections under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than size indicated, the cost of providing additional electrical service and related work must be included under this section.

2.20 SAFETY SYSTEM

Provide and install devices, wiring, remote panels, and local panels, etc., as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. Provide a safety system with a self-test method to verify its operability. Provide alarm signals that have manual acknowledgment and reset devices. The alarm signal systems must reactivate for new signals after acknowledgment is given to any signal. Configure the systems so that loss of any monitoring device will be dealt with as an alarm on that system element.

2.20.1 Audible Signal

Provide audible alarm signal sound at a frequency of 70 Hz at a volume of 75 dB at 10 feet. The sound must be continuously activated upon alarm and silenced upon acknowledgment. Locate signal devices as shown.

2.20.2 Visual Signal

The visual alarm signal must be a panel light. The light must be normally off, activated to be blinking upon alarm. The light must change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display must maintain activated status to indicate the cause of failure and must not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms must be red; all other alarms must be amber.

2.20.3 Alarms and Action Logic

2.20.3.1 Shutdown

Accomplish simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers.

2.20.3.2 Problem

Accomplish activation of the visual signal.

2.20.4 Safety Indications and Shutdowns
Provide a local alarm panel with the following shutdown and alarm functions as indicated mounted either on or adjacent to the engine generator set.

A remote alarm panel is is not required for audible alarms, e.g., in the control room.

Indicator Function (at battery voltage)	NFPA 99 Level 1 CV S RA	NFPA 110 Level 1 CV S RA	NFPA 110 Level 2 CV S RA
Overcrank	X X X	X X X	X X O
Low water temperature	X NA X	X NA X	X NA O
High engine temperature pre-alarm	X NA X	X NA X	O NA NA
High engine temperature	X X X	X X X	X X O
Low lube oil pressure pre-alarm	X NA X	NA NA NA	NA NA NA
Low lube oil pressure	X X X	X X X	X X O
Overspeed	X X X	X X X	X X O
Low fuel main tank	X NA X	X NA X	O NA O
Low coolant level	X O X	X O X	X O X
EPS supplying load	X NA NA	X NA NA	O NA NA
Control switch not in automatic position	X NA X	X NA X	X NA X

Indicator Function (at battery voltage)	NFPA 99 Level 1 CV S RA	NFPA 110 Level 1 CV S RA	NFPA 110 Level 2 CV S RA
High battery voltage	X NA NA	X NA NA	O NA NA
Low cranking voltage	X NA X	X NA X	O NA NA
Low voltage in battery	X NA NA	X NA NA	O NA NA
Battery charger ac failure	X NA NA	X NA NA	O NA NA
Lamp test	X NA NA	X NA NA	X NA NA
Contacts for local and remote common alarm	X NA X	X NA X	X NA X
Audible alarm silencing switch	NA NA X	NA NA X	NA NA O
Low starting air pressure	X NA NA	X NA NA	O NA NA
Low starting hydraulic pressure	X NA NA	X NA NA	O NA NA
Air shutdown damper when used	X X X	X X X	X X O
Remote emergency stop	NA X NA	NA X NA	NA X NA
Symbology: CV: Control panel-mounted visual. S: Shutdown of EPS indication. RA: Remote audible. Symbology: CV: Control panel-mounted visual. S: Shutdown of EPS indication. RA: Remote audible. X: Required. O: Optional. NA: Not applicable.			

2.20.5 Time-Delay on Alarms

For startup of the engine-generator set, install time-delay devices bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. Submit the magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels. The lube-oil time-delay device must return its alarm to normal status after the engine starts. The coolant time-delay device must return its alarm to normal status 5 minutes after the engine starts.

2.21 SYNCHRONIZING PANEL

Provide panel as specified in paragraph PANELS and provide controls, gauges, meters, and displays to include:

a. Frequency meters, dial type, with a range of 90 to 110 percent of rated frequency. Do not use vibrating-reed type meters . One must monitor generator output frequency ("Generator Frequency Meter") and the other must monitor the frequency of the parallel source ("Bus Frequency Meter").

b. Voltmeters, ac, dial type, 3-phase, with 4-position selector switch for the generator output ("Generator Volt Meter") and for the parallel power source ("Bus volt meter").

c. Automatic synchronizer.

d. Manual synchronizing controls.

e. Indicating lights for supplementary indication of synchronization.

f. Synchroscope.

g. Wattmeter, indicating.

2.22 PANELS

Each panel must be of the type and kind necessary to provide specified functions. Mount panels on the engine-generator set base by vibration/shock absorbing type mountings . Mount instruments flush or semiflush. Provide convenient access to the back of panels to facilitate maintenance. Calibrate instruments using recognized industry calibration standards. Provide a panel identification plate identifying the panel function. Provide a plate identifying the device and its function for each instrument and device on the panel. Provide switch plates identifying the switch-position function.

2.22.1 Enclosures

Design enclosures for the application and environment, conforming to NEMA ICS 6. Locking mechanisms are optional.

Provide for each engine-generator set and fabricate from zinc coated or phosphatized and shop primed 16 gage minimum sheet steel in accordance with the manufacturer's standard design. Provide a complete, weatherproof enclosure for the engine, generator, and auxiliary systems and equipment. Support exhaust piping and silencer so that the turbocharger is not subjected to exhaust system weight or lateral forces generated in connecting piping that exceed the engine manufacturer's maximum allowed forces and moments. The housing must have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full load. Design louvered openings to exclude driving rain and snow. Provide properly arranged and sized, hinged panels in the enclosure to allow convenient access to the engine, generator, and control equipment for maintenance and operational procedures. Provide hinged panels with spring type latches which must hold the panels closed securely and will not allow them to vibrate. Brace the housing internally to prevent excessive vibration when the set is in operation

2.22.2 Analog

Provide analog electrical indicating instruments in accordance with UL 1437 with semi-flush mounting. Switchboard, switchgear, and control-room panel-mounted instruments must have 250 degree scales with an accuracy of not less than 99 percent. Unit-mounted instruments must be the manufacturer's standard with an accuracy of not less than 98 percent. The instrument's operating temperature range must be minus 4 to plus 158 degrees F. Distorted generator output voltage waveform of a crest factor less than 5 must not affect metering accuracy for phase voltages, hertz and amps.

2.22.3 Electronic

Electronic indicating instruments must be true RMS indicating instruments, 100 percent solid state, state-of-the-art, microprocessor controlled to provide specified functions. Provide control, logic, and function devices that are compatible as a system, sealed, dust and water tight, and that utilize modular components with metal housings and digital instrumentation. Provide an interface module to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy less than 98 percent for unit mounted devices and 99 percent for control room, panel mounted devices, throughout a temperature range of minus 4 to 158 degrees F is not acceptable. Provide LED or back lit LCD data display. Additionally, the display must provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height must be 0.5 inch .

2.22.4 Parameter Display

Provide indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters. Specify a momentary switch for other panels.

2.23 SURGE PROTECTION

Electrical and electronic components must be protected from, or designed to withstand the effects of surges from switching and lightning.

2.24 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide fully automatic operation for the following operations: engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; paralleling, and load-sharing for multiple engine-generator sets; and stopping of each engine-generator set after cool-down. Devices must automatically reset after termination of their function.

2.24.1 Automatic Transfer Switch

Provide automatic transfer switches in accordance with Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.24.2 Monitoring and Transfer

Provide devices to monitor voltage and frequency for the normal power source and each engine-generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Describe functions, actuation, and time delays as described in Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.24.3 Automatic Paralleling and Loading of Engine-Generator Sets

Provide an automatic loading system to load and unload engine-generator sets in the sequence indicated. Monitor the system load and cause additional engine-generator sets to start, synchronize, and be connected in parallel with the system bus with increasing load. Actuation of the additional engine-generator set start logic must occur when the load exceeds a percentage set-point of the operating set's rating for a period of approximately 10 seconds. Provide an adjustable set-point range from 50 to 100 percent. When the system load falls below the percentage set-point of the operating set's rating for a period of approximately as required, the controller must unload and disconnect engine-generator sets from the system, stopping each engine-generator set after cool-down.

2.25 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide complete facilities for manual starting and testing of each set without load, loading and unloading of each set, and synchronization of each set with an energized bus.

2.26 STATION BATTERY SYSTEM

Provide a station battery system including the battery, battery rack, spacers, automatic battery charger and distribution panelboard with overcurrent protection, metering and relaying. Size components to withstand the seismic acceleration forces specified. Provide batteries that have a rated life of 20 years and a manufacturer's 5-year, no cost replacement guarantee.

2.26.1 Battery

Provide nickel-cadmium battery sized in accordance with IEEE 485 and conforming to the requirements of IEEE 484. Valve-regulated lead-acid batteries are not acceptable.

2.26.2 Battery Capacity

The battery must be rated as required ampere hours at the 8-hour rate, and must have sufficient capacity to serve the following loads without recharging for a period as required.

a. Diesel-generator safety circuits.

b. Switchgear indicating lights, control relays, protective relays, and other switchgear dc components as required for 24 hours.

c. Voltage regulator (dc power supplies).

d. Emergency-lighting and power load at [_____] watts for [_____] hours.

2.26.3 Battery Charger

Furnish a current-limiting, 12 or 24-volt battery charger to automatically recharge the batteries. Provide a charger that is capable of an equalize charging rate which is continuously adjustable and a floating-charge rate for maintaining the batteries in a fully charged condition. Equip the charger with a low-voltage alarm relay, 0- to 24-hour equalizing timer, an ammeter to indicate charging rate, and necessary circuit breakers. The charger must conform to the requirements of UL 1236. A battery is considered to be fully depleted when the voltage falls to a level incapable of operating the equipment loads served by the battery.

2.27 BASE

Provide a steel base. Design the base to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base must permit skidding in any direction during installation and must withstand and mitigate the affects of synchronous vibration of the engine and generator. Provide base with suitable holes for anchor bolts and jacking screws for leveling.

2.28 THERMAL INSULATION

Provide thermal insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.29 PAINTING AND FINISHING

Clean, prime and paintthe engine-generator set in accordance with the manufacturer's standard color and practice.

2.30 FACTORY INSPECTION AND TESTS

Submit six complete reproducible copies of the factory inspection result on the checklist format specified below. Perform the factory tests on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Run each engine-generator set for at least 1 hour at rated output capacity prior to inspections. Complete inspections and make all necessary repairs prior to testing. Use engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.30.1 Factory Inspection

Perform inspections prior to beginning and after completion of testing of the assembled engine-generator set. Look for leaks, looseness, defects in components, proper assembly, etc. and note any item found to be in need of correction as a necessary repair. Use the following checklist for the inspection:

INSPECTION ITEM	GOOD	BAD	NOTES
Drive belts			
Governor and adjustments			

INSPECTION ITEM	GOOD	BAD	NOTES
Engine timing mark			
Starting motor			
Starting aids			
Coolant type and concentration			
Radiator drains			
Block coolant drains			
Coolant fill level			
All coolant line connections			
All coolant hoses			
Combustion air filter			
Combustion air silencer			
Lube oil type			
Lube oil sump drain			
Lube-oil filter			
Lube-oil-level indicator			
Lube-oil-fill level			
All lube-oil line connections			
All lube-oil lines			
Fuel type and amount			
All fuel-line connections			
All fuel lines			
Fuel filter			
Coupling and shaft alignment			
Voltage regulators			
Battery-charger connections			
All wiring connections			

INSPECTION ITEM	GOOD	BAD	NOTES
Instrumentation			
Hazards to personnel			
Base			
Nameplates			
Paint			
Exhaust-heat recovery unit			
Switchboard			
Switchgear			

2.30.2 Factory Tests

Submit a letter giving notice of the proposed dates of factory inspections and tests at least 14 days prior to beginning tests, including:

a. A detailed description of the manufacturer's procedures for factory tests at least 14 days prior to beginning tests.

b. Six copies of the Factory Test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Separate sections by heavy plastic dividers with tabs. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.

   (1) A detailed description of the procedures for factory tests.

   (2) A list of equipment used, with calibration certifications.

   (3) A copy of measurements taken, with required plots and graphs.

   (4) The date of testing.

   (5) A list of the parameters verified.

   (6) The condition specified for the parameter.

   (7) The test results, signed and dated.

   (8) A description of adjustments made.

On engine-generator set tests where the engine and generator are required to be connected and operated together, the load power factor must be the power factor specified in the engine generator set parameter schedule . For engine-generator set with dual-fuel operating capability, perform the following tests using the primary fuel type . Perform electrical measurements in accordance with IEEE 120. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation must be in accordance with IEEE 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

a. Insulation Resistance for Stator and Exciter Test, IEEE 115 and IEEE 43, to the performance criteria in NEMA MG 1, Part 22. Generator manufacturer's production line test is acceptable.

b. High Potential Test, in accordance with IEEE 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.

c. Winding Resistance Test, Stator and Exciter, in accordance with IEEE 115. Generator manufacturer's production line test is acceptable.

d. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

(1) Start and operate the generator at no load.

(2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

(3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(4) Apply 75 percent rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

e. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 percent of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.

f. Voltage Waveform Deviation and Distortion Test in accordance with IEEE 115 to the performance criteria specified in paragraph GENERATOR. Use high-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion. Include appropriate scales to provide a means to measure and interpret results.

g. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

(1) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

(3) Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop percent} = \frac{(\text{No-Load Volts}) - (\text{Rated Capacity Volts})}{(\text{Service-Load Volts})} \times 100$$

$$\text{Frequency droop percent} = \frac{(\text{No-Load Hertz}) - (\text{Rated Capacity Hertz})}{(\text{Service-Load Hertz})} \times 100$$

(4) Repeat steps 1 through 3 two additional times without making any adjustments.

h. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes).

(6) Graphic representations must include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(a) Perform and record engine manufacturer's recommended pre-starting checks and inspections.

(b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(c) With the unit at no load, apply the Maximum Step Load

Increase.

(d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(e) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

(f) Apply the Maximum Step Load Increase.

(g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(h) Repeat steps (c) through (g).

j. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed. This test may be performed using any prime mover.

(1) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2) Apply the specified load between terminals L_1-L_2, L_2-L_0, and L_3-L_0 in turn. Record all instrument readings at each line-neutral condition.

(3) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

(4) Compare the largest differences expressed in percent with the maximum allowable difference specified.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the job, perform a Site Visit to verify the information shown on the drawings, before performing any work. Submit a letter stating the date the site was visited and listing discrepancies found. Notify the Contracting Officer in writing of any discrepancies.

3.2 GENERAL INSTALLATION

Provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Submit a copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure. Install pipe, duct, conduit, and ancillary equipment to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

Weld piping. Provide flanged valve connections. Provide flanged connections at equipment. Provide threaded connections to the engine if the manufacturers standard connection is threaded. Except where otherwise specified, use welded flanged fittings to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Make connections to equipment with vibration isolation-type flexible connectors. Support and align piping and tubing to prevent stressing of flexible hoses and connectors. Flash pipes extending through the roof. Install piping clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and install a 1/2 inch drain valve with cap at each low point.

The installation of gas engines must conform to the requirements of NFPA 37 and its references therein, including NFPA 54, NFPA 58, and ASME B31.3.

3.3.1 Support

Provide hangers, inserts, and supports to accommodate any insulation and conforming to MSS SP-58. Space supports no more than 7 feet on center for pipes 2 inches in diameter or less, no more than 12 feet on center for pipes larger than 2 inches but smaller than 4 inches in diameter, and not more than 17 feet on center for pipes larger than 4 inches in diameter. Provide supports at pipe bends or change of direction.

3.3.1.1 Ceiling and Roof

Support exhaust piping with appropriately sized Type 41 single pipe roll and threaded rods; support all other piping with appropriately sized Type 1 clevis and threaded rods.

3.3.1.2 Wall

Make wall supports for pipe by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.2 Flanged Joints

Provide flanges that are Class 125 type, drilled, and of the proper size and configuration to match the equipment and engine connections. Provide gasketed flanged joints that are square and tight.

3.3.3 Cleaning

After fabrication and before assembly, piping interiors must be manually wiped clean of debris.

3.3.4 Pipe Sleeves

Fit pipes passing through construction such as ceilings, floors, or walls with sleeves. Extend each sleeve through and fasten in its respective structure and cut flush with each surface. Build the structure tightly to the sleeve. The inside diameter of each sleeve must be minimum 1/2 inch, and where pipes pass through combustible materials 1 inch larger than the outside diameter of the passing pipe or pipe insulation/covering.

3.4 ELECTRICAL INSTALLATION

Perform electrical installation in compliance with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, provide flexible fittings for conduit, cable trays, and raceways attached to engine-generator sets; provide flexible stranded conductor for metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set; and provide crimp-type terminals or lugs for terminations of conductors on the engine generator set.

3.5 FIELD PAINTING

Perform field painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE INSPECTION AND TESTS

Perform and report on factory tests and inspections prior to shipment. Provide certified copies of manufacturer's test data and results. Test procedures must conform to ASME, IEEE, IEC, and ANSI standards, and to ISO requirements on testing, as appropriate and applicable. The manufacturer performing the tests must provide equipment, labor, and consumables necessary for tests and measuring and indicating devices must be certified to be within calibration. Tests must indicate satisfactory operation and attainment of specified performance. If satisfactory, equipment tested will be given a tentative approval. Equipment must not be shipped before approval of the factory test reports for the following tests.

Submit a letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

a. Submit a detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests at least 14 days prior to beginning tests.

b. Submit six copies of the onsite test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Separate sections by heavy plastic dividers with tabs. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.

   (1) A detailed description of the procedures for onsite tests.

   (2) A list of equipment used, with calibration certifications.

   (3) A copy of measurements taken, with required plots and graphs.

   (4) The date of testing.

   (5) A list of the parameters verified.

   (6) The condition specified for the parameter.

   (7) The test results, signed and dated.

   (8) A description of adjustments made.

3.6.1 Test Conditions

3.6.1.1 Data

Make and record measurements of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, make adjustments, replacements, or repairs and repeat the step until satisfactory results are obtained. Unless otherwise indicated, record data in 15 minute intervals during engine-generator set operation and include: readings of all engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. Perform electrical measurements in accordance with IEEE 120. Definitions of terms are in accordance with IEEE 100. Provide temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations in accordance with IEEE 1.

3.6.1.2 Power Factor

Submit the generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0. For all engine-generator set operating tests the load power factor must be the power factor specified in the engine-generator set parameter schedule .

3.6.1.3 Contractor Supplied Items

Provide equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors.

3.6.1.4 Instruments

Verify readings of panel gauges, meters, displays, and instruments provided as permanent equipment during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy must be within the following: current plus or minus 1.5 percent, voltage plus or minus 1.5 percent, real power plus or minus 1.5 percent, reactive power plus or minus 1.5 percent, power factor plus or minus 3 percent, frequency plus or minus 0.5 percent. Calibrate test instruments by a recognized standards laboratory within 30 days prior to testing.

3.6.1.5 Sequence

Provide the sequence of testing as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Perform field testing in the presence of the Contracting Officer. Schedule and sequence tests in order to optimize run-time periods; however, follow the general order of testing: Construction Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.6.2 Construction Tests

Perform individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer prior to connection to the engine-generator set.

3.6.2.1 Piping Test

a. Flush lube-oil and fuel-oil piping with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Test fuel piping which is external to the engine-generator set in accordance with NFPA 30. Pressure all remaining piping which is external to the engine-generator set with air pressure at 150 percent of the maximum anticipated working pressure, but not less than 150 psi, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, perform the test before the insulation is applied.

3.6.2.2 Electrical Equipment Tests

a. Perform low-voltage cable insulation integrity tests for cables connecting the generator breaker to the automatic transfer switch . Test low-voltage cable, complete with splices, for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. Apply a test voltage of 500 volts dc for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. Provide the minimum value of insulation as follows:

(1) R in meg-ohms = (rated voltage in kV plus 1) x 304.8/(length of cable in meters)

(2) R in meg-ohms = (rated voltage in kV plus 1) x 1000/(length of cable in feet)

(3) Each cable failing this test must be repaired or replaced. The repair cable must be retested until failures have been eliminated.

b. Perform medium-voltage cable insulation integrity tests for cables connecting the generator breaker to the generator switchgear . After installation and before the operating test or connection to an existing system, perform a high potential test on the medium-voltage cable system. Apply direct-current voltage on each phase conductor of the system by connecting conductors as one terminal and connecting grounds of metallic shields or sheaths of the cable as the other terminal for each test. Prior to making the test, isolate the cables by opening applicable protective devices and disconnecting equipment. Conduct the test with all splices, connectors, and terminations in place. Provide the method, voltage, length of time, and other characteristics of the test for initial installation in accordance with NEMA WC 74/ICEA S-93-639 for the particular type of cable installed, except provide 28kV and 35kV insulation test voltages in accordance with either AEIC CS8 or AEIC CS8 as applicable, and do not exceed the recommendations of IEEE 404 for cable joints and IEEE 48 for cable terminations unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, make necessary repairs or replace cables as directed. Retest repaired or replaced cables.

c. Ground-Resistance Tests. Measure the resistance of each grounding electrode system using the fall-of-potential method defined in IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. Take measurements in normally dry weather, not less than 48 hours after rainfall. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance. The combined resistance of separate systems may be used to meet the requirements resistance, but the specified number of electrodes must still be provided as follows:

(1) Single rod electrode - 25 ohms.

(2) Multiple rod electrodes - 25 ohms.

(3) Ground mat - 25 ohms.

d. Examine and test circuit breakers and switchgear in accordance with the manufacturer's published instructions for functional testing.

3.6.3 Inspections

Perform the following inspections jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Submit a letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use. Perform checks applicable to the installation. Document and submit the results of those which are physical inspections (I) in accordance with paragraph SUBMITTALS. Present manufacturer's data for the inspections designated (D) at the time of inspection. Verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Provide manufacturer's statements to certify provision of features which cannot be verified visually.

Drive belts	I
Governor type and features	I
Engine timing mark	I
Starting motor	I
Starting aids	I
Coolant type and concentration	D
Radiator drains	I
Block coolant drains	I
Coolant fill level	I
Coolant line connections	I
Coolant hoses	I
Combustion air filter	I

Intake air silencer	I
Lube oil type	D
Lube oil sump drain	I
Lube-oil filter	I
Lube-oil level indicator	I
Lube-oil fill level	I
Lube-oil line connections	I
Lube-oil lines	I
Fuel type	D
Fuel level	I
Fuel-line connections	I
Fuel lines	I
Fuel filter	I
Access for maintenance	I
Voltage regulator	I
Battery-charger connections	I
Wiring and terminations	I
Instrumentation	I
Hazards to personnel	I
Base	I
Nameplates	I
Paint	I
Exhaust-heat system	I
Exhaust muffler	I
Switchboard	I
Switchgear	I
Access provided to controls	I

Enclosure is weather resistant	I
Engine and generator mounting bolts (application)	I

3.6.4 Engine Tests

Perform customary commercial factory tests in accordance with ISO 3046 on each engine and associated engine protective device, including, but not limited to the following:

a. Perform dynamometer test at rated power. Record horsepower at rated speed and nominal characteristics such as lubricating oil pressure, jacket water temperature, and ambient temperature.

b. Test and record the values that the low oil pressure alarm and protective shutdown devices actuate prior to assembly on the engine.

c. Test and record values that the high jacket water temperature alarm and protective shutdown devices actuate prior to assembly on the engine.

3.6.5 Generator Tests

Tests must be performed on the complete factory assembled generator prior to shipment. Conduct tests in accordance with IEEE 115, IEC 60034-2A, and NEMA MG 1.

3.6.5.1 Routine Tests

Perform the following routine tests on the generators and their exciters:

a. Resistance of armature and field windings.

b. Mechanical balance.

c. Phases sequence.

d. Open circuit saturation curve and phase (voltage) balance test.

e. Insulation resistance of armature and field windings.

f. High potential tes.t

3.6.5.2 Design Tests

Submit the following design tests made on prototype machines that are physically and electrically identical to the generators specified.

a. Temperature rise test

b. Short circuit saturation curve and current balance test

3.6.6 Assembled Engine-Generator Set Tests

Perform the following tests on the assembled engine-generator set.

3.6.6.1 Initial Stabilization Readings

Operate the engine-generator set and allow the set to stabilize at rated kW at rated power factor, rated voltage, and rated frequency. During this period record instrument readings for output power (kW), terminal voltage, line current, power factor, frequency (rpm) generator (exciter) field voltage and current, lubricating oil pressure, jacket water temperature, and ambient temperature at minimum intervals of 15 minutes. Adjust the load, voltage, and frequency to maintain rated load at rated voltage and frequency. Adjustments to load, voltage, or frequency controls must be recorded on the data sheet at the time of adjustment. Stabilization must be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

3.6.6.2 Regulator Range Test

Remove load and record instrument readings (after transients have subsided). Adjust voltage to the maximum attainable value or to a value just prior to actuation of the overvoltage protection device. Apply rated load and adjust voltage to the minimum attainable value or a value just prior to activation of the under-voltage protection device. The data sheets must indicate the voltage regulation as a percent of rated voltage and the maximum and minimum voltages attainable. Voltage regulation must be defined as follows:

$$\text{Percent Regulation} = \frac{((\text{No-Load Voltage}) - (\text{Rated-Load Voltage})) \times 100}{(\text{Rated-Load Voltage})}$$

3.6.6.3 Frequency Range Test

Adjust the engine-generator set frequency for the maximum attainable frequency at rated load. Record instrument readings. Adjust the engine-generator set frequency for the specified minimum attainable frequency at rated load. Record instrument readings. Reduce the load to zero and adjust the engine-generator set frequency for the maximum attainable frequency. Record instrument readings. Adjust the engine-generator set frequency for the minimum attainable frequency. Record instrument readings. The data sheet must show the maximum and minimum frequencies attained at rated load, and at no load.

3.6.6.4 Transient Response Test

Drop the load to no load and re-apply rated load three times to ensure that the no load and rated load voltage and frequency values are repeatable and that the frequency and voltage regulation is within the limits specified. Record generator terminal voltage and frequency using a high speed strip chart recorder. The data sheet must show the following results:

a. Frequency

(1) Stability bandwidth or deviation in percent of rated frequency.

(2) Recovery time.

(3) Overshoot and undershoot.

b. Voltage

(1) Stability bandwidth or deviation in percent of rated voltage.

(2) Recovery time.

(3) Overshoot and undershoot.

3.6.7 Pre-operational Tests

3.6.7.1 Protective Relays

Visually and mechanically inspect, adjust, test, and calibrate protective relays in accordance with the manufacturer's published instructions. Include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Implement relay settings in accordance with the installation coordination study. Manually or electrically operate relay contacts to verify that the proper breakers and alarms initiate. Field test relaying current transformers in accordance with IEEE C57.13.1.

3.6.7.2 Insulation Test

Test generator and exciter circuits insulation resistance in accordance with IEEE 43. Take stator readings including generator leads to switchgear at the circuit breaker. Record results of insulation resistance tests. Readings must be within limits specified by the manufacturer. Verify mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of switchgear assembly. Do not damage generator components during test.

3.6.7.3 Engine-Generator Connection Coupling Test

When the generator provided is a two-bearing machine, inspect and check the engine-generator connection coupling by dial indicator to prove that no misalignment has occurred. Use the dial indicator to measure variation in radial positioning and axial clearance between the coupling halves. Take readings at four points, spaced 90 degrees apart. Align solid couplings and pin-type flexible couplings within a total indicator reading of 0.0005 to 0.001 inch for both parallel and angular misalignment. For gear-type or grid-type couplings, 0.002 inch will be acceptable.

3.6.8 Safety Run Test

For the following tests, repeat the associated safety tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 2 hours at 75 percent of Service Load.

l. Verify proper operation and set-points of gauges and instruments.

m. Verify proper operation of ancillary equipment.

n. Manually adjust the governor to increase engine speed past the over-speed limit. Record the RPM at which the engine shuts down.

o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

p. Manually adjust the governor to increase engine speed to within 2 percent of the over-speed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.

q. Manually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.

s. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. Move the engine's oil pressure sensor from the engine to the manifold. Open the manifold shutoff valve and close the bleed valve.

t. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100 percent of Service Load. Record the maximum sound level in each frequency band at a distance of 75 feet from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 35 feet from the engine at 45 degrees apart in all directions for vertical piping.

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.6.9 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, repeat the associated tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

3.6.9.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, repeat the entire test. Accomplish the engine load run test during daylight hours, with an average ambient temperature. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Take data taken at 15 minute intervals and include the following:

Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

Pressure: Lube-oil.

Temperature: Coolant, Lube-oil, Exhaust, Ambient.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.

c. Operate the engine generator-set for 2 hours at 75 percent of Service Load.

d. Increase load to 100 percent of Service Load and operate the engine generator-set for 4 hours.

e. For prime rated units, increase load to 110 percent of Service Load and operate the engine generator-set for 2 hours.

f. Decrease load to 100 percent of Service Load and operate the engine generator-set for 2 hours or until all temperatures have stabilized.

g. Remove load from the engine-generator set.

3.6.9.2 Voltage and Frequency Droop Test

For the following steps, verify that the output voltage and frequency return to and stabilize within the specified bandwidth values following each load change. Record the generator output frequency and line-line and line-neutral voltages following each load change.

a. With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency.

b. Increase load to 100 percent of Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

c. Calculate the percent droop for voltage and frequency with the following equations.

$$\text{Voltage droop percent} = \frac{\text{No-load volts} - \text{rated output capacity volts}}{\text{Rated output capacity volts}} \times 100$$

$$\text{Frequency droop percent} = \frac{\text{No load hertz} - \text{rated output capacity hertz}}{\text{Rated output capacity volts}} \times 100$$

d. Repeat steps a. through c. two additional times without making any adjustments.

3.6.9.3 Voltage Regulator Range Test

a. While operating at no load, verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

3.6.9.4 Governor Adjustment Range Test

a. While operating at no load, verify that the governor adjusts from 90 to 110 percent of rated frequency.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the governor adjusts from 90 to 110 percent of rated frequency.

3.6.9.5 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes.

(6) Include the actual instrument trace of voltage and frequency in graphic representations showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

c. With the unit at no load, apply the Maximum Step Load Increase.

d. Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

e. Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

f. Apply the Maximum Step Load Increase.

g. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

h. Repeat steps c. through g.

3.6.10 Parallel Operation Test

Test the capability of each engine-generator set to parallel and share load with other generator sets, individually and in all combinations. This test must be performed with the voltage regulator and governor adjustment settings used for the Frequency and Voltage Stability and Transient Response test. If settings are changed during the performance of this test, a voltage and frequency stability and transient response test must be performed for each engine generator set using the setting utilized in this test. During operations record load-sharing characteristics of each set in parallel operation. Include the following data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Power division and exchange between generator sets.

(5) Real power (watts) and reactive power (vars) on each set.

3.6.10.1 Combinations

Connect each set, while operating at no load, parallel with one other set in the system, operating at service load, until all possible combinations have been achieved. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive loads. Document stabilization of voltage and frequency within specified bandwidth, the active power division, active power exchange, reactive power division, and voltage and frequency stability and transient response in the following steps for each combination.

a. Divide the load proportionally between the sets and operate in parallel for 15 minutes.

b. Increase the load, in steps equal to the Maximum Step Increase, until each set is loaded to its service load.

c. Decrease the load, in steps equal to the Maximum Step Decrease, until each set is loaded to approximately 25 percent of its service load.

d. Increase the load, in steps equal to the Maximum Step Increase, until each set is loaded to approximately 50 percent of its service load Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.

e. Reduce the sum of the loads on both sets to the output rating of the smaller set.

f. Transfer a load equal to the output rating of the smaller of the 2 sets to and from each set. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.

g. Document the active power division, active power exchange, reactive power division, and voltage and frequency stability and transient response.

3.6.10.2 Multiple Combinations

Connect each set, while operating at no load, parallel with all multiple combinations of all other set in the system, while operating at service load, until all multiple combinations of parallel operations have been achieved.

3.6.11 Parallel Operation Test (Commercial Source)

Connect each set parallel with the commercial power source. Operate in parallel for 15 minutes. Verify stabilization of voltage and frequency within specified bandwidths. Record the output voltage, frequency, and loading to demonstrate ability to synchronize with the commercial power source.

3.6.12 Automatic Operation Tests

Test the automatic operating system to demonstrate [automatic starting,] [loading and unloading,] [the response to loss of operating engine-generator sets,] and paralleling of each engine-generator set. Utilize [load banks at the indicated power factor] [and actual loads to be served] for this test, and the loading sequence is the indicated sequence. Record load-sharing characteristics during all operations. Perform this test for a minimum of two successive, successful tests. Include the following data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Generator output frequency (before and after load changes).

(5) Power division and exchange between generator sets.

(6) Real and reactive power on each set.

a. Initiate loss of the preferred power source and verify the specified sequence of operation.

b. Verify resetting of automatic starting and transfer logic.

3.6.13 Automatic Operation Tests for Stand-Alone Operation

Test the automatic loading system to demonstrate [automatic starting,]

[and] [loading and unloading] of each engine-generator set. Utilize the actual loads to be served for this test, and the loading sequence is the indicated sequence. Perform this test for a minimum of two successive, successful tests. Include the following data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Generator output frequency (before and after load changes).

a. Initiate loss of the primary power source and verify automatic sequence of operation.

b. Restore the primary power source and verify sequence of operation.

c. Verify resetting of controls to normal.

3.7 GROUNDING

NFPA 70 and IEEE C2, except that grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.7.1 Grounding Electrodes

Provide driven ground rods as specified in [Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION] [and] [Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION]. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.7.2 Engine-Generator Set Grounding

Provide separate copper grounding conductors and connect them to the ground system as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply.

3.7.3 Connections

Make joints in grounding conductors by exothermic weld or compression connector. Exothermic welds and compression connectors must be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION paragraph regarding GROUNDING.

3.7.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.8 START-UP ENGINEER

Provide the services of a qualified factory trained start-up engineer, regularly employed by the engine-generator set manufacturer. The start-up services must include conducting preliminary operations and functional acceptance tests. The start-up engineer must be present at the engine generator set installation-site, full-time, while preliminary operations and functional acceptance tests are being conducted.

3.9 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the engine-generator set and auxiliary equipment.

3.9.1 Piping Tests

Complete as specified in Section 33 52 10 SERVICE PIPING, FUEL SYSTEMS.

3.9.2 Performance of Acceptance Checks and Tests

The acceptance checks and tests must be accomplished by the testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.9.3 Generator Sets

Complete as specified in the paragraph ACCEPTANCE CHECKS AND TESTS.

3.9.3.1 Automatic Transfer Switches

Complete acceptance checks and tests as specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

3.9.4 Preliminary Operations

The start-up engineer must conduct manufacturer recommended start-up procedures and tests to verify that the engine-generator set and auxiliary equipment are ready for functional acceptance tests. Give the Contracting Officer 15 days' advance notice that preliminary operations will be conducted. After preliminary operation has been successfully conducted, the start-up engineer will notify the Contracting Officer in writing stating the engine-generator set and auxiliary equipment are ready for functional acceptance tests.

3.9.5 Preliminary Assembled Operation and Maintenance Manuals

Preliminary assembled operation and maintenance manuals must have been submitted to and approved by the Contracting Officer. Manuals must be prepared as specified in the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

3.9.6 Functional Acceptance Test Procedure

Test procedure must be prepared by the start-up engineer specifically for the engine-generator set and auxiliary equipment. The test agenda must cover the requirements specified in the paragraph FUNCTIONAL ACCEPTANCE TESTS. The test procedure must indicate in detail how tests are to be conducted. A statement of the tests that are to be performed without indicating how the tests are to be performed is not acceptable. Indicate what work is planned on each workday and identify the calendar dates of the planned workdays. Specify what additional technical support personnel is needed such as factory representatives for major equipment. Specify on which testing workday each technical support personnel is needed. Data recording forms to be used to document test results are to be submitted with the proposed test procedure. A list of test equipment and instruments must also be included in the test procedure.

3.9.7 Test Equipment

Test equipment and instruments must be on hand prior to scheduling field tests or, subject to Contracting Officer approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on-site prior to field testing.

3.10 FIELD QUALITY CONTROL

Give Contracting Officer 30 days' notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The Contractor must be responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The Contractor must provide labor, equipment, fuel, test load, and consumables required for the specified tests. The test load must be a cataloged product. Calibration of measuring devices and indicating devices must be certified. Refer to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, for requirements for a cataloged product. Perform the following field tests.

3.10.1 Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.10.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case

a. Visual and Mechanical Inspection

   (1) Compare nameplate data with specifications and approved shop drawings.

   (2) Inspect circuit breaker for correct mounting.

   (3) Operate circuit breaker to ensure smooth operation.

   (4) Inspect case for cracks or other defects.

   (5) Verify tightness of accessible bolted connections and cable connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

   (6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

   (1) Perform contact-resistance tests.

   (2) Perform insulation-resistance tests.

   (3) Adjust breaker(s) for final settings in accordance with engine-generator set manufacturer's requirements.

3.10.1.2 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform polarity tests.

(3) Perform ratio-verification tests.

3.10.1.3 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watt-hour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer secondary circuits are intact.

3.10.1.4 Battery Systems

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(4) Measure electrolyte specific gravity and temperature and visually check fill level.

(5) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

b. Electrical Tests

(1) Set charger float and equalizing voltage levels.

(2) Verify all charger functions and alarms.

(3) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

(4) Perform a capacity load test.

3.10.1.5 Engine-Generator Set

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect for correct anchorage and grounding.

b. Electrical and Mechanical Tests

(1) Perform an insulation-resistance test on generator winding with respect to ground. Calculate polarization index.

(2) Perform phase rotation test to determine compatibility with load requirements.

3.10.1.6 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method defined in IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. Take measurements in normally dry weather, not less than 48 hours after rainfall. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.10.2 Functional Acceptance Tests

The tests must be performed by the start-up engineer. Upon successful test completion, the start-up engineer must provide the Contracting Officer with a written test report within 15 calendar days showing the tests performed and the results of each test. The report must include the completed approved test data forms and certification from the start-up engineer that the test results fall within the manufacturer's recommended limits and meet the specified requirements performance. The report must be dated and signed by the start-up engineer, and submitted for approval by the Contracting Officer. The Contracting Officer will witness final acceptance tests. Testing must include, but not be limited to, the following:

a. Verify proper functioning of each engine protective shutdown device and pre-shutdown alarm device. Testing of the devices must be accomplished by simulating device actuation and observing proper alarm and engine shutdown operation.

b. Verify proper functioning of the engine over-speed trip device. Testing of the over-speed trip device must be accomplished by raising the speed of the engine-generator set until an over-speed trip is experienced.

c. Verify proper functioning of the crank cycle/terminate relay. Testing of the relay must be accomplished by engaging the starter motor with the engine being prevented from running. Observe the complete crank/rest cycle as described in the paragraph STARTING SYSTEM.

d. Verify proper functioning of the following automatic and manual operations. Testing must include, but not be limited to, the following:

   (1) Loss of Utility: Initiate a normal power failure with connected test load of rated kW at 1.0 power factor. Record time delay on start, cranking time until engine starts and runs, time to come up to operating speed, voltage and frequency overshoot, and time to achieve steady state conditions with all switches transferred to emergency position.

   (2) Return of Utility: Return normal power and record time delay on retransfer for each automatic transfer switch, and time delay on engine cool-down and shutdown.

   (3) Manual starting.

   (4) Emergency stop.

e. Operate the engine-generator set at rated current (amperes) until the jacket water temperature stabilizes. Stabilization will be considered to have occurred when three consecutive temperature readings remain unchanged. Continue to operate the generator set for an additional 2 hours. Record instrument readings for terminal voltage, line current, frequency (Hz), engine speed rpm, lubricating oil pressure, jacket water temperature, and ambient temperature at 5 minute intervals for first 15 minutes and at 15 minute intervals thereafter.

f. Emissions Tests. Provide on-site testing by a certified testing organization of each engine-generator set. Testing must be in accordance with an EPA approved method, 40 CFR 60, (Appendix, Method 7, 7A, 7B, 7C, 7D or 7E). Emissions at rated full load must be within the limits specified in the paragraph ENGINE EMISSIONS LIMITS.

3.11 DEMONSTRATION

Upon completion of the work and at a time approved by the Contracting Officer, the Contractor must provide instructions by a qualified instructor to the Government personnel in the proper operation and maintenance of the equipment. Government personnel must receive training comparable to the equipment manufacturer's factory training. The duration of instruction must be for not less than one 8 hour working day for instruction of operating personnel and not less than one 8 hour working day for instruction of maintenance personnel.

3.11.1 Instructor's Qualification Resume

Instructors must be regular employees of the engine-generator set manufacturer. The instruction personnel provided to satisfy the requirements above must be factory certified by the related equipment manufacturer to provide instruction services. Submit the name and qualification resume of instructor to the Contracting Officer for approval.

3.11.2 Training Plan

Submit training plan 30 calendar days prior to training sessions. Training plan must include scheduling, content, outline, and training material (handouts). Content must include, but not be limited to, the following:

3.11.2.1 Operating Personnel Training

This instruction includes operating the engine-generator set, auxiliary equipment including automatic transfer switches in all modes, and the use of all functions and features specified.

3.11.2.2 Maintenance Personnel Training

Training must include mechanical, hydraulic, electrical, and electronic instructions for the engine-generator set and auxiliary equipment including automatic transfer switches.

a. Mechanical Training: Must include at least the following:

(1) A review of mechanical diagrams and drawings.

(2) Component location and functions.

(3) Troubleshooting procedures and techniques.

(4) Repair procedures.

(5) Assembly/disassembly procedures.

(6) Adjustments (how, when, and where).

(7) Preventive maintenance procedures.

(8) Review of flow diagram.

(9) Valve locations and function.

(10) Valve and hydraulic equipment adjustment and maintenance

procedures.

(11) Hydraulic system maintenance and servicing.

(12) Lubrication points, type, and recommended procedures and frequency.

b. Electrical and Electronic Maintenance Training: Must include at least the following:

(1) A review of electrical and electronic systems including wiring diagrams and drawings.

(2) Troubleshooting procedures for the machine and control systems.

(3) Electrical and electronic equipment servicing and care.

(4) Use of diagnostics to locate the causes of malfunction.

(5) Procedures for adjustments (locating components, adjustments to be made, values to be measured, and equipment required for making adjustments).

(6) Maintenance and troubleshooting procedures for microprocessor or minicomputer where applicable.

(7) Circuit board repair procedures where applicable (with schematics provided).

(8) Use of diagnostic tapes.

(9) Recommended maintenance servicing and repair for motors, switches, relays, solenoids, and other auxiliary equipment and devices.

3.12 ONSITE TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 8 hours of normal working time and must start after the system is functionally completed but prior to final acceptance.

a. Submit a letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the digital video recording to be provided. The course instructions must cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions must demonstrate routine maintenance procedures as described in the operation and maintenance manuals.

b. Submit a digital video recording of the manufacturers operating and maintenance training course.

c. One full size reproducible Mylar ach drawing must accompany the booklets. Mylars must be rolled and placed in a heavy cardboard tube with threaded caps on each end. The manual must include step-by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. The instructions must include procedures for interface and interaction with related systems to include automatic transfer switches . Each booklet must include a CD containing an ASCII file of the procedures.

d. Provide approved operation and maintenance manuals for the training course. Post approved instructions prior to the beginning date of the training course. Coordinate the training course schedule with the using service's work schedule, and submit for approval 14 days prior to beginning date of proposed beginning date of training.

3.13 INSTALLATION

Installation must conform to the applicable requirements of IEEE C2, NFPA 30, NFPA 37, and NFPA 70.

3.14 FINAL TESTING AND INSPECTION

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100 percent of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Verify any corrective action for effectiveness by running the engine for 8 hours at Service Load, then re-examine the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.15 MANUFACTURER'S FIELD SERVICE

The engine generator-set manufacturer must furnish a qualified representative to supervise the installation of the engine generator-set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment.

3.16 POSTED DATA AND INSTRUCTIONS

Post Data and Instructions prior to field acceptance testing of the engine generator set. Provide two sets of instructions/data, typed and framed under weatherproof laminated plastic, and post side-by-side where directed. Include a one-line diagram, wiring and control diagrams and a complete layout of the system in the first set. Include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions in the second set. Submit posted data including wiring and control diagrams showing the key mechanical and electrical control elements, and a complete layout of the entire system.

a. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Provide two sets of typed instructions/data in 8-1/2 x 11 inch format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. Place the binders as directed by the Contracting Officer. Provide the instructions prior to acceptance of the engine generator set installation.

b. Include a one-line diagram, wiring and control diagrams and a complete layout of the system in the first set. Include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions in the second set. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

c. Submit instructions including: the manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Provide weatherproof instructions, laminated in plastic, and post where directed.

3.17 ACCEPTANCE

Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the engine-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings. Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --

SECTION 26 33 53

STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS)
05/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.4 (1983; Amendment 1985; R 2006) Specification for Sound Level Meters (ASA 47)

ASTM INTERNATIONAL (ASTM)

ASTM B173 (2017) Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

IEEE 450 (2020) Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications

IEEE 485 (2020) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

IEEE C57.110 (2008) Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents

IEEE C62.41 (1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

IEEE C62.41.1 (2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001	(2015) Quality Management Systems- Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA PE 1	(2012; R 2017) Uninterruptible Power Systems (UPS) - Specification and Performance Verification

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1778	(2014; Reprint Sep 2017) UL Standard for Safety Uninterruptible Power Systems

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

UPS Drawings; G,

UPS Installation; G

SD-03 Product Data

UPS Module; G

Technical Requirements UPS System

Energy Star Label for Battery Charging Systems and AC-DC/AC-AC Power Supply Products; S

Spare Parts; G

SD-06 Test Reports

Work Plan; G

Factory Test Plan; G

Factory Test Report; G

SD-09 Manufacturer's Field Reports

Initial Inspection and Tests; G

Performance Tests; G

Performance Test Plan; G

Performance Test Report; G

SD-10 Operation and Maintenance Data

UPS Operation and Maintenance, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

SD-11 Closeout Submittals

Installation

1.4 OPERATION AND MAINTENANCE MANUALS

1.4.1 Additions to UPS Operation and Maintenance Manuals

In addition to requirements of SD-10 Data Package 5, include the followings on the actual UPS system provided:

a. An outline drawing, front, top, and side views.

b. Prices for spare parts and supply list.

c. Routine and field acceptance test reports.

d. Date of Purchase.

e. Corrective maintenance procedures.

1.4.2 Spare Parts

Furnish the following spare parts, of the same material and workmanship, meeting the same requirements, and interchangeable with the corresponding original parts.

a. Fuses: Two of each type and rating.

b. Circuit boards: One circuit board for each critical circuit.

c. Air Filters: One set of filters, when used on the UPS unit.

d. Special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment: One complete set.

1.5 QUALITY ASSURANCE

The manufacturer must have a documented quality assurance program including:

a. Inspections of incoming parts, modular assemblies and final product.

b. Final test procedure for the product including proof of performance specifications.

c. The on-site test procedure includes an inspection of controls and indicators after installation of the equipment.

d. ISO 9001 quality certification.

1.5.1 UPS Drawings

Drawings are to include the following: Detail drawings consisting of a complete list of equipment and materials, manufacturer's descriptive and technical literature, battery sizing calculations per IEEE 485, installation instructions, single-line diagrams, elevations, layout drawings, and details required to demonstrate that the system has been coordinated and will function properly as a unit.

a. One-line diagram.

b. Outline drawings including front elevation, section views, footprints, and overall dimensions.

c. Manufacturer's descriptive and technical literature.

d. Markings and NEMA nameplate data.

e. Battery sizing calculations per IEEE 485.

f. Wiring and control diagrams with terminals identified, and indicating prewired interconnections between items of equipment and interconnection between the items.

g. Complete list of materials and equipment covering major components. Ensure the bill of material and the schematic have a direct correlation between items in order to easily identify the various components.

h. Details required to demonstrate that the system has been coordinated and will function properly as a unit.

1.5.2 UPS Installation

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams are to identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings are to indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals include the nameplate data, size, and capacity. Submittals also include applicable federal, military, industry, and technical society publication references.

1.5.3 Work Plan

Submit schedules of dates for factory tests, installation, field tests, and operator training for the UPS system. Furnish a list of instrumentation equipment for factory and field test reports.

1.5.4 Factory Test Plan

Submit factory test plans and procedures at least 21 calendar days prior to the tests being conducted. Provide detailed description of test procedures, including test equipment and setups, to be used to ensure the UPS meets the performance specification and explain the test methods to be used. Provide test procedures that include the test required under the paragraph entitled "Factory Testing."

1.5.5 Factory Test Report

Submit a factory test report within 21 calendar days after completion of tests. Receive approval of test prior to shipping unit. Factory test reports are to be signed by an official authorized to certify on behalf of the UPS manufacturer of that the system meets specified requirements in accordance with the requirements set forth in paragraph entitled "Factory Testing". Provide test reports in booklet form tabulating factory tests and measurements performed, upon completion and testing of the installed system. Reports are to state the Contractor's name and address, the name of the project and location, and list the specific requirements which are being certified.

1.5.6 Performance Test Plan

Submit test plans and procedures at least 15 calendar days prior to the start of field tests. Provide detailed description and dates and times scheduled for performance of tests, and detailed description of test procedures, including test equipment (list make and model and provide functional description of the test instruments and accessories) and setups of the tests to be conducted to ensure the UPS meets the performance specification. Explain the test methods to be used. Provide test procedures that include the tests required under the paragraph entitled "Performance Tests."

1.5.7 Performance Test Report

Submit report of test results as specified by paragraph entitled "Performance Tests" within 15 calendar days after completion of tests. Field test reports are to be signed by an official authorized to certify on behalf of the UPS manufacturer that the system meets specified requirements in accordance with the requirements set forth in paragraph entitled "Performance Tests". Provide test reports in in booklet form tabulating factory tests and measurements performed, upon completion and testing of the installed system. Reports are to state the Contractor's name and address, the name of the project and location, and list the specific requirements which are being certified.

1.5.8 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.8.1 Reference Standard Compliance

Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations such as American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), Underwriters Laboratories (UL), and Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance.

1.5.8.2 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate is to state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.5.9 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

d. The service organization is to be, in the opinion of the Contracting Officer, reasonably convenient to the site.

e. Provide new parts and materials comprising the UPS system from the current manufacture, of a high grade and free of defects and imperfections, and has not been in prior service except as required during aging and factory testing.

1.5.9.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.9.2 Material and Equipment Manufacturing Date

Products manufactured more than 6 months prior to date of delivery to site are not acceptable.

1.6 INSPECTION

Inspection before shipment is required. The manufacturer must notify the Government at least 2 weeks before shipping date so that an inspection can be made.

1.7 DELIVERY AND STORAGE

Protect equipment placed in storage from humidity and temperature variations, moisture, water intrusion, dirt, airborne corrosives, or other contaminants. In harsh environments where temperatures exceed non-operational parameters established within this specification, provide an environmentally controlled equipment storage facility to ensure temperature parameters are within equipment specification. Provide documentation of same to the Government when storage is implemented.

1.8 PROJECT/SITE CONDITIONS

1.8.1 Environmental Conditions

The UPS and battery system must be capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degradation of operating characteristics.

a. Operating altitude: Sea level to 3,300 ft. (Systems applied at higher altitudes are to be derated in accordance with the manufacturer's instructions).

b. Non-operating altitude: Sea level to 36,000 ft.

c. Operating ambient temperature range: 32 to 104 degrees F. Range for batteries is 68 to 77 degrees F. Provide batteries that are capable of operating in a larger ambient temperature range of 50 to 86 degrees F, but some degradation of life span is understood when operating outside the range of 68 to 77 degrees F.

d. Non-operating and storage ambient temperature range: Minus 4 to plus 122 degrees F. Range for batteries or UPS modules with internal batteries: 50 to 86 degrees F.

e. Operating relative humidity: 0 to 95 percent, without condensation.

1.8.2 Sound Pressure Levels

Sound pressure levels produced by the UPS, when operating under full rated load, at a distance of 5 feet in any direction from the perimeter of the unit, must not exceed 75 dB as measured on the A scale of a Type 1 sound level meter at slow response conforming to ASA S1.4.

1.8.3 Verification of Dimensions

The Contractor is to become familiar with details of the work, verify dimensions in the field, and is to advise the Contracting Officer of any discrepancy before performing the work. Do not proceed until the discrepancy or unsatisfactory condition(s) have been corrected.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide continuous duty, three-phase, solid state, on-line double conversion reverse transfer static UPS(s). The UPS by means of solid state conversion techniques, must provide continuous regulated AC power to its output terminals, while operating from an input power source, cabinet or rack-mounted direct current (DC) storage battery or other approved means. The performance of the UPS must not be degraded when operating without a system battery, provided the input AC source is within tolerance. Provide an UPS system that conforms to UL 1778 and consists of UPS module, battery system, battery protective device, system cabinet, static bypass transfer switch, controls and monitoring, system protective devices, means of isolating the UPS system from the critical load, and remote monitoring interfaces. Connect input ac power the normal source ac input of the UPS module. Where indicated, connect alternate power source bypass/maintenance bypass. Connect battery to the dc input of the UPS module through the battery protective device.

2.2 MODES OF OPERATION

2.2.1 Normal

The UPS module rectifier/charger must convert the incoming ac input power to dc power for the inverter and for float charging the battery. The inverter continuously coverts the dc power to ac power to supply the critical load. The inverter output must synchronize with the bypass ac power source, provided that the bypass ac power source is within the specified voltage and frequency range.

2.2.2 Battery - Emergency Operation (Loss or deviation of AC Input Power)

Whenever the ac input power source deviates from the specified tolerances including complete failure, the inverter must draw power from the battery system and supply AC power to the critical load without any interruption or switching transient. The battery system must supply power to the inverter for the specified protection time or until return of ac input source. Provide an audible alarm to indicate the UPS is on battery and provide provisions for a remote alarm signal to be sent via the communication network and a relay output, allowing startup of a secondary power source or orderly shutdown of the critical load.

2.2.3 Failure of AC Input Power to Return

If the ac input power fail to return before the battery voltage reaches the discharge limit, then the UPS system must disconnect from the critical load to safeguard the battery.

2.2.4 Recharge

Upon restoration of normal power to the UPS unit, the input converter and output inverter must simultaneously recharge the batteries and provide regulated power to the critical load.

2.2.5 Transfer to Static Bypass AC Power Source

When the UPS controller senses an overload, two or more inverter shutdown signals or degradation of the inverter output, the static bypass switch automatically transfers the critical load from the inverter output to the bypass ac power source without an interruption of power. If the static bypass ac power source is outside of specified tolerance limits, the UPS and the critical load shut down. Transfer to static bypass can also be done manually (requested bypass). Transfer to bypass does not take place under these conditions: 100% stepload; and, loss or return of input power, momentary sags, surges or spikes on the input to the UPS.

2.2.6 Transfer to Inverter

Provide a static bypass switch that is capable of automatically transferring the load back to the inverter output after the inverter overload condition has returned to normal conditions. Transfer only occurs once the two sources are synchronized. UPS system logic is to monitor the number of retransfer's within any one-hour period and is to allow 1 to 3 transfers in order to prevent cyclical transfers caused by overloads.

2.2.7 Maintenance Bypass

Provide the system with an external make-before-break maintenance bypass cabinet/panel to electrically isolate the UPS during routine maintenance and service. Manual transfer to the maintenance bypass circuit transfers the critical load from the inverter output to the bypass ac power source without disturbing the critical load bus.

2.2.8 Off-Battery (Battery Maintenance)

Provide a battery protective device which disconnects the battery from the rectifier/charger and inverter for maintenance. The device may be located external to the UPS cabinet. The UPS module continues to function and meet the performance criteria specified except for the battery back-up time function.

2.2.9 Failure of a Module

In a redundant configuration, failure of one module causes that module to be disconnected from the system critical load bus by its internal protective devices and its individual output protective device. Remaining module(s) are to continue to carry the load.

2.2.10 UPS Module Servicing

Provide a means the manually disconnect the UPS modules from the critical load bus for maintenance without disturbing the critical load bus.

2.2.11 Component Performance

Do not exceed 75% of the working voltage and current ratings as established by the manufacturer on solid-state power components and electronic devices. Do not exceed 75% of the operating temperature of solid-state component sub-assemblies. Use computer grade electrolytic capacitors and operate at no more than 95% of the voltage rating at the rectifier charging voltage.

2.3 GENERAL UPS SYSTEM COMPONENTS AND FABRICATION

2.3.1 Semiconductor Fusing

Protect power semiconductors with fast-acting fuses to prevent cascaded or sequential semiconductor failures. Bolt fuses at both ends to bus bars to ensure mechanical and electrical integrity. Indicator lamp or display panel denoting blown fuse conditions must be readily observable by the operator without removing panels or opening cabinet doors.

2.3.2 EMI/RFI Protection

Provide an UPS that complies with and is labeled compliant, with FCC Part 15, Subclass B, Class A.

2.3.3 Internal Wiring

Wiring practices, materials, and coding must be in accordance with the requirements of NFPA 70, OSHA, UL 1778, and other applicable standards. Protect wire runs in a manner which separates power and control wiring. Provide control cabling that is at least No. 16 AWG extra-flexible stranded copper. Logic-circuit wiring may be smaller. Provide ribbon cables that are at least minimum No. 22 AWG. Provide control wiring with permanently attached wire numbers.

2.3.4 Internal Assembly

The printed circuit board (PCB) subassemblies are to be mounted in pull-out swing-out trays where feasible. Provide cable connections to the trays that are sufficiently long to allow easy access to all components. Where not feasible to mount PCB subassemblies in pull-out or swing-out trays, then mount them firmly mounted inside the enclosure. Monitor every PCB subassembly. Include self-test and diagnostic circuitry in the logic circuits such that a fault can be isolated down to the PCB subassembly level. When used, control logic cards are to have test points or logic indicators on the front edge of the control logic card and be labeled.

2.3.5 Cable Lugs and Terminations

2.3.5.1 Cable Lugs

Provide appropriate compression type lugs or pre-drilled bus bars on all ac and dc power connections to the UPS system and battery as required. Aluminum or bare copper cable lugs are not suitable.

2.3.5.2 Terminations

Supply terminals for making power and control connections. Provide terminal block for field wiring terminals. Provide terminal blocks that are the heavy-duty, strap-screw type or screw terminals that are integrated into removable plugs. Locate terminal blocks for field wiring in one place in each module. Extend control wiring to the terminal block location. Any terminal point is limited to land a maximum of two wires. Where control wiring is attached to the same point as power wiring, Provide a separate terminal where control wiring is attached to the same point as power wiring, . If bus duct is used, provide bus stubs where bus duct enters cabinets.

2.3.6 Cabinets

Install the UPS system in cabinets of heavy-duty structure meeting the NEMA PE 1 standards for floor mounting. Provide a structurally adequate UPS module that can be forklift handled and lifted. Provide removable lifting eyes on top of each cabinet. Provide the UPS module cabinet with hinged and key lockable doors on the front only and with assemblies and components accessible from the front. Provide dead-front construction behind the door for those UPS module cabinets that are not lockable. Operating controls are to be located outside the locked doors. Install input, output, and battery cables through the top or bottom of the cabinet.

2.3.6.1 Cabinet Finish

Provide an equipment cabinet that is cleaned, primed and painted in the manufacturer's standard colors, in accordance with accepted industry standards. Cabinets are to be labeled in accordance with NFPA 70 and NFPA 70E.

2.3.6.2 Factory Applied Finish

Provide electrical equipment with a factory-applied painting systems which, as a minimum, meets the requirements of NEMA 250 corrosion-resistance test.

2.3.6.3 Drawout Assemblies

Provide a means of lifting, either and overhead device or a hoisting device for drawout assemblies weighing 50 lbs or more. Device can either be part of the UPS or a separate portable device that can be used to perform the lifting.

2.3.7 Manufacturer's Nameplates

Provide a nameplate for each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.3.8 Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Provide an inscription on each nameplate that identifies the name of the item, calculated short circuit rating with date, and source of power e.g. 'Panel A in Electrical Room 103'. Provide nameplates that are made of melamine plastic, 0.125 inch thick, white with black center core. Provide the nameplate with a surface that is matte finished and that has square corners.. Accurately align lettering and engrave into the core. Provide nameplates that are at least 1.0 by 2.5 inches with a minimum lettering size of 0.25 inch high normal block style.

2.3.9 Safety

Provide UPS with instruction plates including warnings and cautions, suitably located, and describing any special or important procedures to be followed in operating and servicing the equipment. Provide control panel displays, which also provide warning messages prior to performing a critical function.

2.3.9.1 Maintenance Isolation

All energized terminals, both AC and DC, and control voltage exposed points are to be insulated or enclosed to ensure the safety of maintenance personnel. Provide the system with the ability to isolate the static switch to enable repair when the UPS is bypassed.

2.3.9.2 Remote Emergency Power Off (REPO) Switch

Provide a remote emergency power off switch that is separate from the UPS. Provide a red, pushbutton with a cover with a label indicating "UPS Emergency Power Off". The switch disconnects all breakers or contactors including battery, input, output, and bypass breakers when activated.

2.4 TECHNICAL REQUIREMENTS UPS SYSTEM RATINGS

Unless stated otherwise, the parameters listed are under full output load over the range of 0.9 lagging power factor to 0.9 leading power factor, with batteries fully charged and floating on the dc bus and with nominal input voltage.

2.4.1 UPS SYSTEM LOAD PROFILE

Provide an UPS system that is compatible with the load characteristics . The UPS system is to provide compensation for UPS/load interaction problems resulting from nonlinear loads or transformer and motor inrush.

2.4.2 System Requirements

The UPS is to support and maintain full battery charging under the following conditions: indicated environmental conditions, a.c input voltage range, air filters blocked up to 50% and a single failed fan. The UPS size and configuration is as required.

2.4.3 Battery Capacity

Discharge time to end voltage: 20 minutes, at 77 degrees F. Provide a battery that is capable of delivering 125 percent of full rated UPS kW load at 0.9 power factor at initial start-up.

2.4.4 Static Switch

Rated as required for supperted load. (continuous duty)

2.4.5 AC Input

a. Voltage As required.

b. Number of phases: As required.

c. Voltage Range: Plus 10 percent, minus 15 percent nominal (no battery discharge), without affecting battery float voltage or output voltage.

d. Frequency: 60 Hz, plus or minus 5 percent.

e. Power walk-in: 20 percent to 100 percent input current over 10 to 15 seconds.

f. Total harmonic current distortion (THD) reflected into the primary line: 5 percent maximum at full load.

g. Sub-cycle magnetizing inrush: 2 to 3 times full load current for modules without an isolation transformer.

h. Input surge protection: per IEEE C62.41.1 and IEEE C62.41.2, meeting IEEE C62.41 requirement of Category B3 6kV, 100k Hz ring wave and 6kV, combined wave.

i. Input power factor: Lagging from 1-100 percent load.

h. Transformer sub-cycle magnetizing inrush: 5 to 8 times full load current with optional isolation transformer and optional input filter.

2.4.6 AC Output

a. Voltage: As required.

b. Number of phases: As required + ground configuration.

c. Voltage regulation:

(1) Balanced load: Plus or minus 1.0 percent.

(2) 50 percent load imbalance, phase-to-phase: Plus or minus 2 percent.

(3) 100 percent load imbalance, phase-to-phase Plus or minus 3 percent.

(4) Voltage drift: Plus or minus 1 percent over any 30 day interval (or length of test) at stated ambient conditions found in paragraph Environmental Conditions.

d. Voltage adjustment: Plus or minus 5 percent.

e. Frequency: 60 Hz.

f. Frequency regulation: Plus or minus 0.1 percent, when on internal oscillator. Internal oscillator is to be temperature compensated.

g. Frequency drift: Plus or minus 0.1 percent over any 24 hour interval (or length of test) at stated ambient conditions when on internal oscillator.

h. Harmonic content (RMS voltage): Provide a system that meets the following voltage THD levels: maximum of 4% RMS total,2 percent total with 100 percent on any single harmonic (linear load) and 5 percent RMS total for up to 100 percent nonlinear load.

i. Load power factor operating range (without derating): 0.9 leading to 0.9 lagging.

j. Phase angle displacement/imbalance:

(1) Balanced load: 120 degrees plus or minus 1 degree of bypass input.

(2) 50 percent load imbalance phase-to-phase: 120 degrees plus or minus 3 degrees of input.

k. Inverter overload capability (at full voltage with plus or minus 2 percent regulation) (excluding battery):

(1) 125 percent load for 10 minutes.

(2) 150 percent load for 60 seconds.

(3) Fault clearing. Provide an UPS that is able to maintain output current during a fault condition for 20 cycles if bypass is unavailable or 1 cycle with bypass available. If the fault is not cleared and a bypass is available, the UPS is to transfer to bypass without interruption to clear the fault.

l. Load sharing of parallel modules: Plus or minus 5 percent at full rated system load.

m. Bypass Overload Capability.

2.4.7 Transient Response

2.4.7.1 Voltage Transients

a. 100 percent load step: Plus or minus 5 percent.

b. Loss or return of ac input: Plus or minus 5 percent.

c. Automatic transfer of load from UPS to bypass: Plus or minus 1 percent.

d. Manual retransfer of load from bypass to UPS: Plus or minus 5 percent.

e. Response time: Recovery to 1 percent of nominal within 20 milliseconds where there was a maximum deviation from nominal system output of volts plus or minus 5 percent.

2.4.7.2 Frequency

a. Transients: Plus or minus 0.6 Hz maximum.

b. Slew Rate: under all conditions of operation, provide 0.4 to 1.0 Hz per second.

2.4.8 Efficiency

b. Minimum System Efficiency: 93 percent at full system load kW.

2.5 UPS MODULE

2.5.1 General Description

UPS module consists of an input converter, output converter, with associated transformers, synchronizing equipment, protective devices, surge suppression, and accessories as required for operation.

2.5.1.1 Interchangeability

The subassemblies in one UPS module are to be interchangeable with the corresponding modules within the same UPS, and from one UPS system to another of identical systems.

2.5.1.2 Rectifier/Charger Unit

Scalable, expandable modular input converts for the system are to be housed within removable power modules. Input converters control the power from the mains input of the system, provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and main inverter regulated output power.

2.5.1.2.1 Input Protective Device

Provide the rectifier/charger unit with an input protective device. Size the protective device to accept simultaneously the full-rated load and the battery recharge current. Provide a protective device that is capable of shunt tripping and has an amperes symmetrical interrupting rating as required. Provide the protective device with an under-voltage release to open automatically when the control voltage is lost.

2.5.1.2.2 Input Isolation Transformer

The rectifier unit is to use a dry-type, isolated-winding power transformer. The transformer's hottest spot winding temperature must not exceed the temperature limit of the transformer insulation material when operating at full load. Provide a transformer with Class H, 150 degrees C rise insulation. Transformer connections are to be accessible from the front. If there is a separate transformer cabinet, it is is to match the UPS cabinet and attach to it. Provide a Department of Energy CSL-3 transformer.

2.5.1.2.3 Power Walk-In

Input convert is to have an adjustable soft-start (either by manufacturer or owner), capable of limiting the input current form 0 percent to 100 percent of the input over a default 10 second period when returning to ac input bus from battery operation. The change in current over time is to be done in a linear manner.

2.5.1.2.4 Sizing

Size the rectifier/charger unit for the following two simultaneous operating conditions:

a. Supplying the full rated load current to the inverter.

b. Recharging a fully-discharged battery to 90 percent of rated ampere-hour capacity within ten times the discharge time after normal ac power is restored.

2.5.1.2.5 AC Input Current Limiting

Provide a circuit to the input converter that controls and limits the current draw form utility to 130 percent of the rated UPS output. During conditions where input current limit is active, the UPS system is to be able to support 100 percent of the load, charge the batteries at 10 percent of the UPS output rating, and provide voltage regulation with mains deviation of +15/-5 percent.

2.5.1.2.6 Battery Charging Current

a. Primary current limiting: Battery-charging current is to be voltage regulated and current limited. Provide a separately adjustable battery-charging current limit that is adjustable from 1 percent to 20 percent of the maximum discharge current. Set the limit at the factory to 10 percent. After the battery is recharged, the rectifier/charger unit maintains the battery at full float charge until the next operation under input power failure. Battery charger is capable of providing equalizing charge to the battery.

2.5.1.2.7 DC Ripple (Output Filter)

Rectifier/charger unit is to minimize ripple current and voltage supplied to the battery; the ripple voltage into the battery is not to exceed 1 percent RMS of the float voltage. Ensure the AC ripple voltage of the rectifier DC output does not exceed 0.5 percent of the float voltage.

2.5.1.2.8 DC Voltage Adjustment

Provide a manual means at the rectifier/charger unit that allows for adjusting the dc voltage for battery equalization in order to provide voltage within plus 10 percent of nominal float voltage.

2.5.1.2.9 Battery Isolation Protective Device

Provide the module or external battery system with a dc protective device to isolate the module from the battery system. The protective device size and interrupting rating are as required by system capacity and is to incorporate the trip required by circuit design. Provide the protective device with a provision for locking in the "off" position.

2.5.1.2.10 Battery Equalize Charge

Equalize charge timer is to provide an equalizing charge automatically to the battery after a 30 second or longer utility outage. The equalize charging time is to be adjustable form 0-72 hours. Provide a manual override for the automatic equalize circuit.

2.5.2 General Description

UPS module consists of a rectifier/charger unit and a 3-phase inverter unit with their associated transformers, synchronizing equipment, protective devices, surge suppression, input isolation transformer (as required), and accessories as required for operation.

2.5.2.1 Interchangeability

The subassemblies in one UPS module are to be interchangeable with the corresponding modules within the same UPS, and from one UPS system to another of identical systems.

2.5.2.2 Rectifier/Charger Unit

Provide a solid state rectifier/charger unit that converts alternating current to direct current, and provides regulated direct current to the dc bus, supplying power to the inverter and charging the battery plant.

2.5.2.2.1 Input Protective Device

Provide the rectifier/charger unit with an input protective device. Size the protective device to accept simultaneously the full-rated load and the battery recharge current. Provide a protective device that is capable of shunt tripping and has an amperes symmetrical interrupting rating as required. Provide the protective device with an under-voltage release to open automatically when the control voltage is lost.

2.5.2.2.2 Power Walk-In

Protect the rectifier/charger unit with a power walk-in feature such that when ac power is returned to the ac input bus, the total initial power requirement will not exceed 20 percent of the rated full load current. This demand is to gradually increase to 100 percent of the rated full load current plus the battery charging current over the specified time interval.

2.5.2.2.3 Sizing

Size the rectifier/charger unit for the following two simultaneous operating conditions:

a. Supplying the full rated load current to the inverter.

b. Recharging a fully-discharged battery to 90 percent of rated ampere-hour capacity within ten times the discharge time after normal ac power is restored.

2.5.2.2.4 AC Input Current Limiting

Provide a circuit on the rectifier/charger to limit AC input current to an adjustable level of 100 percent to 125 percent with a factory setting at 100 percent.

2.5.2.2.5 Battery Charging Current

a. Primary current limiting: Battery-charging current is to be voltage regulated and current limited. Provide a separately adjustable battery-charging current limit that is adjustable from 1 percent to 20 percent of the maximum discharge current. Set the limit at the factory to 10 percent. After the battery is recharged, the rectifier/charger unit maintains the battery at full float charge until the next operation under input power failure. Battery charger is capable of providing equalizing charge to the battery.

2.5.2.2.6 DC Ripple (Output Filter)

Rectifier/charger unit is to minimize ripple current and voltage supplied to the battery; the ripple voltage into the battery is not to exceed 1 percent RMS of the float voltage. Ensure the AC ripple voltage of the rectifier DC output does not exceed 0.5 percent of the float voltage.

2.5.2.2.7 DC Voltage Adjustment

Provide a manual means at the rectifier/charger unit that allows for adjusting the dc voltage for battery equalization in order to provide voltage within plus 10 percent of nominal float voltage.

2.5.2.2.8 Battery Isolation Protective Device

Provide the module or external battery system with a dc protective device to isolate the module from the battery system. The protective device size and interrupting rating are as required by system capacity and is to incorporate the trip required by circuit design. Provide the protective device with a provision for locking in the "off" position.

2.5.3 Inverter Unit

Provide a solid-state inverter with sinusoidal output deriving its power from the dc bus (rectifier or battery source) and providing ac power within specified limits to the critical load. Inverter is to utilize microprocessor controlled solid state Pulse Width Modulation (PWM) controlled insulated gate bipolar transistor (IGBT) power transistor technology to shape the ac output.

2.5.3.1 Output Overload

Provide an inverter that is able to sustain an overload as specified across its output terminals. The inverter is to remain on and continue to operate within rated parameters, with inverse-time overload shutdown protection. If the overload condition persists beyond the rated parameters of the inverter, the load is to be transferred to the bypass source where the inverter disconnects automatically from the critical load bus. If the bypass source is not available and the overload/fault condition continues, the inverter is to current limit for the time as determined by the manufacturer and then shut down to protect the internal components.

2.5.3.2 Output Protective Device

Provide an output protective device that is capable of opening on an applied control signal and has the proper frame size and trip rating to supply overload current as specified. Provide the external output protective device with provision for locking in the "off" position. The inverter output protective device works in conjunction with the bypass protective device for both manual and automatic load transfers to and from bypass power.

2.5.3.3 Output Transformer

The inverter output transformer is capable of handling up to K-13 nonlinear loads as described in IEEE C57.110. Provide a transformer that meets the requirements for Department of Energy CSL-3.

2.5.4 External Protection

Provide the UPS module with built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the ac input source and/or the bypass source. Provide the UPS with built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.

2.5.5 Internal Protection

Provide the UPS module with the ability to be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. Provide the UPS module with output reverse power detection which causes the module to be disconnected from the critical load bus when output reverse power is present. Provide the UPS module with built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shuts down without damage to internal components.

2.5.6 Battery Protection

Provide the inverter with monitoring and controls circuits to protect the battery system from damage due to excessive discharge. Inverter shutdown is be initiated when the battery has reached the end of discharge voltage. Manufacturer is to calculate the end-of-discharge voltage and automatically adjusted for partial load conditions to allow extended operation without damaging the battery. Automatic shutdown based on discharge time is not acceptable.

2.5.7 Modular Inverter Isolation

Provide each inverter in the UPS system with fault sensing and static isolation as well as an output protective device, to remove a faulted module from the system without affecting the critical load bus beyond the stated limits.

2.6 STATIC BYPASS TRANSFER CIRCUIT

Provide the control logic with an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the static bypass ac power source, without exceeding the transient limits specified herein, during times when maintenance is required, when a malfunction occurs in the UPS or when an external overload condition occurs. The power section of the static bypass transfer circuit consists of a plug-in type assembly to facilitate maintenance. The static bypass transfer circuit is to be used to connect the input bypass ac power source to the critical load when required. Provide the static bypass transfer circuit with the following features:

2.6.1 Construction

Provide a static with a continuous duty rating of at least 100 percent of the UPS output rating. Provide a static bypass transfer circuit as an integral part of the UPS that consists of a static switch, made up of two reverse-paralleled SCRs (silicon-controlled rectifiers) per phase conductor, and a bypass protective device, made up of a circuit breaker. The bypass protective device is to be in series with the static switch. The inverter output protective device disconnects and isolates the inverter from the bypass transfer circuit. Provide a static switch that is of a modular design as required.

2.6.2 Automatic Uninterrupted Transfer

The static bypass transfer switch automatically causes the bypass ac power source to assume the critical load without interruption when the bypass control logic senses one of the following conditions and the UPS inverter output is synchronized to the bypass ac power source:

a. Inverter overload exceeds unit's rating.

b. Battery protection period is expired and bypass is available.

c. System failure.

d. Inverter output undervoltage or overvoltage.

2.6.3 Interrupted Transfer

If an overload occurs and the UPS inverter output is not synchronized to the bypass ac power source, the UPS inverter output current-limits for 200 milliseconds minimum. The inverter then turns off and an interrupted transfer to the bypass ac power source is made.

If the bypass ac power source is beyond the conditions stated below, an interrupted transfer is made upon detection of a fault condition:

a. Bypass voltage greater than plus or minus 10 percent from the UPS rated output voltage.

b. Bypass frequency greater than plus or minus 0.5 Hz from the UPS rated output frequency.

c. Phase differential of ac bypass voltage to UPS output voltage greater than plus or minus 3 degrees.

2.6.4 Manual Load Transfer

It must be possible to make a manually-initiated static transfer from the system status and control panel by turning the UPS inverter off or by initiating it through the UPS display interface. The transfer is to make-before-break utilizing the UPS output and system bypass circuit breakers. Do not use the static switch for manual transfer unless there isn't a parallel by-pass circuit breaker or contactor.

2.6.5 Automatic Uninterrupted Forward Transfer

Automatic transfer of the load back to the inverter is to take place when the transfer was caused by an overload and only after the load has returned to a level within the inverter souse. Provide the ability to allow 1 to 3 transfers within any one-hour period to prevent cyclical transfers caused by overloads.

2.6.6 Forced Transfer

Provide control logic circuitry with the means of making a forced or reverse transfer of the static bypass transfer circuit on an interrupted basis. Minimum interruption is 200 milliseconds when the UPS inverter is not synchronized to the bypass ac power source.

2.6.7 Overload Ratings

The static bypass transfer switch is to withstand the following overload conditions:

a. 1000 percent of UPS output rating for one cycle.

b. 125 percent of UPS output rating for 10 minute.

c. 110 percent of UPS output continuously.

2.6.8 System Protection

Incorporate into the static bypass circuit back-feed protection per UL 1778. To achieve back-feed protection, provide a back-feed protection breaker/mechanical contactor upstream and in series with the bypass switch that is controlled by the UPS/static switch, to open immediately upon sensing a condition where back-feeding of the static switch by any source connected to the critical output bus of the system is occurring.

2.6.9 Static Bypass Switch Disconnect

Incorporate a static switch disconnect that can be used to isolate the static bypass transfer switch assembly so it can be removed for servicing. Equip the device with auxiliary contacts and provisions for padlocking in either the "on" or "off" position.

2.7 MAINTENANCE BYPASS CIRCUIT

2.7.1 General

Provide a maintenance bypass switch or arrangement of switch devices in a matching NEMA 250, type 1 cabinet adjacent to the UPS cabinet or in a wall-mounted NEMA 250, type 1 enclosure or in a free-standing floor-mounted NEMA 250, type 1 enclosure. Provide a maintenance bypass enclosure configured as indicated.

2.7.2 Interlock

Electrically and mechanically interlock the switch(es) to prevent interrupting power to the load when switching to bypass mode. Key interlock requires unlocking bypass/isolating switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking. Provide auxiliary contacts for the purpose of relaying status information of each circuit breaker/switch actuator to the UPS and static bypass.

2.7.3 Load Transfer

The maintenance bypass switch provides the capability of transferring the critical load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the critical load.

2.7.4 Load Bank Protection Device

Provide a load bank protective device that allows the UPS system to be tested using a portable load bank. The load bank protective device is connected on the line side of the maintenance bypass switch isolation protective device.

2.8 DISPLAY,CONTROLS AND ALARMS

Provide the UPS module with a microprocessor-controlled display unit located on the hinged door on the front of the system. Provide a LCD color alphanumeric display that operated by touchscreen to access the various information. Controls, meters, alarms and indicators for operation of the UPS module are to be on this panel. Provide a menu driven graphical user interface for browsing the screens. All three-phases of three-phase parameters are to be displayed simultaneously.
Provide the modules with separate, optically isolated, communication paths to the power and static switch modules. Provide redundant power supplies, each having a separate AC and DC input and output for the logic power for the control modules. Provide a microprocessor-controlled display unit with alphanumeric display with back or side lighting. Controls, meters, alarms and indicators for operation of the UPS module are to be on this panel. Provide a menu driven graphical user interface for browsing the screens. All three-phases of three-phase parameters are to be displayed simultaneously.2.8.1 Module Meters

2.8.1.1 Monitored Functions

Display the actual value along with the ability to show the peak, average and low values over various periods of time. Monitor and display the following functions:

a. Input voltage, phase-to-phase (all three phases).

b. Input current, all three phases.

c. Input frequency.

d. Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).

e. Bypass frequency.

f. Battery voltage.

g. Battery current (charge/discharge).

h. Output voltage, phase-to-phase and phase-to-neutral (all three phases).

i. Output current, all three phases.

j. Output frequency.

k. Input power factor.

l. Maintenance bypass voltage, phase-to-phase and phase-to-ground (all three phases)

m. Output kilowatts or kilovoltamps.
n. Bypass voltage, phase-to-phase and phase-to-ground (all three phases).

2.8.1.2 Meter Construction

Display alphanumeric parameters based on true RMS metering with 2 percent accuracy at full scale(minimum 4 significant digits) at the display panel.

2.8.2 Module Controls

Provide a module or equivalent features via touchscreen with the following controls:

a. Silence audible alarm..

b. Display or set the date and time.

c. Adjust setpoints on various alarms.

d. Alarm test/reset pushbutton.

e. Battery protective device trip pushbutton, with guard.

f. Emergency off pushbutton, with guard. Provide a hard-wired pushbutton even if touchscreen system is provided.

g. DC voltage adjustment potentiometer, with locking guard or AC output voltage adjustment potentiometer. Provide potentiometer that is accessible only by authorized personnel.

h. Control power off switch.

i. Transfer load to and from static bypass circuit.

j. Display control pushbuttons: up, down, select.

2.8.3 Module or System Alarm Indicators

Provide the module with indicators for the following alarm items. Any one of these conditions is to turn on an audible alarm and the appropriate summary indicator. The system is to register each new alarm without affecting any previous alarm. Provide a processor that time-date stamps each event.

a. Input ac power source failure.

b. Input protective device open.

c. Input power out of tolerance.

d. Overload.

e. Overload shutdown.

f. DC overvoltage/shutdown.

g. DC ground fault.

h. Low battery.

i. Battery discharged.

j. Battery protective device open.

k. Blower fan failure or overtemperature.

l. Overtemperature shutdown.

m. Hardware shutdown.

n. Equipment overtemperature.

o. Fuse blown with annunciation..

p. Control power failure.

q. Charger off/problem.

r. Inverter fault/off.

s. Emergency power off.

t. External shutdown (Remote Emergency Power Off) activated.

u. Output protective device open.

v. Operating on internal oscillator

w. UPS on battery

x. Critical load on static bypass.

y. Static bypass transfer switch disabled/failure.

z. Inverter output overvoltage.

aa. Inverter output undervoltage.

bb. Inverter output overfrequency.

cc. Inverter output underfrequency.

dd. Bypass source overvoltage.

ee. Bypass source undervoltage.

ff. Bypass source overfrequency.

gg. Bypass source underfrequency.

hh. Bypass source to inverter out of synchronization.

ii. Load no longer above alarm threshold.

jj. Intelligent module inserted or removed.

kk. Redundancy restored.

ll. Need battery replacement.

mm. Bad battery module.

nn. Bad power module.

oo. Redundant intelligent module installed and failed.

pp. Load above alarm threshold.

2.8.4 Module Emergency OFF Button

Provide an emergency off pushbutton with a protective cover. Pressing the emergency off button causes the module input, output, and battery circuit breakers or contactors to open, completely isolating the UPS system from sources of power and transfer of the load to bypass.

System Mimic Panel

Provide a mimic panel in the format of a single-line diagram that graphically depicts whether the load is supplied from the inverter, bypass, or battery. Provide on status on the following:

a. Module on-line, one per UPS module.

b. UPS output protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

c. Static bypass protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

d. Static switch status, one for connected (red), and one for disconnected (green).

e. Status on the AC input circuit breaker, battery circuit breaker, and inverter circuit breaker. Connected (red) and disconnected (green).

2.9 SYSTEM CONTROL CABINET

2.9.1 General Description

Provide the multi-module UPS system with a separate control cabinet for system output that contains; bus bar connections to collect the output from each module, the static switch and its bypass breaker, the UPS system output protective device, and the UPS output switchgear.

2.9.2 UPS Output Switchgear

The UPS output switchgear consists of a main protective device feeding the UPS output switchgear critical load bus, a load bank protective device (connected on the line side of the main protective device), a maintenance bypass protective device and associated feeder protective devices for the critical loads.

2.9.2.1 Switchgear

Provide the UPS output switchgear in accordance with Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.10 SELF-DIAGNOSTIC CIRCUITS

Provide control logic with status indicators for trouble-shooting the control circuits. These indicators are mounted on the circuit card edge or face such that they will be visible without repositioning the card, and are labeled with the function name.

2.11 COMMUNICATIONS AND DATA ACQUISITION

Provide an RS 232Internet Protocol (IP)RS 485 communications and data acquisition port. This port allows the system parameters, status, alarm indication and control panel functions specified to be remotely monitored and controlled.

Additionally, provide additional ports for use with the following:

a. Provide the following Form C contacts for remote indication:

(1) UPS on battery.

(2) UPS on-line.

(3) UPS load on bypass.

(4) UPS in alarm condition.

(5) UPS off (maintenance bypass closed).

b. Provide four spare Form C contacts rated at 120V, 0.5A.

c. Provide a SNMP (Simple Network Management Protocol) adapter to communicate UPS monitoring via a network or direct connection to a personal computer (PC).

d. Provide a standard Web Browser adapter to remotely view and monitor UPS functions over the Internet.

Provide communication ports and contacts that are capable of simultaneous communication.

2.12 TEMPERATURE CONTROL

2.12.1 General

Ensure cabinet and enclosure ventilation is adequate to operate the components within their ratings. Forced-air cooled rectifier, inverter, and control unit will be acceptable. If UPS input power is lost, then the cooling fans are to continue to operate. Provide redundancy that ensures failure of one fan or associated circuit breaker does not cause an overheat condition. Cooling air is to enter the lower front of the cabinets and exhaust at the top. Provide visual and audible alarms on the control panel that indicate blower power failure. Provide replaceable filters on air inlets, which may be located on the inside of the cabinet doors and are easily accessible for replacement.

2.12.2 Blower Power Source

Provide a blower power source that is internally derived from the input and output sides of UPS module, with automatic transfer arrangement.

2.12.3 Temperature Sensors

Provide temperature sensors to monitor the air temperature. Provide a sensor or sensors to monitor the temperature of rectifier and inverter heat sinks. Provide separate sensors to monitor the transformer temperature. Provide critical equipment over-temperature indication that starts a timer that shuts down the UPS system if the temperature does not return below the setpoint level recommended by the UPS manufacturer.

2.13 BATTERY SYSTEM

2.13.1 General

Battery system contains the battery cells, cabinets,racks, battery disconnect, . Provide a storage battery with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration for each UPS module. Provide a battery that is heavy-duty, industrial design suitable for UPS service. Provide the cells with flame arrestor vents, intercell connectors and cables, cell-lifting straps, cell-numbering sets, and terminal grease. Size intercell connectors to maintain terminal voltage within voltage window limits when supplying full load under power failure conditions. Provide cell and connector hardware that is the type of stainless steel capable of resisting corrosion from the electrolyte used. The battery plant is to consist of the following:

2.13.2 Battery Cabinet

Furnish the battery pack assembly in a battery cabinet matching the UPS cabinet. Design the battery cabinet to allow for checking the torque on the connections in the battery system and to provide adequate access for annual housekeeping chores. Provide an external wiring interface through the bottom or top of the assembly. Provide a high temperature alarm that annunciates detection of high temperature within the battery cabinet.

2.13.3 Battery Rack

Provide a suitable number of racks to fit the room layout shown for the number of batteries provided. Provide a steel battery rack that is protected with electrolyte-resistant paint. Ship the battery rack unassembled with all necessary hardware for assembly. Provide each rack with a complete set with bus bars to accommodate cables from UPS module. Provide bus bar connectors for battery-to-battery connections and high-flex multi-stranded copper cable (ASTM B173 stranding class H) with proper cable supports for connecting top row of batteries to bottom row of batteries at rack ends. Cut end sections to length to prevent wasting floor space.

2.13.4 Cell-Terminal Covers

Provide acid-resistant transparent cell-terminal covers not exceeding 6 feet in length and with vent holes drilled on top where needed.

2.13.5 Battery Disconnect

Provide each battery string with a circuit breaker or fused disconnect switch provided in a NEMA 250, type 1 enclosure, finished with acid-resistant paint and located in line with the assembly. Provide each switch with line side and load side bus bars for connection to battery cells. Rate each switch 500 V dc, ampere rating per manufacturer, 3-pole with interrupting rating as required by system capacity, and provide an external operator that is lockable in the "off" position.

2.13.6 Seismic Requirements

.Provide a seismic-restraint design for the battery rackscabinets, assemblies, subassemblies, and components to include fasteners, supports, mounting and anchorage devises that conforms to UFC 3-301-01, Section 13 48 73, SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and to Section 26 05 48.00 10, SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

2.13.7 Battery Monitor

Provide a battery monitor for each battery pack assembly. Monitor the following minimum parameters by the device:

a. Total system voltage.

b. Ambient room temperature.

c. Minimum of 120 days activity history.

d. Programmable alarm functions..

The monitor is to record the total accumulated discharge minutes and accumulated battery system discharge kW hours.

2.14 BATTERY MONITOR - DISCHARGE

The UPS is to have a specialized battery monitor system that collects and stores data related to discharging the UPS battery. The information is to be displayed on a separate screen available through a menu selection. The system is to collect and retain (minimum of 50 events) the following information for each discharge cycle:

a. System time and date.

b. Duration of cycle.

c. DC bus voltage range.

d. kW carried by batteries at the start of the event.

2.15 FACTORY TESTING

Factory test the UPS system to meet the requirements specified using a test battery (not the battery to be supplied with the system) or D.C. simulator. Factory load test the UPS module as an independent assembly with 3-phase ac input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Balance the load at rated kVA and rated power factor.

a. Submit a detailed description of proposed factory test and field test procedures, including proposed dates and steps outlining each test, how it is to be performed, what it accomplishes, and its duration, not later than 1 months prior to the date of each test.

b. Run the factory test for each UPS module under full load that is witnessed by the Government. Should a malfunction occur, correct the problem and repeat the test. As a minimum, the factory tests are to include the parameters described in paragraphs ac Input, ac Output, Transient Response and Efficiency. Tests are to encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings.

c. Notify the Government in writing at least 2 weeks before testing. Do not use factory-test time for system debugging and/or checkout. Perform such work prior to notifying the Government that the system is ready for testing. Perform factory tests during normal business hours. Interconnect and test the system for an additional 8 hours to ensure proper wiring and performance.

d. Submit factory and field test reports in booklet form tabulating factory and field tests and measurements performed, upon completion and testing of the installed system. An official authorized to certify on behalf of the manufacturer of the UPS system that the system meets specified requirements will sign the factory and field test reports. Date each report after the award of this contract, which states the Contractor's name and address, name the project and location, and list the specific requirements, which are being certified.

2.15.1 Transient Tests

Conduct transient tests using high-speed oscillograph type recorders to demonstrate the operation of the components to the satisfaction of the Government. These tests consist of 50 percent to 100 percent load changes, manual transfer, manual retransfer, low dc bus initiated transfer and low ac output bus transfer. Use a recording instrument equipped with an event marker.

2.15.2 Efficiency Tests

Perform testing for efficiency at zero output up to 100 percent of stated kW output in 25 percent steps with battery fully charged and floating on the dc bus, with nominal input voltage, and with module connected to represent actual operating conditions.

PART 3 EXECUTION

3.1 INSTALLATION

Conform electrical installations to IEEE C2, NFPA 70, and to requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise. Set the UPS system in place that is wired and connected in accordance with the approved shop drawings and manufacturer's instructions.

3.1.1 Control Cable

Install UPS control wiring in individual separate rigid steel conduits, unless connections are made between side by side matching cabinets of UPS. Tag control wires with numeric identification tags corresponding to the terminal strip location to where the wires are connected. In addition to manufacturer's requirements, provide four additional spare conductors between UPS module and remote alarm panel in same conduit. When routing control cables inside UPS module, maintain a minimum 6 inches separation from power cables.

3.1.2 Grounding

3.1.2.1 Grounding Conductor Title

Provide a separate grounding conductor that is separate from the electrical system neutral conductor in feeder and branch circuits. Ground battery racks and battery breaker cabinets with a separate equipment grounding conductor to the UPS cabinet.

3.1.2.2 Separately Derived

If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic pipe.

3.1.3 UPS Output Conductors

Isolate the UPS output conductors from the UPS cabinet to the critical load panels and from other conductors by installing in separate conduit.

3.1.4 DC Power Conductors

When installed in conduits, place dc power conductors from the UPS cabinet to the battery circuit breaker such that each conduit contains an equal number of positive and negative conductors, for example, two positive and two negative conductors in each conduit. Size conductor for a maximum of 2 percent voltage drop at full discharge.

3.1.5 Seismic Protection

Provide seismic details conforming to Section 26 05 48.00 10, SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

3.1.6 Conduit Entries

Ensure conduit entries use the available conduit areas shown on manufacturer's installation drawings. Do not make conduit entries through the front, side or rear panels of the UPS.

3.1.7 Battery Rack Assembly

Battery racks are typically shipped dismantled in separate rail, frame, and brace packages. Ensure that manufacturer furnished assembly hardware is used to assemble battery racks. Conform battery rack installation to the manufacturer's instructions.

3.1.8 Battery Cabinet Assembly

Conform battery rack installation to the manufacturer's instructions.

3.1.9 Battery Installation

Conform battery cabinet installation to the manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

Notify the Contracting Officer in writing at least 30 calendar days prior to completion of the UPS system installation. At this time the Contractor, will schedule the UPS manufacturer's technical representative to inspect the completed installation. Provide instruction for activity personnel by the UPS technical representative as specified in paragraph titled "DEMONSTRATION".

3.2.1 Installation Preparation

Completely install the following items by the Contractor and be operational prior to the arrival of the UPS representative for inspection, unit start-up and testing:

a. Ventilation equipment in the UPS and battery rooms.

b. Battery cabinets and cells.

c. Battery connections including cell-to-cell, tier-to-tier, and rack-to-rack connections, with correct polarity;

d. DC power and control connections between UPS and battery circuit breaker, with correct polarity;

e. DC power connection between battery circuit breaker and battery, with correct polarity;

f. Clockwise phase rotation of ac power connections;

g. AC power to rectifier input bus;

h. AC power to UPS bypass input bus;

i. AC power to UPS maintenance bypass circuit breaker;

j. AC power from UPS output to UPS maintenance bypass output circuit breaker;

k. Remote monitors and control wiring;

l. UPS system and battery system properly grounded;

m. Emergency shower and eye wash;

n. Control connections between UPS and emergency engine generator signal contacts;

o. Control connections between UPS module and UPS maintenance bypass cabinet;

p. Clean and vacuum UPS and battery room floors, battery cells, and UPS equipment, both inside and outside

q. Ensure that shipping members have been removed.

r. Provide IEEE 450 battery installation certification.

3.2.2 Initial Inspection and Tests

The UPS technical representative and the Contracting Officer, in the presence of the Contractor, will inspect the completed installation. The Contractor is responsible to correct construction or installation deficiencies as directed. Perform acceptance checks in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections, performed in accordance with NETA ATS.

a. UPS Unit visual and mechanical inspection

(1) Compare equipment nameplate data with drawings, specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware. Inspect the displays for scratches, dark pixels or uneven brightness.

(3) Inspect anchorage, alignment, grounding, and required clearances.

(4) Verify that fuse sizes and types correspond to drawings.

(5) Verify the unit is clean inside and out.

(6) Test all electrical and mechanical interlock systems for correct operation and sequencing.

(7) Inspect bolted electrical connections for high resistance using one of the following methods:

(a) Use a low-resistance ohmmeter.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(c) Perform thermographic survey.

(8) Verify operation of forced ventilation.

(9) Verify that vents are clear and new clean filters are installed.

(10) Inspect batteries and chargers according to requirements in NETA ATS

b. UPS Batteries visual and mechanical inspection

(1) Compare equipment nameplate data with drawings, specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware. Inspect the displays for scratches, dark pixels or uneven brightness.

(3) Inspect anchorage, alignment, grounding, and required clearances.

(4) Verify that fuse sizes and types correspond to drawings.

(5) Verify the unit is clean inside and out.

(6) Verify the application of an oxide inhibitor on battery terminal connections.

(7) Inspect bolted electrical connections for high resistance using one of the following methods:

(a) Use a low-resistance ohmmeter.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(c) Perform thermographic survey.

3.2.3 Performance Tests

Provide equipment, test instruments, power, load bank, materials and labor required for tests. Contracting Officer will witness all tests and the tests are subject to his approval. Perform tests in accordance with the manufacturer's recommendations and include the following electrical tests.

3.2.3.1 UPS Unit Performance Tests

Upon completion of battery activation procedures, Contractor is to connect load bank to UPS output. Size load bank to the full kW rating of the system.

Performance test is to be run under the supervision of the UPS technical representative. Operate UPS unit under full kW load for a minimum of one hour. Operation of the feeder and bypass power feeder breakers during testing of the UPS is the responsibility of the Contractor.

a. Electrical Tests

(1) Test static transfer from inverter to bypass and back. Use normal load, if possible.

(2) Test dc undervoltage trip level on inverter input breaker/relay. Set according to manufacturer's published data.

(3) Test alarm circuits.

(4) Verify synchronizing indicators for static switch and bypass switches.

(5) Perform electrical tests for UPS system breakers.

(6) Perform electrical tests for UPS system batteries.

(a) Measure negative post temperature.

(b) Measure charger float and equalizing voltages.

(c) Verify all charge functions and alarms.

b. Test Values

Verify bolt-torque levels.

c. Maintenance Bypass Panel/Cabinet

Verify interlocks (Kirk-Key or other means) operate properly. Verify that the breaker arrangement operates in the manner required for the number of possible combinations.

d. Load Test

Load test the installed system for a continuous 24 hour period by means of resistive load banks. Continuously test the system at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. Provide variable load banks sized to the full kW load of system to facilitate startup under load conditions, and to conduct load tests described above. Record instrument readings every half hour for the following:

(1) Input voltage (all three phases).

(2) Input current (all three phases).

(3) Input frequency.

(4) Battery voltage.

(5) Output voltage (all three phases).

(6) Output current (all three phases).

(7) Output kilowatts.

(8) Output frequency.

e. Full Load Burn In Test

Provide an additional full load burn-in period of 24 continuous hours for the installed system. If a failure occurs during the burn-in period, repeat the tests. Record instrument readings every half hour as above. Perform the following tests during the burn-in period:

(1) With the UPS carrying maximum continuous design load and supplied from the normal source, switch 100 percent load on and off a minimum of five times within the burn-in period .

(2) With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described in step (1). Also, verify that the UPS module rectifier charger unit(s) go into the second-step current limit mode.

(3) With the UPS carrying maximum continuous design load and operating on battery power, repeat the switching operations described in step (1) above.

(4) Continue operation on battery power for 1 minute, then restore normal power.

Furnish a high-speed dual trace oscillograph to monitor ten or more cycles of the above tests at the ON and OFF transitions and two typical steady-state periods, one shortly after the load is energized (at 30 to 60 seconds) and one after operation has stabilized (at 8 to 10 minutes). Deliver four copies of the traces to the Contracting Officer.

f. Battery Discharge Test

Allow UPS 24 hrs to recharge batteries and an additional 24 hrs cool down prior to commencing this test, if other tests such as the full load test were performed. With the UPS carrying maximum continuous design load and the battery fully charged, the system is to undergo a complete battery discharge test to full depletion and a recharge to nominal conditions. Record instrument readings every minute during discharge for the following:

(1) Battery voltage.

(2) Battery current.

(3) Output voltage (all three phases).

(4) Output current (all three phases).

(5) Output kilowatts.

(6) Output frequency.

3.2.3.2 Generator Operation

Test UPS to observe operation with generator service. UPS technical representative is to verify UPS battery current limiting feature functions properly.

3.2.3.3 Battery Performance Test (Constant kW)

Furnish all labor, material and test equipment necessary to conduct performance test under the direction of UPS technical representative. Accomplish the following:

a. Install a calibrated voltmeter across the battery terminals to measure voltage, and provide current transformers to measure the current from each string.

b. Record temperature of pilot cells in battery immediately prior to start of discharge performance test.

c. Read and record total battery voltage and battery current at start of discharge and every minute during discharge test.

d. Record minutes and seconds when battery voltage drops below minimum discharge voltage. On initial discharge test, a battery may be expected to deliver 95 percent of its rated capacity. This will increase to 100 percent after several complete discharge cycles or after 12 months of float charge service.

e. Should battery fail to meet the requirements of the first discharge performance test, place battery on equalizing charge as defined by the specific battery manufacturer's recommendations. Measure and record time and battery voltage. Run a second discharge performance test.

3.3 DEMONSTRATION

3.3.1 Instructing Government Personnel

Furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors are to be thoroughly familiar with all parts of the installation and be trained in operating theory as well as practical operation and maintenance work. Provide instruction during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. Provide 8 hours of instruction for required personnel.

3.4 FINAL ADJUSTMENTS

a. Remove load bank and reconnect system for normal operation.

b. Equalize battery per manufacturer instructions.

c. Bring electrolyte level of all cells up to the bottom of the high level line by adding original filling gravity electrolyte.

d. Resume charging battery at normal float voltage as defined by battery manufacturer recommendations.

e. Prior to charging, check battery connections are properly torque to manufacturer's specifications. Take and record, for cell-to-cell and terminal connections, detailed micro-ohm resistance readings. Remake connections having a resistance of more than 10 percent above the average.

f. Deliver all manufacturer's data and operation manuals, which are an integral part of, and shipped with UPS, to Contracting Officer.

3.5 NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.6 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting is to comply with Section 09 90 00 PAINTS AND COATINGS.

-- End of Section --

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH
05/20, CHG 1: 08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 110	(2022) Standard for Emergency and Standby Power Systems

UNDERWRITERS LABORATORIES (UL)

UL 508	(2018; Reprint Jul 2021) UL Standard for

	Safety Industrial Control Equipment
UL 1008	(2014) Transfer Switch Equipment
UL 1066	(2012; Reprint Mar 2017) UL Standard for Safety Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING, applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Automatic Transfer Switch Drawings; G

SD-03 Product Data

Automatic Transfer Switches; G,

By-Pass/Isolation Switch (BP/IS); G

Remote Annunciator Panel; G

Remote Annunciator and Control System Panel; G

SD-06 Test Reports

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Factory Testing; G

Factory Test Reports; G,

Factory Testing -Medical Facilities; G

SD-07 Certificates

Proof of Listing; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manual, Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, Data Package 5; G

1.4 OPERATION AND MAINTENANCE MANUAL

Assemble and bind manuals in durable, hard-covered, water resistant binders. Assemble and index the manuals per the following table of contents:

a. Manufacturer's O&M per "SD-10 Operation and Maintenance Data".

b. Catalog data required by "SD-03 Product Data"

c. Drawings required by "SD-02 Shop Drawings".

1.4.1 Additions to Operation and Maintenance Manuals

In addition to requirements of SD-10 Data Package 5, include the followings on the actual equipment provided:

a. An outline drawing, front, top, and side views.

b. Prices for spare parts and supply list.

c. Date of Purchase.

d. Corrective maintenance procedures.

e. Operating manual outlining step-by-step procedures for system startup, operation, and shutdown.

f. Include simplified wiring and control diagrams in the manual for system as installed.

g. Provide typical contact voltage drop readings under specified conditions for use during periodic maintenance. Provide instructions for determination of contact integrity.

1.4.2 Spare Parts

Furnish the following the following minimum spare parts and any other spare parts required in one-year operation, of the same material and workmanship, meeting the same requirements, and interchangeable with the corresponding original parts.

a. Fuses: Two of each type and rating.

1.5 QUALITY ASSURANCE

1.5.1 Proof of Listing

Submit proof of listing by UL 1008.

1.5.2 Automatic Transfer Switch Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. Provide a nameplate of corrosion-resistant material with not less than 1/8 inch tall characters showing manufacturer's name and equipment ratings. Mount nameplate to front of enclosure and meet the nameplate requirements of NEMA ICS 2.

c. Provide detail drawings that include manufacturer's name and catalog number, electrical ratings, total system transfer statement, reduced normal supply voltage at which transfer to the alternate supply is initiated, transfer delay times, short-circuit current rating, wiring diagram, description of interconnections, testing instructions, acceptable conductor type for terminals, tightening torque for each wire connector, and other required UL 1008 markings.

d. Submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Provide diagrams showing interlocking provisions and cautionary notes, if any.

e. Drawings are to indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated

1.5.4 Standard Product

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record are acceptable if the manufacturer has been regularly engaged in the design and production of automatic transfer switches and if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 years prior to date of delivery to site are not acceptable.

1.6 DELIVERY AND STORAGE

Protect equipment placed in storage from humidity and temperature variations, moisture, water intrusion, dirt, dust, or other contaminants. In harsh environments where temperatures exceed non-operational parameters established within this specification, provide an environmentally controlled equipment storage facility to ensure temperature parameters are within equipment specification. Provide documentation of same to the Government when storage is implemented.

1.7 ENVIRONMENTAL CONDITIONS

Provide an ATS that is suitable for prolonged performance under following service conditions:

a. Operating altitude: Sea level to 3,300 ft. (Systems applied at higher altitudes are to be derated in accordance with the manufacturer's instructions).

b. Operating ambient temperature range: 40 to 104 degrees F.

c. Operating relative humidity: 0 to 90 percent, without condensation.

1.8 SEISMIC REQUIREMENTS

Provide seismic details conforming to Section 26 05 48.00 10, SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES

Each automatic transfer switch must be rated and marked for total system transfer and have the current and voltage ratings as indicated. Provide a switch operating mechanism that is electrically operated, have quick-make, quick-break, load break contacts, and be mechanically held in both positions. Provide an ATS that is UL listed. ATS must be manufactured and tested in accordance with applicable requirements of NEMA ICS 2, UL 1008 and UL 1066. ATS must conform to NFPA 110. Provide the ATS with the following characteristics:

a. Voltage: As required/indicated.

b. Amperage: As required/indicated. Provide an ATS with a continuous load current rating of the switch rating.

c. Number of Phases: As required/indicated..

d. Number of Wires: As required/indicated..

e. Frequency: 60 Hz.

f. Poles: As required/indicated.. One of the poles is the neutral.

g. ATS Withstand Current Rating: ATS must be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS terminals. The ATS must be listed in accordance with UL 1008 for 3 [18] [30] cycle close and withstand ratings. Minimum UL listed close and withstand ratings As required/indicated.

h. Nonwelding Contacts: Provide contacts that are nonwelding at the available fault current rating. Contacts must be suitable for repetitive power transfer switching. Switches rated 800 amps and above must have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

i. Phase and Neutral Contacts: Provide contacts with silver alloy composition. Provide neutral contacts with the same continuous current rating as main or phase contacts.

j. Configuration. Provide an ATS for use in emergency systems described in NFPA 70. Provide an ATS that is listed for emergency use.k. ATS Configuration. Neutral is to break and make with the phase contacts. l. Service Entrance Rated. Provide an integrated circuit breaker and automatic transfer switch. Provide a separate deadfront compartment for the circuit breaker on switches 600 amp and larger. Provide label indicating that the ATS is the service disconnect. Provide a circuit breaker that is rated for 100 percent of the switch contact current rating. All components, except as noted herein, are to have a continuous load rating.

2.1.1 Undervoltage Sensing - Normal/Preferred Source

Undervoltage Sensing - Normal Source. Provide undervoltage sensing for each phase in the normal/preferred source. Sense low phase-to-ground voltage on each phase. Provide sensing circuit with adjustable dropout, 75-98 percent of nominal value and adjustable pickup, 85-100 percent of nominal value. Factory set dropout value to 85percent. Factory set pickup value to 90percent.

2.1.2 Adjustable Time Delay - Override Transfer

Adjustable Time Delay - Override Transfer. For override of normal-source voltage sensing to delay transfer[and engine starting] signals. Engine starting control contacts with adjustable commit-to-start delay circuit, 0.0-6.0 seconds. Factory set at 1 second.

2.1.3 Voltage/Frequency Lockout Relay - Alternate/Emergency Source

Voltage/Frequency Lockout Relay. Single- or phase sensing must be provided on the normal and emergency source. Prevent premature transfer to alternate/emergency source. Provide pickup voltage that is adjustable from 85-100 percent of nominal. Factory set for pickup at 90 percent. Provide pickup frequency that is adjustable from 90-97 percent of nominal. Factor set frequency pickup for 95 percent.

2.1.4 Adjustable Time Delay - Transfer to Alternate/Emergency Power Source

Adjustable Time Delay - Transfer to Alternate Power Source. Transfer to alternate power source time delay for transfer switches as indicated, adjustable 0-5 minutes. Factory set to 0 seconds. ATS is to monitor the frequency and voltage of alternate power source and transfer when frequency and voltage are stabilized.

2.1.5 Adjustable Time Delay- Re-transfer to Normal/Preferred Source

Adjustable Time Delay- Transfer to Source. Re-transfer to normal source time delay, adjustable 0-30 minutes. Factory set at 10 minutes. Time delay is automatically defeated upon loss or sustained undervoltage of alternate power source, provided that normal source has been restored.

2.1.6 Engine-Generator Exerciser

Exerciser. Solid-state, programmable-time switch exerciser to allow automatic starting of the generator set, subsequent load transfer, retransfer of load and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from on a daily, weekly, bi-weekly or monthly basis.. Running periods are adjustable from 10-30 minutes. Factory settings are for 7-day exercise cycle, 20 minute running period and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer or dual independent exercisers that allow for unloaded and loaded schedule testing.

b. Push-button programming control with digital display of settings.

c. Integral battery operation of time switch when normal control power is not available.

2.1.7 Engine Shutdown Time Delay

Engine Shutdown. Provide time delay that is adjustable from 0 to 5 minutes and is factory set at 5 minutes.

2.1.8 Front Panel Devices

Provide devices mounted on cabinet front consisting of:

a. Mode selector switch with the following positions and associated functions. Selector switch can be part of the microprocessor controller consisting of an LCD screen with a graphical interface or as a stand-alone test switch.

    (1) TEST - Simulates loss of normal/preferred source system operation.

    (2) NORMAL - Transfers system to normal/preferred source bypassing re-transfer time delay.

b. Switch position indicating lights or graphical LCD display. Indicate source to which load is connected.

c. Source-Available Monitor. Provide source-available indicating lights or graphical LCD display monitor that is labeled to show when one or both sources of power are available. If indicating lights are used, then the preference is to have Green be normal/preferred power and Red be for alternate/emergency power; however, other color schemes are allowed if clearly marked.

d. Provide a transfer override switch. Provide automatic transfer switch microprocessor based controller, which offers field selectable/adjustable inputs and outputs for transfer switch operation. Override switch must bypass automatic transfer controls so ATS will transfer and remain connected to emergency power source, regardless of condition of normal/preferred source. Provide an indicating light to show override status. If emergency source fails and normal source is available, ATS is to automatically retransfer to normal source.

e. Lamp test button.

2.2 BY-PASS/ISOLATION SWITCH (BP/IS)

Include non-load-break by-pass/isolation switches for the indicated automatic transfer switches. Designs which disconnect or interrupt the load when bypassing are not acceptable. Include the following features for each combined by-pass/isolation switch and automatic transfer switch:

a. Bypass/isolation switch (BP/IS) and associated ATS are to be made by the same manufacturer and must be completely interconnected and tested at factory and at project site as specified.

b. ATS is to be manufactured, listed and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH. BP/IS switch current, voltage, closing, and short-circuit withstand closing ratings are to be equal or exceed comparable ratings specified for ATS and have the same phase arrangement and number of poles.

c. Provide externally operated and arranged selector switch or handle so designed and constructed not to stop in an intermediate or neutral position during operation and that one person can safely bypass the ATS. Accomplish isolation of the ATS externally by one person. Bypass and isolation handles must be permanently affixed and operable without opening the enclosure door. Provide interlocks that ensure ATS is disconnected from source and load during isolation. Interlocks prevent ATS operation, except for testing and maintenance, while isolated. BP/IS operation is to be accomplished without disconnecting switch load terminal conductors. Equipment which require separate tools, keys, or other devices to operate the bypass/isolation mechanism which may not be present during an emergency is not acceptable.

d. Provide drawout transfer switch that provides physical separation from bypass switch and live parts and accessibility for testing and maintenance operation.

e. Provide contacts that have the same contact temperature that do not exceed those of the ATS contacts when carrying rated load. Provide contacts as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. Provide manufacturer instructions for determining contact integrity in order To facilitate maintenance.

f. The ATS controls remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source [and automatic starting of the generator in the event of a loss of the normal power source]. In the isolated mode, the bypass section is capable of functioning as a manual transfer to transfer the load to either power source for maintenane purposes or when automatic control has failed. Equipment that requires automatic controls to be functional to operate the bypass switch is not acceptable.. The ATS can be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

h. Construct Bypass/isolation switch for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors.

i. Achieve load by-pass to the source with no load interruption. Bypass/isolation equipment that breaks the load is not accpetalbe.

j. Provide drawout bypass switch that provides physical separation from ATS and live parts and accessibility for testing and maintenance operation. [Provide automatic shutters that closed to isolate the bus.]

k. Provide a means to ensure the switch is transferred to the alternate or emergency power source when normal power source becomes unavailable.

2.2.1 Markings

Mark isolation handle positions with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Provide an indication that shows that BP/IS section is providing power to the load.

b. Provide indication of ATS isolation/test position.

c. Provide suitable control labels and instruction signs describing operating instructions.

d. Indicating lamps or LCD screen for indicating that shows the source availability, bypass switch position, transfer switch position, and isolation handle position. If indicating lights are used, provide a lamp test button that turns the indicating lights on, but does not cause any function to take place.

2.2.2 Interconnection

Interconnect BP/IS and associated ATS with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at withstand current rating specified for associated ATS.

2.3 ENCLOSURE

Provide an enclosure that meets the following:

a. Provide ATS and accessories in a [free-standing, floor-mounted][wall-mounted], [ventilated][unventilated] NEMA 250, Type [1][3R][3RX][4][4X][12], smooth sheet metal enclosure constructed in accordance with applicable requirements of NEMA ICS 6, UL 508, UL 1066, and UL 1008. [Provide screened and filtered intake vents. Provide screened exhaust vents.] [Provide door with suitable hinges, locking handle latch, and gasketed jamb.] Provide at least No. 14 metal gauge.

b. Factory wiring within enclosure and field wiring terminating within enclosure must comply with NFPA 70. Provide wire that is permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing, when wiring is not color coded. Conform terminal block to NEMA ICS 4. Arrange terminals for entrance of external conductors from [top and bottom][top][bottom] of enclosure as shown. Main switch terminals, including neutral terminal if used, must be pressure type suitable for termination of external [copper] [aluminum] conductors shown.

[c. Provide thermostatically controlled heater within enclosure to prevent condensation over temperature range stipulated in paragraph SERVICE CONDITIONS.

]2.3.1 Construction

Construct enclosure for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components.

2.3.2 Cleaning and Painting

Protect both the inside and outside surfaces of an enclosure, including means for fastening against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Provide manufacturer's standard finish material, process, and color that is free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 is acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.3.3 Field Fabricated Nameplates

Nameplate is to comply with ASTM D709. Provide laminated plastic nameplates for each equipment enclosure as specified or as indicated on the drawings. Provide an inscription on each nameplate that identifies the name of the equipment, sources of power, calculated short circuit with date and the location e.g. 'SWB-1 Electrical Room 103'. Provide nameplates that are made of melamine plastic, 0.125 inch thick, white with [black][_____] center core. Provide the nameplate with a surface that is matte finished and that has square corners.. Accurately align lettering and engrave into the core. Provide nameplates that are at least 1.0 by 2.5 inches with a minimum lettering size of 0.25 inch high normal block style.

[2.4 REMOTE ANNUNCIATOR PANEL

[Provide remote annunciation with LED indicating lights, an audible alarm with silence switch as well as all appropriate labeling.][or][Provide a remote annunciator panel that utilizes a touchscreen human machine interface (HMI). Minimum screen size is 7 inches.] The annunciator is to be configured to handle [1][2][_____] transfer switches. Provide a surface mounted cabinet. Provide built-in power supply that accepts either 24 VDC or 120VAC or [_____]. Provide communications module to support monitoring of ATS. Module must provide status, analog parameters, event logs, equipment settings, and configurations over embedded webpage, open protocol, and automated email while utilizing AES 128-bit encryption. Provide a remote annunciation panel to annunciate the following conditions for the indicated transfer switch(es).

a. Sources available

b. Switch position.

c. Switch in test mode.

d. Failure of communication link.

][2.5 REMOTE ANNUNCIATOR AND CONTROL SYSTEM PANEL

Provide a remote annunciator and control system that utilizes a touchscreen human machine interface (HMI) with the ability to remotely monitor and control multiple transfer switches from a single panel. Minimum screen size is 7 inches. Provide password protection and date/time stamped alarm history. The controller is to have internal battery backup. In the event of a communication link failure, the system is to automatically revert to stand-alone, self-contained operation. Automatic transfer switch sensing, controlling or operating function is not to depend on remote panel for proper operation. Provide a surface mounted cabinet. Communication is to be by a [Modbus] RS-485 connection. The annunciator controller is to be configured to monitor and control [1][2][_____] transfer switches.

2.5.1 Monitor

Monitor the following:

a. Sources available

b. Switch position.

c. Switch in test mode.

d. Overvoltage

e. Failure of communication link.

[f. Engine test or exercise.
]

2.5.2 Alarm Screen

Alarm for the following conditions:

a. Alternate source closed

b. Undervoltage

c. Lockout.

2.5.3 Control Functions

Provide a means to perform the following functions from the controller: an alarm silence button in addition to monitoring the following items:

a. Control of switch-test initiation.

b. Control of switch operation in either direction.

c. Control of time-delay bypass for transfer to normal source.

d. Control to perform an engine test.

[e. Provide a means to remotely configure transfer switch controller setpoints. The means to perform these changes must be password protected.
]

[f. Manage up to eight (8) transfer switches from a single remote annunicator and control panel
]

]2.6 FACTORY TESTING

Submit a description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than 2 weeks prior to test date. Submit certified factory and field test reports, within 14 days following completion of tests. Provide reports that are certified and dated and that demonstrate that tests were successfully completed prior to shipment of equipment.

2.6.1 Prototype Factory Testing

A prototype of specified ATS is to be factory tested in accordance with UL 1008. In addition, perform factory tests on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.6.2 Factory Test Reports

Provide three certified copies of factory test reports from the manufacturer.

2.7 FACTORY TESTING -MEDICAL FACILITIES

The factory tests for ATS and By-Pass/Isolation switches used in medical facilities must be conducted in the following sequence:

a. General

b. Normal

c. Overvoltage

d. Undervoltage

e. Overload

f. Endurance

g. Temperature Rise

h. Dielectric Voltage-Withstand

i. Contact Opening

j. Dielectric Voltage-Withstand (Repeated)

k. Withstand

l. Instrumentation and Calibration of High Capacity

m. Closing

n. Dielectric Voltage-Withstand (Repeated)

o. Strength of Insulating Base and Support

PART 3 EXECUTION

3.1 INSTALLATION

Installation must conform to the requirements of NFPA 70 and manufacturer's recommendation.

3.2 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the automatic transfer switch.

3.2.1 Performance of Acceptance Checks and tests

Complete as specified in paragraph entitled "Acceptance Checks and Tests". The Acceptance Checks and Tests are to be accomplished by the Testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.2.2 Manufacturers O&M Information

The manufacturers O&M information required by the paragraph entitled "SD-10 Operation and Maintenance Data", is to be submitted to and approved by the Contracting Officer.

3.2.3 Test Equipment

Ensure all test equipment and instruments is on hand prior to scheduling field tests, or subject to Contracting Officer's approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on site prior to field testing.

3.3 FIELD QUALITY CONTROL

Give Contracting Officer 15 days notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The contractor is responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The contractor provides labor, equipment, apparatus, including test load, and consumables required for the specified tests. Calibration of all measuring devices and indicating devices must be certified. Provide the services of a qualified factory-trained manufacturer's representative to assist the contractor in installation and start-up of the equipment specified under this section. The manufacturer's representative is to provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly components contained herein. Provide a test load that is a cataloged product in accordance with Section

26 20 00 INTERIOR DISTRIBUTION SYSTEM. Perform the following field tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.3.1 Automatic Transfer Switch Acceptance Checks and Tests

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify that manual transfer warnings are attached and visible.

(5) Verify tightness of all control connections.

(6) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is not required.

(7) Perform manual transfer operation.

(8) Verify positive mechanical interlocking between normal and alternate sources.

b. Electrical Tests

(1) Measure contact-resistance. Correct values that exceed 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

(2) Perform insulation-resistance on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole for one minute. Perform tests in both source positions.

(3) Verify settings and operations of control devices.

(4) Calibrate and set all relays and timers.

(5) Test ground-fault protective device.

3.3.2 Functional Acceptance Tests

Functional Acceptance Tests must be coordinated with Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Include simulating power failure and demonstrating the following operations for each automatic transfer switch. Demonstrate in service that the automatic transfer switches are in good operating condition, and function not less than five times.

a. Perform automatic transfer tests:

(1) Simulate loss of normal/preferred power.

(2) Return to normal/preferred power.

(3) Simulate loss of emergency/alternate power.

(4) Simulate all forms of single-phase conditions.

b. Verify correct operation and timing of the following functions:

(1) Normal source voltage-sensing relays.

(2) Engine start sequence.

(3) Time delay upon transfer.

(4) Alternate source voltage-sensing relays.

(5) Automatic transfer operation.

(6) Interlocks and limit switch function.

(7) Time delay and retransfer upon normal power restoration.

(8) By-pass/isolation functional modes and related automatic transfer switch operations.

3.3.3 Infrared Scanning

After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after acceptance.

b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 TRAINING

Provide 4 hours of training to maintenance personnel on the proper operation, maintenance and adjustment of the automatic transfer switch. Coordinate this training with that of the generator equipment.

-- End of Section --

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SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM
11/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

U.S. AIR FORCE (USAF)

AFI 32-1065	(2017) Grounding Systems

UNDERWRITERS LABORATORIES (UL)

UL 96	(2016) UL Standard for Safety Lightning Protection Components
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with NFPA 70, NFPA 780, and UL 96.

1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overall lightning protection system; G

Each major component; G

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Lightning Protection and Grounding System Test; G

SD-07 Certificates

Lightning Protection System Installers Documentation; G

Component UL Listed and Labeled; G

Lightning protection system inspection certificate; G

Roof manufacturer's warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.4.1 Installation Drawings

1.4.1.1 Overall System Drawing

Submit installation shop drawing for the overall lightning protection system. Include on the drawings the physical layout of the equipment (plan view and elevations), mounting details, relationship to other parts of the work, and wiring diagrams.

1.4.1.2 Major Components

Submit detail drawings for each major component including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in UL Electrical Construction, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

1.4.4 Lightning Protection System Inspection Certificate

Provide certification from a commercial third-party inspection company whose sole work is lightning protection, stating that the lightning protection system complies with NFPA 780 and AFI 32-1065. Third party inspection company cannot be the system installer or the system designer. Alternatively, provide a UL Lightning Protection Inspection Master Label Certificate for each facility indicating compliance to NFPA 780 and AFI 32-1065. In either case, AFI 32-1065 takes precedence over NFPA 780, whether or not it is more stringent.

Inspection must cover every connection, air terminal, conductor, fastener, accessible grounding point and other components of the lightning protection system to ensure 100% system compliance. This includes witnessing the tests for the resistance measurements for ground rods with test wells, and for continuity measurements for bonds. It also includes verification of proper surge protective devices for power, data and telecommunication systems. Random sampling or partial inspection of a facility is not acceptable.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before changing the design.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of UL 96 classes as applicable.

2.1.1 Main and Bonding Conductors

NFPA 780 and UL 96 Class I, Class II, or Class II modified materials as applicable.

2.2 COMPONENTS

2.2.1 Air Terminals

Provide solid air terminals with a blunt tip. Tubular air terminals are not permitted. Support air terminals more than 24 inches in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods made of copper-clad steel conforming to conform to UL 467. Provide ground rods that are not less than 3/4 inch in diameter and 10 feet in length. Do not mix ground rods of copper-clad steel or solid copper on the job.

2.2.3 Grounding Plates

Provide grounding plates made of copper-clad steel conforming to UL 96.

2.2.4 Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.5 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780 and UL 96.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of NFPA 780, including tie-ins to existing lightning protection systems. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes and ground ring electrode conductor. Expose conductors on the structures except where conductors are required to be in protective sleeves. Bond secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

3.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the roof manufacturer's warranty is not violated by the installation methods for air terminals and roof conductors.

3.1.1.1 Air Terminals

Use adhesive shoes with adhesive approved by the roof manufacturer when installing air terminals on "rubber" (EPDM) type roofs. Use a standing seam base for installation of air terminals on a standing seam metal roof that does not produce any roof penetrations.

3.1.1.2 Roof Conductors

3.1.2 Down Conductors

Protect exposed down conductors from physical damage as required by NFPA 780. Use Schedule 80 PVC to protect down conductors. Paint the Schedule 80 PVC to match the surrounding surface with paint that is approved for use on PVC. Down conductors are to be concealed within the wall cavities.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to ground rods by welding (including exothermic), brazing, or compression. All connections to ground rods below ground level must be by exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

3.1.4 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less 10 feet. Set ground rods not less than 3 feet nor more than 8 feet, from the structure foundation, and at least beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a driven ground rod is 25 ohms, under normally dry conditions . Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than 10 feet into the ground, a minimum of 10 feet apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven.

3.2 APPLICATIONS

3.2.1 Nonmetallic Exterior Walls with Metallic Roof

Bond metal roof sections together which are insulated from each other so that they are electrically continuous, having a surface contact of at least

3 square inches.

3.2.2 Personnel Ramps and Covered Passageways

Place a down conductor and a driven ground at one of the corners where the ramp connects to each building or structure. Connect down conductor and driven ground to the ground ring electrode or nearest ground connection of the building or structure. Where buildings or structures and connecting ramps are clad with metal, separately bond the metal of the buildings and ramps to a down conductor as close to grade as possible.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Fences

Bond metal fence and gate systems to the lightning protection system whenever the fence or gate is within 6 feet of any part of the lightning protection system in accordance with ANSI C2.

3.3.2 Exterior Overhead Systems

Bond to the nearest down conductor as close to grade as possible. This includes overhead pipes, conduits, cable trays, or any other metallic objects on the exterior of the building that enter a building. In addition, bond pipes, conduits, and cable trays to any metallic objects (such as steel structural support of air handling units or cooling towers) that are within 6 feet.

3.4 RESTORATION

Where sod has been removed, place sod as soon as possible after completing the backfilling. Restore, to original condition, the areas disturbed by trenching, storing of dirt, cable laying, and other work. Overfill to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

3.5 FIELD QUALITY CONTROL

3.5.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 25 ohms. Provide documentation for the measured values at each test point. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

-- End of Section --

SECTION 26 42 13

GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM
05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B418	(2016a; R2021) Standard Specification for Cast and Wrought Galvanic Zinc Anodes
ASTM B843	(2018) Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D2028/D2028M	(2015) Cutback Asphalt (Rapid-Curing Type)
ASTM D3381/D3381M	(2018) Standard Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction
ASTM F1182	(2007; R 2019) Anodes, Sacrificial Zinc Alloy

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 15589-2	(2012) Petroleum, Petrochemical and Natural Gas Industries - Cathodic Protection of Pipeline Transportation Systems - Part 2: Offshore Pipelines

NACE INTERNATIONAL (NACE)

NACE SP0106	(2018) Control of Internal Corrosion in Steel Pipelines and Piping Systems
NACE SP0176	(2007) Corrosion Control of Submerged Areas of Permanently Installed Steel Offshore Structures Associated with Petroleum Production
NACE SP0177	(2019) Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
NACE SP0186	(1986; R 2007) Application of Cathodic Protection for External Surfaces of Steel Well Casings
NACE SP0188	(1999; R 2006) Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE SP0193	(2016) Application of Cathodic Protection to Control External Corrosion of Carbon Steel On-Grade Storage Tank Bottoms
NACE SP0196	(2020) Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel

	Water Storage Tanks
NACE SP0200	(2014) Standard Practice Steel-Cased Pipeline Practices
NACE SP0285	(2021) External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection
NACE SP0286	(1997; R 2007) Standard Practice Electrical Isolation of Cathodically Protected Pipelines
NACE SP0388	(2018) Impressed Current Cathodic Protection of Internal Submerged Surfaces of Carbon Steel Water Storage Tanks - Item No. 21040
NACE SP0607	(2007) Petroleum and Natural Gas Industries — Cathodic Protection of Pipeline Transportation Systems — Part 2: Offshore Pipelines
NACE SP21424	(2018) Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation and Monitoring
NACE TPC 11	(2008) A Guide to the Organization of Underground Corrosion-Control Coordinating Committees

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-18001	(1993) Anodes, Sacrificial Zinc Alloy
MIL-I-1361	(1985; Rev C; Notice 1 1991; Notice 2 2021) Instrument Auxiliaries, Electrical Measuring: Shunts, Resistors and Transformers

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings

1.2 DEFINITIONS

It is convenient to classify corrosion by the forms in which it manifests itself, the basis for this classification being the appearance of the corroded metal. Each form can be identified by visual observation, although, in some cases, magnification is required. Valuable information for the solution of a corrosion problem can often be obtained through careful observation of the corroded test specimens or failed equipment. Examination before cleaning is particularly desirable. Cathodic Protection is a method used to control corrosion.

1.2.1 Cathodic Protection

Cathodic Protection (CP) is an electrochemical (half electrical and half chemical) method used to control corrosion of buried or submerged metallic structures. It prevents corrosion by making the protected structure a cathode by installing a more anodic metal (sacrificial or galvanic) anode or a metallic (impressed current) anode connected to a Direct Current (DC) power source. When the proper amount of current is applied to the structure, it becomes a cathode. Since all corrosion occurs at the anode, the structure no longer corrodes. The electrons move in the metallic path (electrical). Reduction (chemical) reactions occur at the surface of the cathode resulting in a hydrogen coating and more alkaline environment. Oxidation (chemical) reactions occur at the surface of the anode resulting in corrosion and a more acidic environment. After a CP system is installed and adjusted to provide adequate protection, the hydrogen coats the defects in the coating and polarizes in the negative direction (to a copper/copper sulfate reference electrode) over time the current and potentials remain relatively stable; changes in currents or potentials indicate a problem. An error-free measurement of negative 850 millivolts DC or more negative to the copper/copper-sulfate reference electrode proves the structure is a cathode and corrosion has been mitigated.

1.2.2 Corrosion

It is convenient to classify corrosion by the forms in which it manifests itself, the basis for this classification being the appearance of the corroded metal. Each form can be identified by visual observation, although, in some cases, magnification is required. Valuable information for the solution of a corrosion problem can often be obtained through careful observation of the corroded test specimens or failed equipment. Examination before cleaning is particularly desirable. Some of the eight forms of corrosion are unique, but all of them are more or less interrelated.

The eight forms of corrosion are: (1) Uniform Attack, (2) Galvanic or Two-Metal Corrosion, (3) Crevice Corrosion, (4) Pitting Corrosion, (5) Intergranular Corrosion, (6) Selective Leaching, (7) Erosion Corrosion, and (8) Stress Corrosion Cracking. This listing is arbitrary but covers practically all corrosion failures and problems. The forms are not listed in any particular order of importance. Below, the eight forms of corrosion are discussed in terms of their characteristics, mechanisms, and preventive measures. Hydrogen damage, although not a form of corrosion, often occurs indirectly as a result of corrosive attack and is, therefore, included in this discussion.

1.2.3 Alternating Current (AC) Corrosion

AC corrosion occurs when there is a source of AC current, typically from a high voltage overhead AC (OHAC) power-line, when there is a low soil resistivity - typically less than 5,000 ohm-cm and there is a very small coating holidays. The AC corrosion pits typically have a tubercle of corrosion product at the pit. AC interference study modeling software can determine the mitigation solution to solve this problem. Typically, AC Corrosion mitigation is done in conjunction with high AC potentials and fault current mitigation.

1.2.4 AC Interference

AC interference occurs when a pipeline parallels a high-voltage overhead AC (OHAC) power-line. An interference study is required when this situation occurs as AC interference can cause high AC potentials along the pipeline (safety), can cause a fault condition between the pipeline and power-line and could cause AC corrosion to occur. The pipeline coating when exposed can have blisters/bubbles caused by the excessive AC. The interference study will use modeling software to determine what combination of interference may be occurring (if any) and provide the mitigation solution to solve the problem.

1.2.5 Uniform Attack

Uniform attack is the most common form of corrosion. It is normally characterized by a chemical or electrochemical reaction that proceeds uniformly over the entire exposed surface or over a large area. The metal becomes thinner and eventually fails. For example, a piece of steel or zinc immersed in dilute sulfuric acid normally dissolves at a uniform rate over its entire surface. A sheet iron roof shows essentially the same degree of rusting over its entire outside surface.

Uniform attack, or general overall corrosion, represents the greatest destruction of metal on a tonnage basis. This form of corrosion, however, is not of great concern from a technical standpoint, because the life of equipment can be accurately estimated on the basis of comparatively simple tests. Merely immersing specimens in the fluid involved is often sufficient. Uniform attack can be prevented or reduced by (1) materials, such as coatings, that reduce contact between metal and electrolytes, (2) inhibitors, or (3) CP.

1.2.6 Galvanic or Two-Metal Corrosion

A potential difference usually exists between two dissimilar-metals when they are immersed in a corrosive or conductive solution. If these metals are placed in contact (or otherwise electrically connected), this potential difference produces electron flow between them. Corrosion of the less corrosion-resistant metal is usually increased, and attack of the more resistant material is decreased, compared to the behavior of these metals when they are not in contact. The less resistant metal becomes anodic and the more resistant metal becomes cathodic. Usually the cathode or cathodic metal corrodes very little or not at all in this type of couple. Because of the electric currents and dissimilar-metals involved, this form of corrosion is called galvanic, bi-metallic or two-metal, corrosion. Galvanic corrosion is restricted to electrochemical corrosion caused by dissimilar-metal effects. It is electrochemical corrosion, but this document must restrict the term galvanic to dissimilar-metal effects for purposes of clarity.

1.2.7 Crevice Corrosion

Intense localized corrosion frequently occurs within crevices and other shielded areas on metal surfaces exposed to corrosives. This type of attack is usually associated with small volumes of stagnant solution caused by holes, gasket surfaces, lap joints, surface deposits, and crevices under bolt and rivet heads. As a result, this form of corrosion is called crevice corrosion or, sometimes, deposit or gasket corrosion.

1.2.8 Pitting Corrosion

Pitting is a form of extremely localized attack that results in holes in the metal. These holes may be small or large in diameter, but in most cases they are relatively small. Pits are sometimes isolated or so close together that they look like a rough surface. Generally a pit may be described as a cavity or hole with the surface diameter about the same as or less than the depth. Pitting is one of the most destructive and insidious forms of corrosion. It causes equipment to fail because of perforation with only a small percent weight loss of the entire structure. It is often difficult to detect pits because of their small size and because the pits are often covered with corrosion products. In addition, it is difficult to measure quantitatively and compare the extent of pitting because of the varying depths and numbers of pits that may occur under identical conditions. Pitting is also difficult to predict by laboratory tests. Sometimes the pits require a long time (several months or a year) to show up in actual service. Pitting is particularly vicious because it is a localized and intense form of corrosion, and failures often occur with extreme suddenness.

1.2.9 Intergranular Corrosion

Grain boundary effects are of little or no consequence in most applications or uses of metals. If a metal corrodes, uniform attack results since grain boundaries are usually only slightly more reactive than the matrix. However, under certain conditions, grain interfaces are very reactive and intergranular corrosion results. Localized attack at and adjacent to grain boundaries, with relatively little corrosion of the grains, is intergranular corrosion. The alloy disintegrates (grains fall out) or loses its strength. Intergranular corrosion can be caused by impurities at the grain boundaries, enrichment of one of the alloying elements, or depletion of one of these elements in the grain-boundary areas. Small amounts of iron in aluminum, wherein the solubility of iron is low, have been shown to segregate in the grain boundaries and cause intergranular corrosion. It has been shown that, based on surface tension considerations, the zinc content of a brass is higher at the grain boundaries. Depletion of chromium in the grain-boundary regions results in intergranular corrosion of stainless steels.

1.2.10 Selective Leaching

Selective leaching is the removal of one element from a solid alloy by corrosion processes. The most common example is the selective removal of zinc in brass alloys (dezincification). Similar processes occur in other alloy systems in which aluminum, iron, cobalt, chromium, and other elements are removed. Selective leaching is the general term to describe these processes, and its use precludes the creation of terms such as de-aluminumification, de-cobaltification. Parting is a metallurgical term that is sometimes applied, but selective leaching is preferred.

1.2.11 Erosion Corrosion

Erosion corrosion is the acceleration or increase in rate of deterioration or attack on a metal because of relative movement between a corrosive fluid and the metal surface. Generally, this movement is quite rapid, and mechanical wear effects or abrasion are involved. Metal is removed from the surface as dissolved ions, or it forms solid corrosion products, which are mechanically swept from the metal surface. Sometimes, movement of the environment decreases corrosion, particularly when localized attack occurs under stagnant conditions; this is not erosion corrosion because deterioration is not increased. Erosion corrosion is characterized in appearance by grooves, gullies, waves, rounded holes, and valleys and usually exhibits a directional pattern. In many cases, failures because of erosion corrosion occur in a relatively short time, and they are unexpected largely because evaluation corrosion tests were run under static conditions or because the erosion effects were not considered.

1.2.12 Stress-Corrosion Cracking

Stress-corrosion cracking refers to cracking caused by the simultaneous presence of tensile stress and a specific corrosive medium. Many investigators have classified all cracking failures occurring in corrosive media as stress-corrosion cracking, including failures due to hydrogen embrittlement. However, these two types of cracking failures respond differently to environmental variables. To illustrate, CP is an effective method for preventing stress-corrosion cracking; however, hydrogen-embrittlement may be caused when excessive current is applied, especially on stainless steel. Hence, the importance of considering stress-corrosion cracking and hydrogen embrittlement as separate phenomena is obvious. During stress-corrosion cracking, the metal or alloy is virtually unattacked over most of its surface, while fine cracks progress through it. This cracking phenomenon has serious consequences, since it can occur at stresses within the range of typical design stress.

1.2.13 Exothermic Welding

Exothermic welding is used in CP to connect a copper wire to a metallic structure, usually steel or cast-iron. It is a pyrotechnic composition of copper oxide, aluminum powder and magnesium powder. The magnesium powder is ignited with a spark gun or electronic ignition equipment. The aluminum powder serves as fuel, and melts the copper oxide, which bonds the wire to the structure. Although not explosive, it can create brief bursts of heat and high temperature in a small area.

1.2.14 Error-Free

Potential measurement error due to a voltage drop caused by current flowing through a resistor (the electolyte) between the reference electrode and the protected structure.

1.3 ADMINISTRATIVE REQUIREMENTS

After award of the contract, but prior to commencement of any work at the site, meet with the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Develop a mutual understanding relative to the administration of the value engineering, the safety program, preparation of the schedule of prices or the earned value report. Review shop drawings, and other submittals, scheduling programming, execution of the work, and clear expectations of the "Interim Department of Defense (DD) Form 1354" submittal. Major subcontractors who will engage in the work must also attend.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Preconstruction Survey

SD-02 Shop Drawings

Drawings; G

Isolation flange kits

Anode junction boxes, bonding boxes, and test stations

Joint bonds

Contractor's Modifications; G

SD-03 Product Data

Qualifications

Equipment; G

Anodes; G

Anode junction boxes, bonding boxes, and test stations

Dielectric unions

Wires

Cable and wire

Casings, isolation, and seals

Shunts

Permanent reference electrodes; G

Spare Parts

SD-06 Test Reports

Tests and Measurements; G

Contractor's Modifications; G

SD-10 Operation and Maintenance Data

Cathodic Protection System; G

Training Course; G

Cathodic Protection System, Data Package 5; G

SD-11, Closeout Submittals

Initial Cathodic Protection System Field Testing; G

One Year Warranty Period Cathodic Protection System Field Test Report; G

Final Cathodic Protection System Field Test Report; G

1.4.1 Material and Equipment Manufacturer Data

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<tr><th>DATE</th><th>ISSUE NO.</th><th>REQUEST</th><th>REQUESTED BY</th><th>REQUEST REF. NO.</th></tr>
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DATE	ISSUE NO	REQUEST	REQUESTED BY	REQUEST REF. NO

1.5 MAINTENANCE MATERIAL SUBMITTALS

1.5.1 Spare Parts

After approval of shop drawings, furnish spare parts data for each different item of material and equipment specified. The data must include a complete list of parts, special tools, and supplies, with current unit prices and source of supply.

After approval of shop drawings, furnish revised spare parts for any changes made from original submittal. One spare anode of each type must be furnished. In addition, supply information for material and equipment replacement for all other components of the complete system, including anodes, cables, splice kits and connectors, corrosion test stations, and any other components not listed above. Furnish one reference electrode on a hand reel with 350 feet of conductor and one digital voltmeter that can be used in the maintenance of this CP system. Demonstrate use of furnished equipment in actual tests during the training course. Provide a description of equipment of the pipe-to-soil protected structure and foreign structures at electrical isolation between the utility supplier and the facility piping.

1.5.2 Extra Materials

Furnish one reference electrode on a hand reel with350 feet of conductor and one high-input-impedance digital multimeter that can be used in the maintenance of this CP system. Demonstrate use of furnished equipment in actual tests during the training course. Provide a description of equipment of the pipe-to-soil protected structure and foreign structures at electrical isolation between the utility supplier and the facility piping. Include a description of the equipment and measurement of the pipe-to-soil potentials, anode voltage, anode current and soil condition.

1.6 QUALITY CONTROL

1.6.1 Regulatory Requirements

Obtain the services of a corrosion expert to supervise, inspect, and test the installation and performance of the cathodic protection system. The term "corrosion expert" refers to a person, who by thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of buried or submerged metallic structures.

1.6.2 Qualifications

The corrosion expert must be accredited or certified by NACE International, as a CP-4 CP Specialist or be a NACE International certified Corrosion Specialist or a registered professional engineer who has certification or licensing that includes education and experience in CP of the type of CP system being installed. The corrosion expert must have not less than five years of experience in the type of CP for buried or submerged metallic structures under this contract. Submit evidence of qualifications of the corrosion expert including their name and qualifications certified in writing to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager prior to the start of construction. Certification must be submitted giving the name of the firm, the number of years of experience, and a list of not less than five of the firm's installations, three or more years old, that have been tested and found satisfactory.

1.6.3 Services of Corrosion Expert

The "corrosion expert" must make a minimum of three visits to the project site. The first of these visits will include obtaining soil resistivity data, acknowledging the type of pipeline coatings to be used and reporting to the contractor the type of CP required (GACP or ICCP). Once the submittals are approved and the materials delivered, the "corrosion expert" will revisit the site to verify the materials meet submittal requirements, ensure the contractor understands installation practices and that the contractor is capable and qualified to complete the installation.

The "corrosion expert" will be available (but not necessarily be onsite the entire time) during the installation of the CP system to answer questions, approve any changes or additions required during construction, or to provide recommendations as required. The third visit is to complete the training and demonstrations to applicable personnel on proper testing and maintenance techniques and to complete testing the installed CP systems to ensure it has been installed properly and meets adequate CP criteria. An additional visit is required if the One-Year-Warranty-Period-Testing is required.

1.7 DELIVERY, STORAGE AND HANDLING

Storage area for corrosion materials will be designated by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. If materials are not stored in a building, tarps or similar protection must be used to protect material from inclement weather. Resack and add backfill to packaged anodes that are damaged as a result of improper handling or exposure to rain.

1.8 PROJECT/SITE CONDITIONS

1.8.1 Environmental Requirements

1.8.2 Existing Conditions

Prior to start of any onsite construction activities, perform a Preconstruction Survey of the project site with the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager, and take photographs showing existing environmental conditions in and adjacent to the site. Submit a report for the record. Include in the report a plan describing the features requiring protection under the provisions of the Contract Clauses, which are not specifically identified on the drawings as environmental features requiring protection along with the condition of trees, shrubs and grassed areas immediately adjacent to the site of work and adjacent to the contractor's assigned storage area and access route(s), as applicable. The Contractor and the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager will sign this survey report upon mutual agreement regarding its accuracy and completeness. Protect those environmental features included in the survey report and any indicated on the drawings, regardless of interference that their preservation may cause to the work under the Contract.

1.9 WARRANTY

Provide equipment items that are supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Corrosion Control System Description

A corrosion control system consists of several systems which work together to mitigate corrosion on buried or submerged metallic structures. Failure to comply with the requirements of any one of these systems may result in inadequate corrosion control and premature failure of the structure being protected. Each system's guide specifications must be included in the design and installation of a complete corrosion control system and must be adhered to in the design and execution of the corrosion control of a structure being protected. Determination of Need for CP must be made by government requirements and policy directives.

a. Construction Design Requirements (CDR) for protected structures are found in the UFGS for the structure being protected. For water storage tanks refer to Section 33 16 15 WATER STORAGE STEEL TANKS, NACE SP0388, and NACE SP0196, underground storage tanks NACE SP0285, aboveground storage NACE SP0193, fuel storage piping Section 33 52 40 FUEL SYSTEMS PIPING (NON-HYDRANT), aviation fuel piping Section 33 52 43.13 AVIATION FUEL PIPING, leak detection systems Section 33 01 50.31 LEAK DETECTION FOR FUELING SYSTEMS, offshore pipelines NACE SP0607 and ISO 15589-2, offshore structures and NACE SP0176, pipeline casings structures (railroad, highway and water crossing) NACE SP0200 and for well casings NACE SP0186.

b. Coating Systems (CS) are a critical factor in performance of a GACP system. All coatings, including coatings in structure guide specifications and Green Seal (GS) coatings, must be compatible with the structure and the CP system, and have high disbondment capabilities. A high resistance to cathodic disbondment is critical for long term service life of coatings on buried or submerged metallic structures under CP. For paints and coatings refer to Section 09 90 00 PAINTS AND COATINGS, and for discontinuity (Holiday) testing of new protective coatings on conductive substrates refer to NACE SP0188.

c. Mechanical Damage Systems (MDS) such as bedding and rock control barriers normally included in Structure GS may be required by design for some locations. Electrical Isolation is required for all galvanic anode CP systems. For an Electrical Isolation System (EIS) refer to NACE SP0286.

d. An Electrical Continuity System (ECS) of the protected structure is critical to the operation of the CP system. The types of joints such as bonding and couplings are normally included in Structure GS, this is particularly important to nonwelded pipelines to allow sufficient CP current to conduct to the entire structure.

e. Stray Current (Interference) Systems must be considered in design, monitored during construction, and interference testing must be completed during the final testing. Design must consider all other cathodic protection systems which may affect other systems or systems which may affect the project, including foreign systems. All foreign systems must be contacted for information and notification and any joint testing which may be required. Corrosion Coordinating Committees may exist. Reference NACE TPC 11.

f. Pipelines that parallel overhead high voltage AC transmission power systems are subject to induced AC. Induced AC has several potential adverse impacts on the safety of personnel and pipeline integrity. Assuming that these conditions exist, there are several measures that can be taken to mitigate the induced AC present on a pipeline. These induced AC mitigation strategies are detailed in various international standards including NACE SP0177.

g. Galvanic Anode CP Monitoring System is a solution for remote monitoring (and optionally controlling) different kinds of galvanic anode CP applications, mainly to protect underground pipelines used in oil and gas distribution systems, but the same system can be used to monitor other galvanic anode CP applications like tank farms and oil platforms. These Monitoring Systems are detailed in various international standards including NACE TPC 11.

h. When a project is connecting to an existing infrastructure with CP the design must be compatible with the existing structure(s) CP system. Existing structures may have Impressed Current CP (ICCP) Anode Systems using Remote Anode Systems, Deep Anode Systems, Linear Anode Systems, or Distributed Anode Systems. Existing structures may also have Galvanic CP (GACP) Systems which may be distributed or remote. Existing structures might not have CP. They may use alternative methods of corrosion mitigation instead of CP such as Inhibitor System/Internal Corrosion Control. For control of internal corrosion in steel pipelines and piping systems refer to NACE SP0106. Due to the limited voltage and current of galvanic anodes the protected structure must be coated and isolated from other structures.

i. A highly dielectric bonded coating is required to attain adequate CP. Unbonded coatings block the protective current from the pipeline or structure and must not be used with CP. Failure to isolate other metallic structures will result in loss of protection. Isolation from other metallic structures must be maintained.

j. Continuity of the structure with low resistance is crucial to proper operation of a galvanic anode system. All joints must be continuous or be bonded to both sides of the joint.

k. A conductive electrolyte is required to allow current flow from the galvanic anodes. Use of galvanic anode systems are normally restricted to electrolytes with resistivities below 30,000 ohm-cm. Small well coated structures such as coated valves, tees and elbows have very high resistance to earth in high resistance soils. Galvanic anodes in electrolytes over 30,000 ohms also have very high resistance to earth. High circuit resistance with the low voltage of galvanic anodes will not allow sufficient current to meet instant off or depolarization criteria. Additional anodes under these conditions will not noticeably increase the current applied to the structure. Reference SP0169 for criteria in high resistance electrolytes.

2.1.2 Design Requirements

2.1.2.1 Electrical Isolators

Isolators are required to isolate the protected structure or pipes from any other structure. Provide isolators at all locations where the indicated protected structure or pipes contact any other metallic structure. Provide locations and detailed drawings of required installations. Include any requirements for lightning protection, test stations, surge protection, or other requirements and include locations and details in design drawings.

2.1.2.2 Anode and Bond Wires

Provide magnesium anodes at uniform distances along the metallic pipelines as required. Use test stations for these anodes as required. Provide these anodes in addition to anodes for the pipe under concrete slab and casing requirements. For each cathodic system, provide metallic components and structures that are electrically continuous by installing bond wires between the various structures. Bonding of existing buried structures may also be required to preclude detrimental stray current effects and safety hazards. Return stray current to its source without damaging structures intercepting the stray current. Provide electrical isolation of underground facilities in accordance with acceptable industry practice. All tests must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

2.1.2.3 Surge Protection

Install approved zinc grounding cells or sealed weatherproof lightning and surge arrestor devices across isolation flanges or fittings installed in underground piping as indicated on the drawings. Provide gapless, self-healing, solid state type arrestor. Provide zinc anode composition conforming to ASTM B418, Type II. Provide number 4 AWG copper lead wires with High Molecular Weight Polyethylene (HMWPE) insulation. Zinc grounding cells must be prepackaged in backfill install as detailed on the drawings. Lightning arrestors or zinc grounding cells are not required for isolation flanges on metallic components used on non-metallic piping systems.

2.1.2.4 Non-metallic Pipe System

In the event pipe other than metallic pipe is approved and used in lieu of metallic pipe, protect all metallic components of this pipe system with CP. Submit detailed drawings of CP for each component to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager for approval within 45 days after date of receipt of notice to proceed, and before commencement of any work.

2.1.2.5 Coatings

Provide coatings for metallic components as required for metallic fittings. Complete and test protective coating on each metallic component (such as valves, hydrants and fittings). Provide coating as required for underground metallic pipe. Each test must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Select, apply, and inspect coatings as specified in these specifications. The use of non-metallic pipe does not change other requirements of the specifications. Submit any deviations due to the use of non-metallic pipe for approval.

2.1.2.6 Tracer Wire

When a non-metallic pipeline is used to extend or add to an existing metallic line, exothermic-weld No. 8 AWG copper wire with THHN insulation to the existing metallic line and run the length of the new non-metallic line. Use this wire as a locator tracer wire and to maintain continuity to any future extensions of the pipeline.

2.1.2.7 Drawings

Submit six copies of detail drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, contractor's modifications, results of system design calculations including soil-resistivity, installation instructions and certified test data showing location of anodes and stating the maximum recommended anode current output density. Include in the detail drawings complete wiring and schematic diagrams, isolation fittings, test stations, permanent reference electrodes and bonding and any other details required to demonstrate that the system has been coordinated and will function properly as a unit. Reference locations to two permanent facilities or mark points. Provide one electronic PDF copy and digital photos of the completed installation.

2.1.2.8 Summary of Services Required

Include the following scope of services:

a. Close-interval potential surveys,

b. CP Installation System,

c. System testing,

d. Casing corrosion control,

e. Interference testing,

f. Training,

g. Operating and maintenance manual,

h. Isolation testing and bonding testing,

i. Coating and holiday testing.

2.1.2.9 Tests of Components

Perform a minimum of four tests at each metallic component in the piping system. Two measurements must be made directly over the anodes and the other two tests must be over the outer edge of the component, but at the farthest point from the anodes. Provide a field drawing showing the component, the structure, all components of the CP system and their relationship to each other. Also provide a narrative describing how the CP system will work and the testing at each component. Components requiring CP must include but not be limited to the following:

a. Pipes beneath the floor slab or foundations.

b. Post Indicator Valve (PIV).

c. Shutoff valves.

d. Metallic pipes extended from aboveground locations.

e. Connectors or change-of-direction devices.

f. Metallic pipe components or sections.

g. Backflow preventers.

h. Culverts.

i. Casings.

2.1.2.10 Electrical Potential Measurements

Make all potential tests at a minimum of 10 foot intervals witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Provide submittals identifying test locations on separate drawings, showing all metal to be protected and all CP equipment. Distinguish and identify test points, equipment, and protected metal.

2.1.2.11 Typical Metallic Components on Non-metallic Systems

2.1.2.11.1 Metallic Components

As a minimum, protect each metallic component with two galvanic anodes. This number of anodes is required to achieve minus 850 millivolts "instant off" potential on the metallic area and at the same time not provide overvoltage above 1200 millivolts "instant off." As a minimum, the galvanic anode unpackaged weight must be as required. Locate the galvanic anodes on each side of the metallic component and route through a test station.

2.1.2.11.2 Fire Hydrants

Provide fire hydrant pipe components with a minimum of two anodes.

2.1.2.11.3 Pipe Beneath Concrete Slab

Pipe beneath concrete slab must have galvanic anodes as required. These galvanic anodes must have an unpackaged weight as required. Pipe beneath concrete slab must have permanent reference electrodes located beneath the slab. Locate one permanent reference electrode where the pipe enters the concrete slab. Route all conductors to a test station.

2.1.2.11.4 Valves

Protect each valve with galvanic anodes as required. The galvanic anode must have an unpackaged weight as required.

2.1.2.11.5 Metallic Pipe Component or Section

Protect each section of metallic pipe with galvanic anodes as required. The galvanic anodes must have an unpackaged weight as required.

2.1.2.11.6 Connectors or Change-of-Direction Devices

Protect each change-of-direction device with galvanic anodes as required. The galvanic anode must have an unpackaged weight as required.

2.1.2.12 Metallic Component Coating

Coatings for metallic components will be required for metallic fittings as indicated. These metallic fittings will include fire hydrants, tees, elbows, and valves. Coatings must be selected, applied, and inspected as specified in the coating specifications referenced and be compatible with the structure being protected. All coatings must be in accordance with all applicable Federal, State, and local regulations. Unbonded coatings must not be used with CP.

2.1.2.13 Location of Test Stations

Provide test stations of the type and location shown and mount. Provide buried isolation joints with test wire connections brought to a test station. Reference all test stations with GPS coordinates. Unless otherwise shown, locate other test stations as follows:

a. At 1,000-foot intervals or less.

b. Where the pipe or conduit crosses any other metal pipe.

c. At both ends of casings under roadways and railways.

d. Where both sides of an isolation joint are not accessible above ground for testing purposes.

2.1.2.14 Electrical Isolation of Structures

As a minimum, provide isolating flanges or unions at the following locations:

a. Connection of new metallic piping or components to existing piping.

b. Pressure piping beneath floor slab to a building.

Provide isolation at metallic connection of all lines to existing system and where connecting to a building. Additionally, provide isolation between water or gas line; and foreign pipes that cross the new lines within 10 feet. Install isolation fittings, including isolating flanges and couplings, aboveground or in a concrete pit.

2.1.2.14.1 Gas Distribution Piping

Provide electrical isolation at each building riser pipe to the pressure regulator, at all points where a short to another structure or to a foreign structure may occur, and at other locations as indicated on the drawings.

2.1.2.14.2 Isolation Joint Testing

An isolator checker or insulation tester will be used for isolation or insulating joint (flange or dielectric) electrical testing.

2.1.2.14.3 Underground Structure Coating

This coating specification takes precedence over any other project specification and drawing notes, whether stated or implied, and also applies to the pipeline or tank supplier. Variance in coating quality is not allowed by the contractor or Base Construction Representative without the written consent of the designer. All underground metallic pipelines and tanks to be cathodically protected must have a high quality factory-applied coating. This includes all carbon steel, cast-iron and ductile-iron pipelines or vessels. Select, apply, and inspect coatings as specified. If non-metallic pipelines are installed, coat all metallic fittings on pipe sections in accordance with this specification section.

a. The nominal coating thickness for the metallic pipe joint or other component coating must be 16 mils, plus or minus 5 percent.

b. Apply pipe and joint coating for factory applied or field repair material as recommended by the manufacturer. Coating must be one of the following:

    (1) Continuously extruded polyethylene and adhesive coating system.
    (2) Polyvinyl chloride pressure-sensitive adhesive tape.
    (3) High density polyethylene/bituminous rubber compound tape.
    (4) Butyl rubber tape.
    (5) Coal tar epoxy.

2.1.2.14.4 Field Joints

Coat all field joints with materials compatible with the pipeline coating compound. Apply the joint coating material to an equal thickness as the pipeline coating. Do not use unbonded coatings for these buried metallic components. This includes the elimination of all unbonded polymer wraps or tubes. Once the pipeline or vessel is set in the trench, conduct an inspection of the coating. This inspection must include electrical holiday detection. Repair any damaged areas of the coating. The Contracting Officer or the Contracting Officer's Representative, Technical Expert or Project Manager must be asked to witness inspection of the coating and testing using a holiday detector.

2.1.2.14.5 Inspection of Pipe Coatings

Any damage to the protective coating during transit and handling must be repaired before installation. After field coating has been applied, inspect the entire pipe using an electric holiday detector in accordance with NACE SP0188 using a full-ring, spring-type coil electrode. The holiday detector must be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Upon detection, immediately repair all holidays in the protective coating. Occasional checks of holiday detector, operation will be made by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager to determine suitability of the detector. Provide all labor, materials, and equipment necessary for conducting the inspection.

2.1.2.14.6 Protective Coating for Aboveground Piping System

Provide finish painting conforming to the applicable paragraph of Section 09 90 00 PAINTS AND COATINGS and as follows:

2.1.2.14.7 Ferrous Surfaces

Touch-up shop-primed surfaces with ferrous metal primer. Solvent-clean surfaces that have not been shop-primed. Surfaces that contain loose rust, loose mill scale, and other foreign substances must be mechanically-cleaned by power wire-brushing and primed with ferrous metal primer. Finish primed surface with two coats of exterior oil paint and vinyl paint.

2.1.3 Performance Requirements

The design must allow for synchronized interruption of all applied current.

2.1.3.1 Criteria of Cathodic Protection

The design must allow for synchronized interruption of all applied current. All galvanic anode leads, or header cables, must be connected to the protected structure through test stations or junction boxes and must never be connected directly to the protected structure.

a. Determination of the on and polarized (instant off) potentials must be made with the protective current applied to the structure, tank, or pipeline for a minimum of 2. Polarized potentials may be determined using a coupon test station (Error-Free (IR Free) test station). Polarized potentials must be determined by interrupting all the current being applied to the structure or coupon.

b. The potential measurements for the native measurement and the polarized potential must be made with the reference electrode at the same exact location. The polarization decay measurements must also be made with the reference electrode at the same exact location as the polarization potential.

c. The polarization decay measurements will be the difference between the polarized potential and a voltage measurement made 48 hours after the interruption of protective current.

2.1.3.1.1 Steel

A negative polarized potential of 0.85 volts (850 millivolts) or more negative. The voltage must not be more negative than a negative polarized potential of 1.200 volts (1200 millivolts).

2.1.3.1.2 Aluminum

Aluminum underground component must not be protected to a potential more negative than minus 1200 millivolts, measured between the underground component and a saturated copper/copper sulfate reference electrode contacting the earth, directly over the metallic component. Resistance, if required, must be inserted in the anode circuit within the test station to reduce the potential of the aluminum to a value which will not exceed a potential more negative than minus 1200 millivolts. Voltage shift criterion must be a minimum negative polarization shift of 100 millivolts measured between the metallic component and a saturated copper/copper sulfate reference electrode contacting the earth, directly over the metallic component. The polarization voltage shift must be determined as outlined for iron and steel.

2.1.3.1.3 Copper Piping

For copper piping, the following criteria must apply: A minimum of 100 millivolts of cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The polarization voltage shift must be determined as outlined for iron and steel.

2.2 EQUIPMENT

2.2.1 Remote Monitoring

Remote monitoring equipment must be designed, manufactured and procured specifically for cathodic protection use and must be provided as per design and drawings to monitor potential (requires permanent reference electrode), bond(s), interference bond and/or test station(s) shunts as required and must match or be compatible with previously installed remote monitoring equipment in use at the installation.

2.2.2 Corrosion Rate Monitoring

Corrosion probes must be designed, manufactured and procured specifically for the application and matched to the structure being protected. Manufacturer must match or be compatible with previously installed rate monitoring equipment in use at the installation.

2.2.3 Polarization Cell Replacement (PCR) and (PCRH) for Hazardous Locations

PCRs and PCRHs must be designed, manufactured, and procured specifically for the application and must exceed the modeled AC steady-state current and fault conditions. For Hazardous locations, the PCRH model must be used.

Characteristic	**PCR**	**PCRH**
AC steady-state current, rms	45A, 80A	45A
AC fault current, rms. at 0.5s	3.7 kA to 15 kA	3.7 kA to 15 kA
Lightning current, 8x20 micros, peak	100 kA	100 kA
Hazardous location certification	Division 2, Zone 2	Division 1, Zone 1
Rain Proof, IP66	Yes	Yes
Submersible, IP68 or NEMA 6P	Optional	No

PCRs must be installed with a protective ground-based enclosure to secure the cable connections and prevent electrical hazards. The PCRH must be installed with an explosion-proof enclosure and must be mounted. Structure and Grounding conductors must be properly sized for the application.

AC Fault Current Rating	Minimum Wire Size (AWG)	Minimum Wire Size (Metric)
1.2 kA, 2kA, 3.7 kA	#6	$16mm^2$
5kA 9kA 10kA	#2	$35mm^2$
14kA 15kA	#2/0	$70mm^2$

2.2.4 Solid State Decoupler (SSD)

SSDs must be designed, manufactured, and procured specifically for the application and must exceed the modeled AC steady-state current and fault conditions. For Hazardous locations, the PCRH model must be used. SSDs must be installed with a protective ground-based enclosure to secure the cable connections and prevent electrical hazards.

Characteristic	SSD
AC steady-state current, rms	45A
AC fault current, rms. at 0.5s	1.2 to 5 kA
Lightning current, 8x20micros, peak	75-100 kA
Hazardous location certification	Division 2, Zone 2
Rain Proof, IP66	Yes
Submersible, IP68 or NEMA 6P	Yes

2.3 COMPONENTS

2.3.1 Test Stations

2.3.1.1 Flush Mounted

NEMA ICS 6. Metallic or non-metallic with terminal board, 6 terminal posts and lockable lid. A non-metallic enclosure must be molded of glass filled polycarbonate and urethane coated or Acrylonitrile Butadiene Styrene (ABS) plastic and mounted on a 18 inch length of PVC conduit. The unit must be of standard design, manufactured for use as a CP test station, complete with cover, terminal board, shunts, and brass or Type 316 stainless steel hardware. The terminal board must be removable for easy access to wires. Provide traffic valve box capable of withstanding H-20 traffic loads. The cover must have a cast in legend "CP TEST."

2.3.1.2 Post Top Mounted

NEMA ICS 6. Metallic or non-metallic with terminal board, 6 terminal posts and lockable lid. A non-metallic enclosure must be high impact strength molded plastic. The unit must be of standard design, manufactured for use as a CP test station, complete with cover, terminal board, shunts, and brass or Type 316 stainless steel hardware. The terminal board must be removable for easy access to wires. The test station must be mounted atop 6 foot long polyethylene conduit with anchor. Terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, and reference electrodes).

2.3.1.3 Wall Mounted

NEMA ICS 6, Type 4X enclosure with Type 316 stainless steel hinges and clamped or latched cover and padlocked hasp. Enclosure will be of painted steel construction with terminal board and labeled with nameplate. Provide nameplate in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Enclosure mounting posts must be galvanized steel pipe, schedule 40 , as indicated. Mount enclosure 42 inches above finished grade as indicated. Terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, and reference electrodes).

2.3.1.4 IR-Free Test Station

Must be flush, post top, or wall mounted test station to include coupon of the same material as the structure, shunt, permanent reference electrode with means of momentary isolation of the coupon with provided circuitry designed, manufactured and procured exclusively for CP instant off testing of a cathodically protected structure. Must be waterproof if used in flush test stations.

2.3.2 Shunts for Test Stations and Junction Boxes

[MIL-I-1361.] [0.1] [0.01] [_____] ohm, [2] [8] ampere, accuracy plus or minus one percent, polycarbonate circuit board type, color coded for value recognition [red for 0.1 ohm shunt] [yellow for 0.01 ohm shunt] with nickel-plated brass posts and standard 0.25 inch inch holes on [2.54] cm [1] inch centers to fit test stations and terminal boards [0.01 ohm 6] ampere, accuracy plus or minus one percent, manganin wire type.

2.3.3 Junction Box Enclosures

NEMA ICS 6, Type [3R] [4X] [_____] enclosure with [clamped cover] [Type [304] [316] stainless steel hinges and [clamped] [latched] cover] [and padlocked hasp]. Enclosure must be of [galvanized steel] [painted steel] [aluminum] [fiberglass] [non-metallic] construction with terminal board. Knockout for conduit must be the size and location as per design drawings.

2.3.3.1 Nameplates

Provide nameplate in accordance with Section26 20 00 INTERIOR DISTRIBUTION SYSTEM and ASTM D709. Provide laminated plastic nameplates for each enclosure as specified or as indicated on the drawings. Each nameplate inscription must identify the function. Nameplates will be melamine plastic, 0.125 inch thick, white with [black] [_____] center core. Surface will be matte finish. Corners will be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 25 inch by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.3.4 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic [1/8] [1/4] [_____] inch thick with dimensions as indicated. Insulated terminal boards must have the required number of terminals (one terminal required for each conductor). Install solderless copper lugs and copper buss bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, reference electrodes and coupons).

2.3.5 Anode Junction Boxes

2.3.5.1 Enclosure

NEMA ICS 6, Type [3R] [4X] [_____] enclosure with [clamped cover] [Type [304] [316] stainless steel hinges and [clamped] [latched] cover] [and padlocked hasp]. Enclosure must be of [galvanized steel] [painted steel] [aluminum] [fiberglass] [non-metallic] construction with terminal board and labeled with nameplate. Provide nameplate in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3.5.2 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic [1/8] [1/4] [_____] inch thick with dimensions as indicated. Insulated terminal boards must have the required number of terminals (one terminal required for each conductor). Install solderless copper lugs and copper buss bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, and reference electrodes).

2.4 MATERIALS

2.4.1 Galvanic Anodes

2.4.1.1 Dimensions and Weights

Bare anode weight [9] [17] [20] [32] [_____] pounds not including core.

2.4.1.2 [High Potential] [Standard] Magnesium Anodes

Install a minimum of [2] [3] [10] [12] [_____] anodes on the [Pipe] [Tank] [_____] system. See Paragraph METALLIC COMPONENTS ON NON-METALLIC SYSTEMS AND TYPICALS for additional anodes under slab.

2.4.1.2.1 Anode Composition

Anodes must be of high-potential magnesium alloy, made of primary magnesium obtained from sea water or brine, and not made from scrap metal. Magnesium anodes must conform to ASTM B843 and to the following analysis (in percent) otherwise indicated:

Aluminum	0.010 percent
Manganese	0.50 to 1.30 percent max
Zinc	0.05 percent max
Silicon	0.05 percent max
Copper	0.02 percent max
Nickel	0.001 percent max
Iron	0.03 percent max
Other impurities	0.05 each or 0.3 percent max total
Magnesium	Remainder

Furnish spectrographic analysis on samples from each heat or batch of anodes used on this project.

2.4.1.2.2 Dimensions and Weights

The following dimensions and weights of anodes are not all inclusive and are presented as examples, various manufacturers may have additional sizes not included in the following table:

a. Bare anode weight: [[9] [17] [20] [32] [_____] pounds] [not including core].

Typical Magnesium Anode Size (may be round, square, or D shaped)													
Nominal Weight Bare		**Approximate Size**						**Packaged Weight**		**Nominal Packaged Dimensions**			
		Width		**Height**		**Length**				**Diameter**		**Length**	
kg	**lbs**	**mm**	**inch**	**mm**	**inch**	**mm**	**inch**	**kg**	**lbs**	**mm**	**inch**	**mm**	**inch**
	1		1.75		1.75		8		5		3.25		9
	3		3.5		3.75		5		8		6		10
	5		3.5		3.75		8.5		17		6		12
	9		2.75		3		27	15.9	35		5.5		32
	9		3.5		3.75		14		27		6		17
	17		2.75		2.75		50.25		60		6		55

Typical Magnesium Anode Size (may be round, square, or D shaped)													
Nominal Weight Bare		Approximate Size						Packaged Weight		Nominal Packaged Dimensions			
	17		3.5		4		25.75		45		6.5		29
	20		2.75		3.75		59.75		70		5		66
	32		3.5		3,75		45.25		91		6.5		53
	32		5.5		5		20.5		70		8		28
	40		3.5		3.75		59.75		96		6.5		66
	48		5.5		5.75		31		100		8		38
	60		4		4		60		125		7		64

2.4.1.2.3 Packaged Anodes

Provide anodes in packaged form with the anode surrounded by specially-prepared quick-wetting backfill and contained in a water permeable cloth or paper sack. Anodes must be centered by means of spacers in the backfill material.

The backfill material will have the following composition, unless otherwise indicated:

Material	Approximate Percent by Weight
Gypsum	75
Bentonite	20
Sodium Sulfate	5
Total	100

2.4.1.3 [Cast] [Wrought] Zinc Anodes

[ASTM B418, Type [I] [II].] [ASTM F1182.] [MIL-A-18001] Bare anode weight: [5] [30] [_____] pounds [not including core].

Bare Weight		Width		Height		Length		Total Packaged Weight	
kg	pounds	mm	inches	mm	inches	mm	inches	kg	pounds
	5		1.4		1.4		10		20
	12		1.4		1.4		24		40
	15		1.4		1.4		30		50
	15		2.0		2.0		15		36

Bare Weight		Width		Height		Length		Total Packaged Weight	
kg	pounds	mm	inches	mm	inches	mm	inches	kg	pounds
	18		1.4		1.4		36		55
	30		1.4		1.4		60		86
	30		2.0		2.0		30		67
	45		2.0		2.0		45		100
	60		2.0		2.0		60		120

2.4.1.3.1 Anode Composition

Chemical composition as follows:

Zinc	[4.5] [_____] percent maximum
Indium	[0.02] [_____] percent maximum
Silicon	[0.01] [_____] percent maximum
Aluminum	Remainder

2.4.1.4 Aluminum Anodes

2.4.1.4.1 Anode Composition

Chemical composition as follows:

Zinc	[4.5] [_____] percent maximum
Indium	[0.02] [_____] percent maximum
Silicon	[0.01] [_____] percent maximum
Aluminum	Remainder

2.4.1.4.2 Dimensions and Weights

Anode Weight [_____] pounds not including core.

2.4.1.4.3 Anode Core

Iron [galvanized steel] rod [pipe] [strap] [_____], [1/8] [1/4] [1/2] inch diameter [_____] by [_____].

2.4.2 Wire and Cable

2.4.2.1 Anode Lead Wire

Wire must be No. 12 AWG solid copper wire, not less than 10 feet long, without any splices, complying with NFPA 70, Type Thermoplastic Heat and Water-resistant Nylon-coated (THHN) THHN Rubber Heat (resistant) Wire (RHW) insulation. Connecting wires for magnesium anodes will be factory installed with the place or emergence from the anode in a cavity-sealed flush with a dielectric sealing compound. Connecting wires for zinc anodes must be factory installed with the place of connection to the protruding steel core completely sealed with a dielectric material.

2.4.2.2 [Bolted] [Welded] Connected Anodes

[UL 83, Type [THWN] [THHN]] [ASTM D1248, Type HMWPE] [UL 44, Type RHW], [solid] [stranded] copper conductors, not less than [No. 12] [_____] AWG, [10] [20] [_____] feet long, [of sufficient length to extend to the accompanying junction box without splicing]. Anode lead wire will be factory installed. [Silver solder the lead wire to the anode core, and seal the soldered connection and recessed end of the anode with an [asphaltic] [epoxy] dielectric sealing compound.] [Silver solder the lead wire to the protruding anode core, and completely seal the soldered connection with an [asphaltic] [epoxy] dielectric material.] Dielectric material must extend past the connection and cover the lead wire insulation by not less than 1/2 inch. [Cover the connection with heat-shrinkable tubing.]

2.4.2.3 Anode Header Cable

Cable for anode header and distribution will be No. [_____] AWG stranded copper wire with type CP HMWP, 7/64 inch thick insulation, 600-volt rating.

2.4.2.4 Structure (Negative) Cable

Structure connecting wire must be No. [4][2][_____] AWG stranded copper wire with type [THHN] [THWN] [PVC] [TW] [RHW] [polyethylene] [CP high molecular weight insulation, 7/64 inch thick] [polyethylene] insulation, 600 volt rating. Copper conductors conforming to ASTM B3 and ASTM B8.

2.4.2.5 Test Wires

Test wires must be No. 12 AWG stranded copper wire with NFPA 70 Type Thermoplastic Wire (TW) or RHW or polyethylene insulation. Copper conductors conforming to ASTM B3 and ASTM B8.

2.4.2.6 Joint and Continuity Bond Cables

Provide bonds across joints or any electrically discontinuous connections in the piping, and other pipes and structures with other than welded or threaded joints included in this CP system. Unless otherwise specified, bonds between structures and across joints in pipe with other than welded or threaded joints must be with No. 4 AWG stranded copper cable with polyethylene insulation. Bonds between structures must contain sufficient slack for any anticipated movement between structures. Bonds across pipe joints must contain a minimum of 4 inch of slack to allow for pipe movement and soil stress. Bonds must be attached by exothermic welding. Exothermic weld areas must be insulated with coating compound and approved by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Continuity bonds must be installed as necessary to reduce stray current interference. Additional joint bonding must be done where determined during construction or testing or as directed. Joint bonding must include excavation and backfilling. There must be a minimum of 2 continuity bonds between each structure and other than welded or threaded joints. Electrical continuity must be tested across joints with other than welded or threaded joints and across metallic portions of sewage lift stations and water booster stations. Copper conductors conforming to ASTM B3 and ASTM B8.

2.4.2.7 Resistance Bond Wires

Resistance bonds must be adjusted for minimum interference while achieving the criteria of protection. Alternate methods may be used when approved.

2.4.2.8 Polyethylene Insulation

Polyethylene insulation must comply with the requirements of ASTM D1248 and of the following types, classes, and grades:

2.4.3 Cable and wire Identification Tags

[Laminated plastic material with black letters on a yellow background] [[Brass] [Stainless steel] material with engraved letters]. Print letters and numbers a minimum of 3/16 inch in height. Provide identifier legend [in accordance with the drawings] [_____].

2.4.4 Anode Connection

2.4.4.1 End-Connected Anode

[Drill] [Cast] a recess [6] [_____] inches deep in one end of the anode. Attach the lead wire to the anode with an anchor device. Not more than 1/2 inch of bare wire must protrude from the anchor device. Attachment must withstand a 325 pound pull without loosening the wire or anchor device. Fill the recess with an epoxy sealing compound [, leaving sufficient space for a plug]. [Provide non-metallic plug flush with the anode end surface.] [Install a heat-shrinkable anode cap over the attachment. Cap must extend not less than 2 1/2 inches on the lead wire and 3 inches on the anode.] Cable-to-anode contact resistance must not exceed 0.02 ohms.

2.4.4.2 Center-Connected Anode

Attach the lead wire to the center of the anode with an anchor device suitably fastened to the wire. Not more than one inch of bare wire must protrude from the anchor device. Encapsulate [each side of] the connection point with [a minimum of 6 inches [_____] of] high voltage insulating compound mastic and 4 inches [_____] of epoxy resin. Attachment must withstand [900] [1500] [_____] pounds pull without loosening the wire or anchor device. Provide a non-metallic [plug flush with the anode end] [end cap] to prevent chaffing of the anode lead wire. Cable-to-anode contact resistance must not exceed 0.02 ohms.

2.4.5 AC Mitigation Materials

If required, AC mitigation materials typically consist of a mitigation material either zinc ribbon or copper cable, interconnecting coated copper cables, solid state decouplers to control the AC current flow and test stations.

2.4.6 Backfill Material

The backfill material must have the following composition, unless otherwise indicated:

Material	Approximate Percent by Weight
Gypsum	75
Bentonite	20
Sodium Sulfate	5
Total	100

2.4.7 Permanent Reference Electrodes

Permanent reference electrodes must be [copper/copper-sulfate] [silver silver-chloride] [zinc] [Hydrocarbon-Proof Palladium (Pd/$PdCl_2$)] specifically manufactured for [underground] [submersible] [_____] use, [1 1/4] [_____] inch diameter, by [8] [10] [_____] inches long, [plastic [_____] tube with an ion trap to minimize contamination of the electrode] [, and a minimum surface sensing area of [_____] square inches]. Must never need recharging, maintenance, or recalibration. Must have impregnated membrane which keeps electrode electrolytes from drying out or getting the reference electrode electrolyte contaminated. Must have ion trap to prevent reference electrode damage from hydrogen sulfide or excess chloride ions. [The electrode will be prepackaged by the manufacturer with a backfill material as recommended by the manufacturer.] Provide electrodes with No. [10] [12] [_____] AWG, [RHW] [THHN] [_____] cable of sufficient length to extend to the [test station] [junction box] [rectifier] without splicing. Reference electrodes will have a minimum 20-year life, stability of plus or minus 5 millivolts under 3 microamp load. The manufacturer must calibrate the PRE to 316 mV plus or minus 10mV referenced to a standard hydrogen electrode (SHE) and provide a calibration certificate detailing the results of the calibration. Procedures for evaluating the accuracy annually must be included in the Operation and Maintenance Manual.

2.4.8 Pavement Inserts

Pavement insert must be a non-metallic flush type test station without terminal board, and must allow a copper/copper sulfate reference electrode to contact the electrolyte beneath the pavement surface. [Provide traffic valve box capable of withstanding [H-20] [_____] traffic loads.]

2.4.9 Coupons

Coupons must match the material of the structure, with [1] [2] integrated connection(s) with electrical wire(s) and be designed, manufactured and procured for use as a corrosion coupon, IR-Free reference electrode, or AC reading electrode.

2.4.10 Zinc Grounding Cells

Two Zinc [Type II] [Type I] anodes separated with 1 inch isolating spacers. Minimum 10 feet of #6 AWG HMWPE CP cable crimped securely to each anode. Both anodes centered in one cloth bag and surrounded with low resistance backfill mixture consists of 75 percent hydrated gypsum, 20 percent bentonite, and 5 percent sodium sulfate.

Element	Content Percent	
	MIL-A-18001 ASTM B418 Type I	**ASTM B418 Type II**
Al	0.1 - 0.5 percent	0.005 percent max
Cd	0.02 - 0.07 percent	0.003 percent max
Fe	0.005 percent max	0.0014 percent max
Pb	0.006 percent max	0.003 percent max
Cu	0.005 percent max	0.002 percent max
Zinc	Remainder	Remainder

Bare Weight		Width		Height		Length		Total Packaged Weight	
kg	pounds	mm	inches	mm	inches	mm	inches	kg	pounds
	5		1.4		1.4		10		20
	12		1.4		1.4		24		40
	15		1.4		1.4		30		50
	15		2.0		2.0		15		36
	18		1.4		1.4		36		55
	30		1.4		1.4		60		86
	30		2.0		2.0		30		67
	45		2.0		2.0		45		100
	60		2.0		2.0		60		120

2.4.11 Isolation Flange Kits

Provide full-faced gaskets, isolating sleeves and washers, and steel washers. Provide isolation flange kits rated for operation at the rated pressure and temperature.

2.4.11.1 Gaskets

ASME B16.21. [Neoprene faced phenolic] [Laminated phenolic] material for operation at [_____] psi, [450] [_____] degrees F.

2.4.11.2 Isolating Washers and Sleeves

Two sets 1/8 inch [laminated phenolic] [_____] for operation at [450] [_____] degrees F. Isolating washers must fit within the bolt facing on the flange over the outside of the fabric reinforced phenolic sleeve.

2.4.11.3 Washers

Steel, cadmium plated, to fit within the bolt facing on the flange.

2.4.12 Steel Flanges and Bolting

2.4.12.1 Steel Flanges

ASME B16.5, [150 lb.] [300 lb.].

2.4.12.2 Bolting

ASTM A307, Grade B for bolts; ASTM A194/A194M, Grade 2 for nuts. Dimensions: ASME B18.2.1 for bolts, ASME B18.2.2 for nuts. Threads: ASME B1.1, Class 2A fit for bolts, Class 2B fit for nuts. Bolts must extend completely through the nuts and may have reduced shanks of a diameter not less than the diameter at the roof of threads.

2.4.13 Dielectric Unions

ASME B16.39, Class [1] [2] for dimensional, strength, and pressure requirements. Insulation barrier must limit galvanic current to one percent of the short-circuit current in a corresponding metallic joint. Provide insulating material impervious to [water] [oil] [gas].

2.4.14 Isolation and End Seals

2.4.14.1 Casing Isolator/Centralizer

[High density (linear), injection molded virgin Polyethylene] [Polycarbonate Hi-Temp isolators/spacers rated for service at least 280 degrees F [or more]] [High Grade Thermoplastic] positive electrical isolation, high abrasion resistance and low coefficient of friction.

2.4.14.2 End Seals

Ethylene Propylene Diene Monomer (EPDM) Neoprene rubber end seals, thickness of 1/8 inch or more, with [2] [4] Stainless Steel Pipe Clamps per end seal, 1/8 inch thick and 1/2 inch wide or more.

2.5 ACCESSORIES

2.5.1 Conduit

[UL 6, rigid galvanized steel], [Outlet boxes: UL 514A and fittings UL 514B, threaded hubs]. [Metallic conduit and fittings to be PVC coated in accordance with NEMA RN 1, Type A40], [NEMA TC 2, Type EPC-40-PVC]. Non-metallic conduit must conform to NEMA TC 2.

2.5.2 Joint, Patch, Seal, and Repair Coating

Sealing and dielectric compound must be a black, rubber based compound that is soft, permanently pliable, tacky, moldable, and unbacked. Compound will be applied as recommended by the manufacturer, but not less than 1/2-inch thick. Coating compound must be [cold-applied coal-tar base mastic] [hot-applied coal-tar enamel]. Pressure-sensitive vinyl plastic electrical tape and rubber insulated tape must conform to UL 510.

2.5.3 Underground Splices

Provide splices with a compression connector on the conductors, and insulation and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.5.3.1 Cast-Type Splice

Provide cast-type splice insulation by means of molded casting process employing a thermosetting epoxy resin insulating material applied by a gravity poured method or pressure injected method. Provide component materials of the resin insulation in a packaged form ready for convenient mixing without removing from the package.

2.5.3.2 Gravity-Poured Splice

Gravity-poured method must employ materials and equipment contained in and approved commercial splicing kit which includes a mold suitable for the cables to be spliced. When the mold is in place around the joined conductors, prepare the resin mix and pour into the mold.

2.5.3.3 Heat Shrinkable Splice

Provide [heavy wall] heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which must be applied by a clean burning propane gas torch.

2.5.4 Electrical Isolation of Structures

2.5.4.1 Electrically Isolating Pipe Joints

Electrically isolating pipe joints will be of a type that is in regular factory production.

2.5.4.2 Electrically Isolating Couplings

Electrically isolating couplings will be of a type that has a published maximum electrical resistance rating given in the manufacturer's literature. Cradles and seals will be of a type that is in regular factory production made for the purpose of electrically isolating the carrier pipe from the casing and preventing the incursion of water into the annular space.

2.5.5 Electrical Insulating Coating

[Heat-shrinkable tape] [Conformable watertight sealant having dielectric strength not less than 15 kV for a 1/8 inch thick layer].

2.5.6 Buried Cable Warning and Identification Tape

Polyethylene tape, manufactured for warning and identification of buried cable and conduit. Tape must be [3] [_____] inches wide, [Yellow] [_____] in color and read "Caution Buried Cable Below" or similar. Color and lettering must be permanent and unaffected by moisture or other substances in backfill materials.

2.5.7 Electrical Connection to Structures

2.5.7.1 Exothermic Welds

Electrical connections to metallic structures must be made using exothermic welds in strict accordance with the manufacturer's recommendations.

2.5.7.2 Electrical-Shielded Arc Welds

Electrical-shielded arc welds must be approved for use on steel pipe by shop drawing submittal action.

2.5.7.3 Brazing

Brazing will be as specified by manufacturer using specialized equipment designed for that purpose.

2.5.8 Electrical Tape

Pressure-sensitive vinyl plastic electrical tape and rubber insulated tape must conform to UL 510.

2.5.9 Exothermic Weld Kits

Exothermic weld kits specifically designed by the manufacturer for exothermic welding wires to metallic surfaces. Molds must be for specific type of metallic structure (steel, cast iron), specific diameter of pipe or metallic surface and specific size (AWG)and type of wire (solid, stranded).

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

2.6.1 Non-Destructive Testing of Anodes

Contractor must perform the tests in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. One anode of each type will be chosen at random for non-destructive testing and will be submerged in a container of fresh water for about 30 minutes. Contractor must then measure the anode-to-water potential difference between a calibrated copper/copper sulfate reference electrode. Potential differences must generally be within the following ranges:

Anode Type	**DC Volts to Calibrated Cu/CuSO4 Reference Electrode**
High Potential Magnesium	More Negative than Negative 1.65 Volts DC
Standard Magnesium	More Negative than Negative 1.4 Volts DC
Zinc	More Negative than Negative 1.0 Volts DC
Aluminum	More Negative than Negativee 1.0 Volts DC

Failure of the test anode to conform to this specification can be cause for rejecting all anodes from the same lot as the test anode. The contractor must mark all rejected anodes on the ends with a 6 inch high "X" using yellow spray paint. Failed anodes must be removed from the job site by the end of the day. The contractor must replace any rejected anodes at the contractor's expense. The destructive testing provision must also apply to replacement anodes as well.

2.6.2 Destructive Testing of Anodes

Contractor must perform the tests in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Contractor must include the cost of an additional anode [of each different type] with the longest lead wire for the destructive test in the contractor's bid. One completed [prepackaged] anode of each type with lead wires will be chosen at random for destructive testing and must be submitted to a static pull test. Anode wire connections must have sufficient strength to withstand a minimum tensile load of [300] [_____] pounds. [The anode must be cut into sections or broken with a sledgehammer to verify conformance with this specification. Such items as anode-to-wire connection, complete encapsulation of the wire connector, and wire to anode electrical resistance must be checked.] [Failure of the test anode to conform to this specification can be cause for rejecting all anodes from the same lot as the test anode. The contractor must mark all rejected anodes on the ends with a 6 inch high "X" using yellow spray paint. Failed anodes must be removed from the job site by the end of the day. The contractor must replace any rejected anodes at the contractor's expense. The destructive testing provision will also apply to replacement anodes as well.]

PART 3 EXECUTION

3.1 SAFETY PRECAUTIONS AND HAZARDOUS LOCATIONS

Any personnel performing operations that will generate heat, sparks, or flame in hazardous locations must first perform adequate safety precautions. A trained responsible person must ensure the area is safe to perform the operation. Required actions include ensuring adequate ventilation before work starts, air monitoring, and a fire watch must be provided and remain for 30 minutes after the operation is completed. A minimum of 20 pound ABC type fire extinguisher must be available and must be inspected before each use. Equipment being used must be inspected and used in accordance with manufacturer recommendations. Combustibles that are in the work area(s) must be moved or if they cannot be moved, be covered with fire retardant welding blankets. When performing exothermic welding, properly sized charges and inspection of the structure condition must be accomplished to ensure a safe operation.

3.2 INSTALLATION

3.2.1 Excavation and Trenching

Perform trenching and backfilling in accordance with [Section 31 00 00 EARTHWORK] [_____]. In the areas of the anode beds, all trees and underbrush will be cleared and grubbed to the limits shown or indicated. In the event rock is encountered in providing the required depth for anodes, determine an alternate approved location and, if the depth is still not provided, submit an alternate plan to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Alternate techniques and depths must be approved prior to implementation.

3.2.2 Anode Excavation

a. Excavate hole to a minimum 3 inches larger than the packaged anode diameter, [_____] feet deep.

3.2.3 Lead Wire Trench

b. Excavate lead wire trench to [24] [_____] inches deep, [_____] inches wide.

3.3 ANODES AND LEAD WIRE

3.3.1 Anode Installation

Unless otherwise authorized, installation must not proceed without the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Anodes of the size specified must be installed to the depth indicated and at the locations shown. Locations may be changed to clear obstructions with the approval of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Anodes will be installed in sufficient number and of the required type, size, and spacing to obtain a uniform current distribution over the surface of the structure. The anode system will be designed for a life of 25 years of continuous operation. Anodes must be installed as indicated in a dry condition after any plastic or waterproof protective covering has been completely removed from the water permeable, permanent container housing the anode metal. The anode connecting wire must not be used for lowering the anode into the hole. The annular space around the anode must be backfilled with fine earth in 6 inch layers and each layer must be hand tamped.

3.3.1.1 Single Anodes

Single anodes, spaced as shown, will be [connected] [connected through a test station] to the pipeline, allowing adequate slack in the connecting wire to compensate for movement during backfill operation.

3.3.1.2 Group of Anodes

Groups of anodes, in quantity and location shown, must be connected to an anode header cable. The anode header cable must make contact with the structure to be protected only through a test station. Anode lead connection to the anode header cable must be made by an approved crimp connector or exothermic weld and splice mold kit with appropriate potting compound.

3.4 INSTALLATION DETAILS

3.4.1 Anode Installation

Do not lift or support anode by the lead wire. Where applicable, remove manufacturer's plastic wrap/bag from the anode. Exercise care to preclude damaging the cloth bag and the lead wire insulation. Center the packaged anode in the hole with native soil in layers not exceeding 6 inches. Hand tamp each layer to remove voids taking care not to strike the anode lead wire. When the backfill is 6 inches above the top of the anode, pour at least ten gallons of water into the hole to saturate the anode backfill and surrounding soil. Anodes must not be backfilled prior to inspection and approval by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

3.4.2 Lead Wire Installation

Cover the lead wire trench bottom with a 3 inch layer of sand or stone free earth. Center wire on the backfill layer. Do not stretch or kink the conductor. Place backfill over wire in layers not exceedingsix inches deep. Compact each layer thoroughly. Do not place tree roots, wood scrap, vegetable matter and refuse in backfill. Place cable warning tape within [18] [_____] inches of finished grade, above cable and conduit.

3.4.2.1 Lead Wire Connections

Connect anode lead wire(s) [to the test station terminal board(s)] [directly to the protected structure(s) by use of exothermic weld kit(s). Clean the structure surface by scraping, filing or wire brushing to produce a clean, bright surface. Weld connections using exothermic welding kit(s) in accordance with the kit manufacturer's instructions. Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 2 pound hammer. Cover connections with an electrically insulating coating [which is compatible with the existing coating on the structure]]. The coating must be completely cured before backfilling. Allow sufficient slack in the lead wire to compensate for movement during backfilling operation.

3.4.2.2 Field Drawing

Complete a field drawing of each anode installation showing location of anode, [test station], depth of anode, color and size of anode lead wire and any other pertinent details. Submit copy with daily report to the government.

3.4.2.3 Metallic Underground Pipeline Connection

To facilitate periodic electrical measurements during the life of the sacrificial anode system and to reduce the output current of the anodes, if required, all anode lead wires must be connected to a test station and buried a minimum of 24 inches in depth. The cable must be No. 10 AWG, stranded copper, polyethylene or RHW-USE insulated cable. The cable must make contact with the structure only through a test station. Resistance wire must be installed between the cable and the pipe cable, in the test station, to reduce the current output, if required. Anode connections, except in the test station, must be accomplished by exothermic welding, and must be insulated by means of at least three (3) layers of electrical tape; and all lead wire connections must be installed in a moisture-proof splice mold kit and filled with epoxy resin. Lead wire-to-structure connections must be accomplished by an exothermic welding process. All welds must be in accordance with the manufacturer's recommendations. A backfill shield filled with a pipeline mastic sealant and material compatible with the coating must be placed over the weld connection and be of such diameter as to cover the exposed metal adequately. Anodes must be installed at a minimum of 8 feet and a maximum of 10 feet from the structure to be protected.

Contractor must take proper safety precautions prior to and during welding to live pipelines [tanks]. Contractor must notify the activity Fuel Office via the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of three days before performing exothermic welding to live lines. Exothermic welding must be conducted with product flowing through the pipeline to eliminate vapor spaces within the pipe and to dissipate the heat on the pipe. Exothermic weld charges for connections to live lines must be limited to a maximum 15 gram charge to prevent burning through the pipe wall. Exothermic weld connections must be spaced a minimum of6 inches apart. In the event of an unsuccessful weld, the new weld location must be located a minimum of 6 inches from the unsuccessful weld and any other existing welds. Contractor must obtain the services of a certified safety professional [to monitor the construction site during exothermic welding work and certify that the area is free of flammable vapors and otherwise safe for work.] [to approve the contractor's exothermic welding safety procedures. Results of this consultation must be included in the Contractor's Daily Report.]

3.4.3 Underground Pipe Joint Bonds

Underground pipe having other than welded or threaded coupling joints must be made electrically continuous by means of a bonding connection installed across the joint.

3.4.4 Anode Junction Boxes

Provide junction boxes and mark each of the wires terminating in each box.

3.4.5 Bonding Boxes

Provide structure bonding boxes in locations [as indicated] [where the protected structure crosses or comes into close proximity to other metal structures that are unprotected or protected by its own electrically isolated CP system(s)].

3.4.6 Test Stations and Permanent Reference Electrodes

Test stations will be of the type and location shown and will be [curb box] [post] [wall] mounted. Provide buried isolation joints with test wire connections brought to a test station. Reference all test stations with GPS coordinates. Unless otherwise shown, locate other test stations [and permanent reference electrodes] [as indicated.] as follows:

a. At [1000] [_____] foot intervals.

b. At all isolation joints.

c. At both ends of casings.

d. Where the pipe crosses any other metal pipes.

e. Where the pipe connects to an existing piping system.

f. Where the pipe connects to a dissimilar-metal pipe.

Do not fill the bottom of the test station with concrete unless otherwise specified. Do not place rubbish, scrap or other debris into the test station.

3.4.7 Permanent Reference Electrode Verification

Verify permanent reference electrodes against a calibrated portable electrode in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager before installation. Verify in a non-metallic container of water. Permanent electrode must measure a reference potential agreeing with that measured by the portable electrode within plus or minus 0.010 volts when the sensing windows of the two electrodes being compared are not more than 1/6 inch apart but not touching. Remove permanent reference electrodes not within this potential range from the construction site by the end of the day and replace at the contractor's expense. The testing provision applies to replacement permanent reference electrodes as well.

3.4.7.1 Field Drawings

Complete a field drawing of [each anode installation showing location of anode, depth of anode, color and size of anode lead wire and any other pertinent details] [test station location and diagram] [Underground Pipe Joint bond locations and details] [Anode Junction Box Location and details] [Bonding Box location and details] [Permanent Reference Electrode locations] [Location of all Electrical Isolations]. Submit copy with daily report to the government.

3.5 ELECTRICAL ISOLATION OF STRUCTURES

3.5.1 Isolation Fittings

Isolating fittings, including isolating flange kits, dielectric unions and couplings, must be installed aboveground, or within manholes, wherever possible. Where isolating joints must be covered with soil, they must be fitted with a proper joint cover specifically manufactured for covering the particular joint, and the space within the cover filled with hot coal-tar enamel or hot petrolatum wax. Isolating fittings in lines entering buildings must be located at least 12 inch above grade of floor level, when possible. Isolating joints must be provided with grounding cells to protect against over-voltage surges or approved surge protection devices. The cells must provide a low resistance across isolating joint without excessive loss of cathodic current.

3.5.2 Dielectric Unions

[Cut pipe ends square, remove fins and burrs, cut taper pipe threads in accordance with ASME B1.20.1.] Provide isolation unions as indicated. Work piping into place without springing or forcing. Apply joint compound or thread tape to male threads only. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed. [Cover unions with an electrically insulating coating.]

3.5.3 Gas Distribution Piping

Electrical isolation will be provided at each building riser pipe to the pressure regulator, at all points where a short to another structure or to a foreign structure may occur, and at other locations as indicated on the drawings. If an isolating joint is located inside a vault, the pipe must be sleeved when entering and leaving the vault. A non-metallic sleeve is to be used.

3.5.4 Joint Bonds

Provide joint bonds on metallic pipe to and across buried flexible couplings, mechanical joints, flanged joints [except at places where isolation joints are specified] and joints not welded or threaded to provide electrical continuity. Connect bond wire(s) to the structure(s) by use of exothermic weld kit(s). Clean the structure surface by scraping, filing or wire brushing to produce a clean, bright surface. [Weld connections using exothermic kits in accordance with the kit manufacturer's instructions.] Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 2 pound hammer. Cover connections with an electrically insulating coating [which is compatible with the existing coating on the structure].

3.5.5 Casings, Isolation, and Seals

Where the pipeline is installed in a casing under a roadway or railway, isolate the pipeline from the casing, and seal the annular space against intrusion of water.

3.6 FIELD QUALITY CONTROL

Field tests must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager or their designated representative. Advise the Contracting Officer or Contracting Officer's Representative [5] [_____] days prior to performing each field test. Quality control for the cathodic protection system must consist of the following:

a. Initial field testing by the contractor upon construction.

b. Government Field Testing after contractor initial field test report submission.

c. Warranty period field testing by the contractor.

d. Final field testing by the contractor after one year of service.

3.6.1 Tests and Measurements

3.6.1.1 Native Potentials

Notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of five (5) working days prior to each test. Base potential tests: At least [one week] [24 hours] [_____] after [backfilling of the pipe] [installation of structure to be protected] [initial operation of structures containing fluids] and installation of the anodes, but before connection of anodes to the structure, measure base (native) structure-to-electrolyte potentials of the [pipe [and casings]] [structure]. Perform measurements at anode junction boxes, test stations and other locations suitable for test purposes (such as service risers or valves), at intervals not exceeding [100] [400] [_____] feet [with readings at each end point and the midpoints as a minimum]. The locations of these measurements must be identical to the locations specified for potential measurements with anodes connected. Use the same measuring equipment that is specified for measuring protected potential measurements.

3.6.1.2 Protected Potentials

Systems must be tested and inspected by the contractor's corrosion engineer in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager corrosion protection engineer or an approved representative. Notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of five working days prior to each test. At least [one week] [24 hours] [_____] after native potential testing and connection of anodes to the structure, measure protected structure-to-electrolyte potentials. The locations of these measurements must be identical to the locations specified for native potential measurements. [For underground storage tanks, take a minimum of three measurements with the reference electrode located as follows: Directly over the longitudinal and transverse centerlines of the tank at intervals not exceeding the diameter of the tank and to a distance from the tank of two times the tank diameter.] Use the same measuring equipment that is specified for measuring protected potential measurements. Record test data, including date, time, and locations of testing and submit report to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Contractor must correct and retest, at the contractor's and Technical Expert's expense, deficiencies in the materials and installation observed by these tests and inspections.

3.6.1.3 Isolation Testing

Before the anode system is connected to the [pipe] [tank], an isolation test must be made at each isolating joint or fitting. This test will demonstrate that no metallic contact, or short circuit exists between the two isolated sections of the [pipe] [tank]. Any isolating fittings installed and found to be defective must be reported to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

3.6.1.4 Isolation Tester

An Isolation Tester designed and manufactured for use in CP, using the continuity check circuit, must be used for all isolating joint (flange) electrical testing. Testing must conform to the manufacturer's operating instructions. Test must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. An isolating joint that is good will read full scale on the meter. If an isolating joint is shorted, the meter pointer will be deflected or near zero on the meter scale. Location of the fault will be determined from the instructions, and the joint must be repaired.

3.6.1.5 Anode Output

As the anodes or groups of anodes are connected to the pipe or tank, current output will be measured with an approved clamp-on milliammeter, calibrated shunt with a suitable millivoltmeter or multimeter, or a low resistance ammeter. (Of the three methods, the low-resistance ammeter is the least desirable and most inaccurate. The clamp-on milliammeter is the most accurate.) The values obtained and the date, time, and location must be recorded.

3.6.1.6 Reference Electrode Potential Measurements

Upon completion of the installation and with the entire CP system in operation, electrode potential measurements must be made using a copper/copper sulfate reference electrode and a potentiometer-voltmeter, or a direct-current voltmeter having an internal resistance (sensitivity) of not less than 10 megohms per volt and a full scale of 10 volts. The locations of these measurements must be identical to the locations used for baseline potentials. The values obtained and the date, time, and locations of measurements must be recorded. No less than eight (8) measurements will be made over any length of line or component. Additional measurements will be made at each distribution service riser, with the reference electrode placed directly over the service line.

3.6.1.7 Casing Tests

Before final acceptance of the installation, the electrical isolation of carrier pipe from casings must be tested and any short circuits corrected.

3.6.1.8 Holiday Test

Any damage to the protective coating during transit and handling must be repaired before installation. After field-coating has been applied, the entire pipe must be inspected by an electric holiday detector with impressed current in accordance with NACE SP0188 using a full-ring, spring-type coil electrode. The holiday detector will be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Holidays in the protective coating must be repaired upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager to determine suitability of the detector. Labor, materials, and equipment necessary for conducting the inspection must be furnished by the contractor. The coating system must be inspected for holes, voids, cracks, and other damage during installation.

3.6.1.9 Stray Current Measurements

Before final acceptance of the installation, stray current tests must be performed on any foreign pipes, tanks, or other metallic structures in close proximity to the installed anodes. A full report of the tests giving all details must be made.

3.6.1.10 Induced AC Testing

Before final acceptance of the installation, induced AC Voltage tests must be performed on the pipes, tanks, or other metallic structures near high AC Voltage infrastructure and where crossing above ground and underground AC transmission systems. A full report of these tests must be included in the final testing reports with all details and data taken. The touch potential of any testing over 5 volts must be reported to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Any touch potential over 10 Volts must be mitigated by effective mitigation techniques. Refer to NACE SP0177 and NACE SP21424.

3.6.1.11 Interference Tests

Before final acceptance of the installation, interference tests will be made with respect to any foreign pipes or tanks in cooperation with the owner of the foreign pipes or tanks. A full report of the tests giving all details must be made. Stray current measurements must be performed at all isolating locations and at locations where the new pipeline crosses foreign metallic pipes; results of stray current measurements must also be submitted for approval. The method of measurements and locations of measurements must be submitted for approval. As a minimum, stray current measurements must be performed at the following locations:

a. Connection points of new pipeline to existing pipeline.

b. Crossing points of new pipeline with other existing metallic pipelines.

3.6.1.12 Initial Cathodic Protection System Field Testing

Initial field testing must be completed by the contractor upon completion of construction. Field testing must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager or their designated representative. Advise the Contracting Officer or Contracting Officer's Representative 5 days prior to performing each field test. Field testing must include native and protected potentials, and anode current testing.

The contractor must submit an initial field test report of the cathodic protection system. All structure-to-electrolyte measurements, including initial potentials, anode outputs, and other required testing must be recorded on applicable forms. Identification of test locations, test station and anode test stations will coordinate with the as-built drawings and be provided on system drawings included in the report. The contractor must locate, correct, and report to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager any short circuits encountered during the checkout of the installed CP system.

3.6.1.13 Government Field Testing

The government corrosion program manager must review the contractor's initial field testing report. Approximately four weeks after receipt of the contractor's initial test report, the system will be tested and inspected in the contractor's presence by the government corrosion program manager. The contractor must correct, at the contractor's expense, materials and installations observed by these tests and inspections to not be in conformance with the plans and specifications. The contractor will pay for all retesting done by the government engineer made necessary by the correction of deficiencies.

3.6.1.14 One-Year-Warranty-Period-Testing

The contractor must inspect, test, and adjust the cathodic protection system quarterly for one year, interim inspections total, to ensure its continued conformance with the criteria outlined below. The performance period for these tests will commence upon the completion of all cathodic protection work, including changes required to correct deficiencies identified during initial testing, and preliminary acceptance of the cathodic protection system by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Copies of the One Year Warranty Period Cathodic Protection System Field Test Report, including field data, and certified by the contractor's corrosion engineer must be submitted to the Contracting Officer or Contracting Officer's Representative, the activity, and the geographic EFD corrosion Technical Expert.

3.6.1.15 Final Acceptance Field Testing

Conduct final field testing of the cathodic protection system utilizing the same procedures specified under, "Initial Field Testing of the Galvanic Cathodic Protection Systems". The contractor will inspect, test, and adjust the cathodic protection system after one year of operation to ensure its continued conformance with the criteria outlined below. The performance period for these tests will commence upon preliminary acceptance for the cathodic protection system by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Copies of the Final Cathodic Protection System Field Test Report, certified by the contractor's corrosion engineer must be submitted to the Contracting Officer or the Contracting Officer's Representative, Technical

Expert and Project Manager and the geographic EFD corrosion program manager for approval, and as an attachment to the operation and maintenance manual in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. The government corrosion program manager must review the contractor's final field testing report.

3.7 CLOSEOUT ACTIVITIES

3.7.1 Reconditioning of Surfaces

3.7.1.1 Concrete

Concrete must be 3000 psi minimum ultimate 28-day compressive strength with one inch minimum aggregate conforming to Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.7.1.2 Restoration of Sod

Restore unpaved surfaces disturbed during the installation of anodes and wires to their original elevation and condition. In areas where grass cover exists, it is possible that sod can be carefully removed, watered, and stored during construction operations, and replaced after the operations are completed since it is estimated that no section of pipeline must remain uncovered for more than two (2) days. Where the surface is disturbed in a newly seeded area, re-seed the area with the same quality and formula of seed as that used in the original seeding. Seeding must be done as directed, in all unsurfaced locations where sod and topsoil could not be preserved and replaced. The use of sod in lieu of seeding will require approval by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

3.7.1.3 Restoration of Pavement

Repair pavement, sidewalks, curbs, and gutters where existing surfaces are removed or disturbed for construction. Saw cut pavement edges. Graded aggregate base course must have a maximum aggregate size of 1 1/2 inches. Prime base course with liquid asphalt, ASTM D2028/D2028M, Grade RC-70 prior to paving. Match base course thickness to existing but must not be less than 6 inches. Asphalt aggregate size must be 1/2 inch , asphalt cement must conform to ASTM D3381/D3381M, Grade AR-2000. Match asphalt concrete thickness to existing but must not be less than 2 inches. Repair Portland cement concrete pavement, sidewalks, curbs, and gutters using 3,000 psi concrete conforming to Section 03 30 00 CAST-IN-PLACE CONCRETE. Match existing pavement, sidewalk, curb, and gutter thicknesses.

3.7.1.4 Cleanup

The contractor is responsible for cleanup of the construction site. All paper bags, wire clippings, must be disposed of as directed. Paper bags, wire clippings and other waste will not be put in bell holes or anodes excavation.

3.7.2 Training

3.7.2.1 Instruction to Government Personnel

During the warranty testing or at a time designated by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager, make available the services of a technician regularly employed or authorized by the manufacturer of the Cathodic Protection System for instructing government personnel in the proper operation, maintenance, safety, and emergency procedures of the Cathodic Protection System. The period of instruction must be not less than eight hours and not more than one 8-hour working day. Conduct the training at the jobsite or at another location mutually satisfactory to the government and the contractor. The field instructions will cover all of the items contained in the operation and maintenance manual.

-- End of Section --

SECTION 26 42 15

CATHODIC PROTECTION SYSTEM FOR THE INTERIOR OF STEEL WATER TANKS
05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA D104	(2011) Automatically Controlled, Impressed-Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Storage Tanks

ASTM INTERNATIONAL (ASTM)

ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A518/A518M	(1999; R 2018) Standard Specification for Corrosion-Resistant High-Silicon Iron Castings
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B418	(2016a; R2021) Standard Specification for Cast and Wrought Galvanic Zinc Anodes

ASTM B843	(2018) Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D2028/D2028M	(2015) Cutback Asphalt (Rapid-Curing Type)
ASTM D3381/D3381M	(2018) Standard Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction
ASTM F1182	(2007; R 2019) Anodes, Sacrificial Zinc Alloy

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

NACE INTERNATIONAL (NACE)

NACE SP0188	(1999; R 2006) Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE SP0193	(2016) Application of Cathodic Protection to Control External Corrosion of Carbon Steel On-Grade Storage Tank Bottoms
NACE SP0196	(2020) Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks
NACE SP0388	(2018) Impressed Current Cathodic Protection of Internal Submerged Surfaces of Carbon Steel Water Storage Tanks - Item No. 21040

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed

	Insulated Underground Connector Systems Rated 600 Volts
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 1	(1988; R 1994; R 1997) Specialty Transformers (Except General Purpose Type)
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

NSF INTERNATIONAL (NSF)

NSF/ANSI 61	(2020) Drinking Water System Components - Health Effects

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-18001	(1993) Anodes, Sacrificial Zinc Alloy
MIL-I-1361	(1985; Rev C; Notice 1 1991; Notice 2 2021) Instrument Auxiliaries, Electrical Measuring: Shunts, Resistors and Transformers

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors

UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 854	(2020) Standard for Service-Entrance Cables

1.2 DEFINITIONS

It is convenient to classify corrosion by the forms in which it manifests itself, the basis for this classification being the appearance of the corroded metal. Each form can be identified by visual observation, although, in some cases, magnification is required. Valuable information for the solution of a corrosion problem can often be obtained through careful observation of the corroded test specimens or failed equipment. Examination before cleaning is particularly desirable. Cathodic Protection is a method used to control corrosion.

1.2.1 Cathodic Protection

Cathodic Protection (CP) is an electrochemical (half electrical and half chemical) method used to control corrosion of buried or submerged metallic structures. It prevents corrosion by making the protected structure a cathode by installing a more anodic metal (sacrificial or galvanic) anode or a metallic (impressed current) anode connected to a Direct Current (DC) power source. When the proper amount of current is applied to the structure, it becomes a cathode. Since all corrosion occurs at the anode, the structure no longer corrodes. The electrons move in the metallic path (electrical). Reduction (chemical) reactions occur at the surface of the cathode resulting in a hydrogen coating and more alkaline environment. Oxidation (chemical) reactions occur at the surface of the anode resulting in corrosion and a more acidic environment. After a CP system is installed and adjusted to provide adequate protection, the hydrogen coats the defects in the coating and polarizes in the negative direction (to a copper/copper sulfate reference electrode) over time the current and potentials remain relatively stable; changes in currents or potentials indicate a problem. An error-free measurement of negative 850 millivolts DC or more negative to the copper/copper-sulfate reference electrode proves the structure is a cathode and corrosion has been mitigated.

1.2.2 Corrosion

It is convenient to classify corrosion by the forms in which it manifests itself, the basis for this classification being the appearance of the corroded metal. Each form can be identified by visual observation, although, in some cases, magnification is required. Valuable information for the solution of a corrosion problem can often be obtained through careful observation of the corroded test specimens or failed equipment. Examination before cleaning is particularly desirable. Some of the eight forms of corrosion are unique, but all of them are more or less interrelated.

The eight forms of corrosion are: (1) Uniform Attack, (2) Galvanic or Two-Metal Corrosion, (3) Crevice Corrosion, (4) Pitting Corrosion, (5) Intergranular Corrosion, (6) Selective Leaching, (7) Erosion Corrosion, and (8) Stress Corrosion Cracking. This listing is arbitrary but covers practically all corrosion failures and problems. The forms are not listed in any particular order of importance. Below, the eight forms of corrosion are discussed in terms of their characteristics, mechanisms, and preventive measures. Hydrogen damage, although not a form of corrosion, often occurs indirectly as a result of corrosive attack and is, therefore, included in this discussion.

1.2.3 Alternating Current (AC) Corrosion

AC corrosion occurs when there is a source of AC current, typically from a high voltage overhead AC (OHAC) power-line, when there is a low soil resistivity - typically less than 5,000 ohm-cm and there is very small coating holidays. The AC corrosion pits typically have a tubercle of corrosion product at the pit. AC interference study modeling software can determine the mitigation solution to solve this problem. Typically, AC Corrosion mitigation is done in conjunction with high AC potentials and fault current mitigation.

1.2.4 AC Interference

AC interference occurs when a pipeline parallels a high-voltage overhead AC (OHAC) power-line. An interference study is required when this situation occurs as AC interference can cause high AC potentials along the pipeline (safety), can cause a fault condition between the pipeline and power-line and could cause AC corrosion to occur. The pipeline coating when exposed can have blisters/bubbles caused by the excessive AC. The interference study will use modeling software to determine what combination of interference may be occurring (if any) and provide the mitigation solution to solve the problem.

1.2.5 Uniform Attack

Uniform attack is the most common form of corrosion. It is normally characterized by a chemical or electrochemical reaction that proceeds uniformly over the entire exposed surface or over a large area. The metal becomes thinner and eventually fails. For example, a piece of steel or zinc immersed in dilute sulfuric acid normally dissolves at a uniform rate over its entire surface. A sheet iron roof shows essentially the same degree of rusting over its entire outside surface.

Uniform attack, or general overall corrosion, represents the greatest destruction of metal on a tonnage basis. This form of corrosion, however, is not of great concern from a technical standpoint, because the life of equipment can be accurately estimated on the basis of comparatively simple tests. Merely immersing specimens in the fluid involved is often sufficient. Uniform attack can be prevented or reduced by (1) materials, such as coatings, that reduce contact between metal and electrolytes, (2) inhibitors, or (3) cathodic protection.

1.2.6 Galvanic or Two-Metal Corrosion

A potential difference usually exists between two dissimilar-metals when they are immersed in a corrosive or conductive solution. If these metals are placed in contact (or otherwise electrically connected), this potential difference produces electron flow between them. Corrosion of the less corrosion-resistant metal is usually increased, and attack of the more resistant material is decreased, compared to the behavior of these metals when they are not in contact. The less resistant metal becomes anodic and the more resistant metal becomes cathodic. Usually the cathode or cathodic metal corrodes very little or not at all in this type of couple. Because of the electric currents and dissimilar-metals involved, this form of corrosion is called galvanic, bi-metallic or two-metal, corrosion. Galvanic corrosion is restricted to electrochemical corrosion caused by dissimilar-metal effects. It is electrochemical corrosion, but this document must restrict the term galvanic to dissimilar-metal effects for purposes of clarity.

1.2.7 Crevice Corrosion

Intense localized corrosion frequently occurs within crevices and other shielded areas on metal surfaces exposed to corrosives. This type of attack is usually associated with small volumes of stagnant solution caused by holes, gasket surfaces, lap joints, surface deposits, and crevices under bolt and rivet heads. As a result, this form of corrosion is called crevice corrosion or, sometimes, deposit or gasket corrosion.

1.2.8 Pitting Corrosion

Pitting is a form of extremely localized attack that results in holes in the metal. These holes may be small or large in diameter, but in most cases they are relatively small. Pits are sometimes isolated or so close together that they look like a rough surface. Generally a pit may be described as a cavity or hole with the surface diameter about the same as or less than the depth. Pitting is one of the most destructive and insidious forms of corrosion. It causes equipment to fail because of perforation with only a small percent weight loss of the entire structure. It is often difficult to detect pits because of their small size and because the pits are often covered with corrosion products. In addition, it is difficult to measure quantitatively and compare the extent of pitting because of the varying depths and numbers of pits that may occur under identical conditions. Pitting is also difficult to predict by laboratory tests. Sometimes the pits require a long time (several months or a year) to show up in actual service. Pitting is particularly vicious because it is a localized and intense form of corrosion, and failures often occur with extreme suddenness.

1.2.9 Intergranular Corrosion

Grain boundary effects are of little or no consequence in most applications or uses of metals. If a metal corrodes, uniform attack results since grain boundaries are usually only slightly more reactive than the matrix. However, under certain conditions, grain interfaces are very reactive and intergranular corrosion results. Localized attack at and adjacent to grain boundaries, with relatively little corrosion of the grains, is intergranular corrosion. The alloy disintegrates (grains fall out) or loses its strength. Intergranular corrosion can be caused by impurities at the grain boundaries, enrichment of one of the alloying elements, or depletion of one of these elements in the grain-boundary areas. Small amounts of iron in aluminum, wherein the solubility of iron is low, have been shown to segregate in the grain boundaries and cause intergranular corrosion. It has been shown that, based on surface tension considerations, the zinc content of a brass is higher at the grain boundaries. Depletion of chromium in the grain-boundary regions results in intergranular corrosion of stainless steels.

1.2.10 Selective Leaching

Selective leaching is the removal of one element from a solid alloy by corrosion processes. The most common example is the selective removal of zinc in brass alloys (dezincification). Similar processes occur in other alloy systems in which aluminum, iron, cobalt, chromium, and other elements are removed. Selective leaching is the general term to describe these processes, and its use precludes the creation of terms such as de-aluminumification, de-cobaltification. Parting is a metallurgical term that is sometimes applied, but selective leaching is preferred.

1.2.11 Erosion Corrosion

Erosion corrosion is the acceleration or increase in rate of deterioration or attack on a metal because of relative movement between a corrosive fluid and the metal surface. Generally, this movement is quite rapid, and mechanical wear effects or abrasion are involved. Metal is removed from the surface as dissolved ions, or it forms solid corrosion products, which are mechanically swept from the metal surface. Sometimes, movement of the environment decreases corrosion, particularly when localized attack occurs under stagnant conditions; this is not erosion corrosion because deterioration is not increased. Erosion corrosion is characterized in appearance by grooves, gullies, waves, rounded holes, and valleys and usually exhibits a directional pattern. In many cases, failures because of erosion corrosion occur in a relatively short time, and they are unexpected largely because evaluation corrosion tests were run under static conditions or because the erosion effects were not considered.

1.2.12 Stress-Corrosion Cracking

Stress-corrosion cracking refers to cracking caused by the simultaneous presence of tensile stress and a specific corrosive medium. Many investigators have classified all cracking failures occurring in corrosive media as stress-corrosion cracking, including failures due to hydrogen embrittlement. However, these two types of cracking failures respond differently to environmental variables. To illustrate, CP is an effective method for preventing stress-corrosion cracking; however, hydrogen-embrittlement may be caused when excessive current is applied, especially on stainless steel. Hence, the importance of considering stress-corrosion cracking and hydrogen embrittlement as separate phenomena is obvious. During stress-corrosion cracking, the metal or alloy is virtually unattacked over most of its surface, while fine cracks progress through it. This cracking phenomenon has serious consequences, since it can occur at stresses within the range of typical design stress.

1.2.13 Exothermic Welding

Exothermic welding is used in CP to connect a copper wire to a metallic structure, usually steel or cast-iron. It is a pyrotechnic composition of copper oxide, aluminum powder and magnesium powder. The magnesium powder is ignited with a spark gun or electronic ignition equipment. The aluminum powder serves as fuel, and melts the copper oxide, which bonds the wire to the structure. Although not explosive, it can create brief bursts of heat and high temperature in a small area.

1.2.14 Error-Free

Potential measurement error due to a voltage drop caused by current flowing through a resistor (the electolyte) between the reference electrode and the protected structure.

1.3 ADMINISTRATIVE REQUIREMENTS

After award of the contract, but prior to commencement of any work at the site, meet with the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Develop a mutual understanding relative to the administration of the value engineering, the safety program, preparation of the schedule of prices or the earned value report. Review shop drawings, other submittals, scheduling programming, execution of the work, and clear expectations of the "Interim Department of Defense (DD) Form 1354" submittal. Major subcontractors who will engage in the work must also attend.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Preconstruction Survey

SD-02 Shop Drawings

Drawings; G

Wiring and Schematic Diagram

Anode junction boxes

Contractor's Modifications; G

SD-03 Product Data

Qualifications

Equipment; G

Components; G

Rectifiers; G

Remote Monitoring Equipment; G

Anodes; G

Permanent reference electrodes; G

Anode junction boxes

Cable and wire

Shunts

Extra Materials; G

Spare Parts

SD-05 Design Data

Contractor's Modifications; G

SD-06 Test Reports

Anode Connecting Cables

Rectifier Testing

SD-10 Operation and Maintenance Data

Cathodic Protection System; G

Training Course;; G

Contractor's Modifications; G

SD-11, Closeout Submittals

Initial Cathodic Protection System Testing; G

One Year Warranty Period Cathodic Protection System Field Test Report; G

Final Acceptance Field Testing; G

1.4.1 Material and Equipment Manufacturer Data

DATE	ISSUE NO.	REQUEST	REQUESTED BY	REQUEST REF.
MANUFACTURER NAME				
DESCRIPTION OF EQUIPMENT				

DATE	ISSUE NO.	REQUEST	REQUESTED BY	REQUEST REF.

1.5 MAINTENANCE MATERIAL SUBMITTALS

1.5.1 Spare Parts

After approval of shop drawings, furnish spare parts data for each different item of material and equipment specified. The data must include a complete list of parts, special tools, and supplies, with current unit prices and source of supply.

After approval of shop drawings, furnish revised spare parts for any changes made from original submittal. One spare anode of each type must be furnished. In addition, supply information for material and equipment replacement for all other components of the complete system, including anodes, cables, splice kits and connectors, corrosion test stations, and any other components not listed above. Furnish one reference electrode on a hand reel with 350 feet of conductor, and one digital voltmeter that can be used in the maintenance of this CP system. Demonstrate use of furnished equipment in actual tests during the training course. Provide a description of equipment of the pipe-to-soil protected structure and foreign structures at electrical isolation between the utility supplier and the facility piping.

1.5.2 Extra Materials

Furnish one submersible reference electrode on a reel with enough wire to reach the bottom of the tank, or the bottom of the riser as required and one high input impedance multimeter that can be used in the maintenance of this CP system. Demonstrate equipment in actual tests during the training course. Include a description of the equipment and measurement of the tank-to-water potentials, anode voltage, anode current and water level.

1.6 QUALITY CONTROL

1.6.1 Regulatory Requirements

Obtain the services of a corrosion expert to supervise, inspect, and test the installation and performance of the CP system. The term "corrosion expert" refers to a person, who by thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of buried or submerged metallic structures.

1.6.2 Qualifications

The corrosion expert must be accredited or certified by NACE International, as a CP-4 CP Specialist or be a NACE International certified Corrosion Specialist or a registered professional engineer who has certification or licensing that includes education and experience in CP of the type of CP system being installed. The corrosion expert must have not less than five years of experience in the type of CP for buried or submerged metallic structures under this contract. Submit evidence of qualifications of the corrosion expert including their name and qualifications certified in writing to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager prior to the start of construction. Certification must be submitted giving the name of the firm, the number of years of experience, and a list of not less than five of the firm's installations, three or more years old, that have been tested and found satisfactory.

1.6.3 Services of Corrosion Expert

The corrosion expert must make a minimum of three visits to the project site. The first of these visits will include obtaining water/electrolyte resistivity data, acknowledging the type of tank coatings to be used and reporting to the contractor the type of CP required (GACP or ICCP). Once the submittals are approved and the materials delivered, the corrosion expert will revisit the site to verify the materials meet submittal requirements, ensure the contractor understands installation practices and that the contractor is capable and qualified to complete the installation.

The "corrosion expert" will be available (but not necessarily be onsite the entire time) during the installation of the CP system to answer questions, approve any changes or additions required during construction, or to provide recommendations as required. The third visit is to complete the training and demonstrations to applicable personnel on proper testing and maintenance techniques and to complete testing the installed CP systems to ensure it has been installed properly and meets adequate CP criteria. An additional visit is required if the One-Year-Warranty-Period-Testing is required.

1.7 DELIVERY, STORAGE AND HANDLING

Storage area for corrosion material will be designated by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. If materials are not stored in a building, tarps or similar protection must be used to protect materials from inclement weather.

1.8 PROJECT/SITE CONDITIONS

1.8.1 Environmental Requirements

1.8.2 Existing Conditions

Prior to start of any onsite construction activities, perform a Preconstruction Survey of the project site with the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager, and take photographs showing existing environmental conditions in and adjacent to the site. Submit a report for the record. Include in the report a plan describing the features requiring protection under the provisions of the Contract Clauses, which are not specifically identified on the drawings as environmental features requiring protection along with the condition of trees, shrubs and grassed areas immediately adjacent to the site of work and adjacent to the contractor's assigned storage area and access route(s), as applicable. The Contractor and the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager will sign this survey report upon mutual agreement regarding its accuracy and completeness. Protect those environmental features included in the survey report and any indicated on the drawings, regardless of interference that their preservation may cause to the work under the Contract.

1.9 WARRANTY

Provide equipment items that are supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Corrosion Control System Description

Coating Systems (CS) are a critical factor in performance of all CP systems. All coatings, including coatings in structure guide specifications and Green Seal (GS) coatings, must be compatible with the structure and the CP system, and have high disbondment capabilities. A high resistance to cathodic disbondment is critical for long term service life of coatings on buried or submerged metallic structures under CP. Due to the limited voltage and current of galvanic anodes, a highly dielectric bonded coating is required to attain adequate using galvanic CP systems. For paints and coatings refer to Section 09 90 00 PAINTS AND COATINGS, steel coatings Section 09 97 13.00 40 STEEL COATINGS, interior coating of welded steel water tanks Section 09 97 13.16 INTERIOR COATING OF WELDED STEEL WATER TANKS. For discontinuity (Holiday) testing of new protective coatings on conductive substrates refer to NACE SP0188. Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

a. Construction Design Requirements (CDR) for the interior of steel water tanks are found in the UFGS. Section 33 16 15 WATER STORAGE STEEL TANKS NACE SP0196 and NACE SP0388, External CP of On-Grade Carbon Steel Tank Bottoms NACE SP0193.

2.1.2 Design Requirements

2.1.2.1 Drawings

Submit six copies of detail drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, contractor's modifications, results of system design calculations including water/electrolyte-resistivity, installation instructions and certified test data showing location of anodes and stating the maximum recommended anode current output density. Include in the detail drawings complete wiring and schematic diagrams, permanent reference electrodes and bonding and any other details required to demonstrate that the system has been coordinated and will function properly as a unit. Reference locations to two permanent facilities or mark points. Provide one electronic PDF copy and digital photos of the completed installation.

2.1.2.2 Summary of Services Required

Include the following scope of services:

a. CP Installation System requirements,

b. System testing,

c. Training,

d. Operating and maintenance manual,

e. Coating and holiday testing.

Take potential test measurements on all permanent reference electrodes, witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

Provide submittals identifying test locations on separate drawing, showing all metal to be protected and all CP equipment. Distinguish and identify test points equipment and protected metal.

2.1.3 Performance Requirements

The design must allow for synchronized interruption of all applied current.

2.1.3.1 Criteria of Cathodic Protection

The design must allow for synchronized interruption of all applied current. Criteria for adequate CP must be identified by the designer or the contractor's corrosion engineer and approved by the Government corrosion engineer. The method of voltage drop consideration must also be identified by the contractor's corrosion engineer and approved by the Government. Use of the 100 mV shift criteria is not applicable to bi-metallic structures.

a. The measurements for the native potential measurement must be made before the CP system is energized. If CP has previously been applied, use the polarized potentials or the polarization decay potentials to determine if adequate CP has been achieved.

b. Determination of the on and polarized (instant off) potentials must be made with the protective current applied to the tank for a minimum of 4 .

c. The polarization decay (off) potentials must be made with the protective current off for a minimum of 48 hours.

d. Polarized (instant off) potentials and polarization decay potentials must be made with the reference electrode at the same location.

e. The polarization decay will be the difference between the polarized potential and the polarization decay (off) potential made after the interruption of protective current.

2.1.3.1.1 Maximum Potential

The polarized potential between a copper/copper sulfate reference electrode and the tank at any point must not be more negative than a negative 1.1 volts (with the protective current interrupted instantaneously or modulated). Do not use on potentials to determine maximum allowed potentials.

2.1.3.1.2 Tanks Subject to Icing Conditions

Suspend anodes in a manner similar to that in non-icing climates, except provisions must be made to prevent the anodes and suspending cables from being damaged by freezing or falling ice or by suspended floating flexible anode rings from the tank walls.

2.2 EQUIPMENT

2.2.1 Remote Monitoring

Remote monitoring equipment must be designed, manufactured and procured specifically for CP use and must be provided as per design and drawings to monitor potential (requires permanent reference electrode), , or and must match or be compatible with previously installed remote monitoring equipment in use at the installation.

2.2.2 Corrosion Rate Monitoring

Corrosion probes must be designed, manufactured and procured specifically for the application and matched to the structure being protected. Manufacturer must match or be compatible with previously installed rate monitoring equipment in use at the installation.

2.2.3 Rectifiers

2.2.3.1 Air Cooled Enclosure

NEMA ICS 6 Type as required for the environment, Air Cooled enclosure suitable for wall, post, or pad mounting. Enclosures must be of (11 gauge) steel or heavier. Enclosure must include front hinged door with [padlock hasp] [key lock, provide [three] [_____] keys.] [locks keyed alike.] [left side door] [right side door] fit with screened openings to provide for cooling by natural convection. Provide holes, conduit knockouts and threaded hubs of sufficient size and location. The cabinet and mounting support must be [painted][hot-dipped galvanized] [aluminum] [stainless] steel [according to the manufacturer's standards].

2.2.3.2 Oil Cooled Enclosure

NEMA ICS 6 Type 11-Oil Immersed Enclosure, suitable for pad mounting. Enclosure must include top hinged door with [padlock hasp] [key lock, provide [three] [_____] keys.] [locks keyed alike.] Enclosures must be of 11 gauge steel or heavier, with an accessible drain plug. The oil level must be clearly marked. The lid must be hinged and have quick release clamps to secure it in the closed position. A stop must limit the swing of the lid when opened. A compressible, oil resistant, positive sealing gasket must be provided. The gasket must return to its original shape upon release of lid pressure. The gasket attached to the tank or lid and joints must be free of gaps. Base mounting using 4 inch high channels provided. Conduits entering the enclosure must be internally sealed and enter or exit above the oil fill line.

2.2.3.3 Explosion Proof Enclosure

NEMA ICS 6 Type 7 Explosion Proof Enclosure suitable for pad mounting. Enclosure must include top hinged lid with [padlock hasp] [key lock, provide [three] [_____] keys.] [locks keyed alike.] Enclosures must be of 11 gauge steel or heavier, with an accessible drain plug. The oil level must be clearly marked. The lid must have quick release clamps to secure it in the closed position. A stop must limit the swing of the lid when opened. A compressible, oil resistant, positive sealing gasket must be provided. The gasket must return to its original shape upon release of lid pressure. The gasket attached to the tank or lid and joints must be free of gaps. Base mounting using 4 inch high channels provided. Conduits entering the enclosure must be internally sealed and enter or exit above the oil fill line.

2.2.3.4 Cabinet Paint System

[The cabinet and mounting support must be [painted] [hot dipped galvanized] [aluminum] [stainless steel] with the manufacturer's standard painting system.] [The mounting support for the fiberglass cabinet must be [painted] [hot dipped galvanized] [aluminum] [stainless steel] with the manufacturer's standard painting system.]

2.2.3.5 Transformers

UL 506 and NEMA ST 1, as applicable.

2.2.3.6 Electrical Ratings

Electrical ratings as follows: Input voltage at 60 Hz: [[115] [208] [230] volts single phase] [[208] [230] [460] volts three phase].

a. Output voltage, dc: [9] [12] [18] [24] [_____] volts [as indicated].

b. Output current, dc: [8] [16] [24] [32] [_____] amperes [as indicated].

The rectifier must be capable of supplying continuous full rated output at an ambient temperature of 112 degrees F in full sunlight with expected life of 10 years minimum.

2.2.3.7 Rectifying Elements

Provide silicon diode rectifying elements, connected in such manner as to provide full-wave rectification. [Protect silicon diodes with selenium cells or varistors against overvoltage surges and by current limiting devices against overcurrent surges.]

2.2.3.8 Wiring and Schematic Diagram

Provide a complete wiring and schematic diagram of the power unit showing both the ac and the dc connections to anodes on the inside of the cabinet door. Show and label components.

2.2.3.9 Overload and Short Circuit Protection

Provide UL 489, single-pole, flush-mounted molded case circuit breaker, [magnetic] [thermal-magnetic] type, in the primary circuit of the rectifier supply transformer.

2.2.3.9.1 Circuit Breaker(s)

A [single] [double] [three]-pole, flush-mounted, fully magnetic, properly rated non-terminal type circuit breaker must be installed in the primary circuit of the rectifier supply transformer.

2.2.3.9.2 Fuses

Cartridge-type fuses conforming to NEMA FU 1. Provide suitable fuse holders in each leg of the D.C. circuit.

2.2.3.9.3 Surge Protection

Protect silicon diodes by use of AC and DC lightning arresters or metal oxide varistors against overvoltage surges and by current-limiting device against overcurrent surges.

2.2.3.10 DC Output Control

Provide adjustable DC output voltage by [transformer taps] [automatic controls].

2.2.3.10.1 Transformer Taps

[Transformer taps, [5] [_____] coarse, [5] [_____] fine.] [Variac.] [_____].

2.2.3.10.2 Automatic Controls

Provide a control system capable of maintaining a preselected tank-to-water potential, within plus or minus 0.025 volt regardless of changes in water chemistry, temperature, or water level in the tank. [Provide separate dc output circuits, means of adjustment, reference electrodes, and metering for the tank bowl and riser pipe.] Make provisions for readily changing the range and limits of the operating potential. Refer to AWWA D104 Automatically Controlled Impressed-Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Storage Tanks.

2.2.3.11 Meters

Provide separate panel voltmeter and ammeter, not less than 2 1/2 inch [round] [rectangular] 2 percent full scale accuracy at 80 degrees F, temperature stability above and below 80 degrees F of at least 1 percent per 10 degrees F. Provide toggle switch for each meter.

2.2.3.12 Grounding Provisions

Grounding provisions must [be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.] [comply with NFPA 70 and UL 467 including a ground terminal in the cabinet.] The grounding conductor from the terminal to the earth grounding system must be solid or stranded copper not smaller than No. 6 AWG. Provide an earth grounding system consisting of one or more rods. Ground rods must be [copper-clad steel conforming to UL 467] [zinc-coated steel conforming to IEEE C135.30] [solid stainless steel] not less than [5/8] [3/4] inch in diameter by [8] [10] feet in length. Drive rods full length into the earth. Sectional type rods may be used.

2.2.3.13 Resistance to Ground

Measure the resistance to ground using the fall-of-potential method described in IEEE 81. The maximum resistance of driven ground must not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, [_____] additional rods not less than 6 feet on centers, or if sectional type rods are used, [_____] additional couple sections and drive with the first rod. In high-ground-resistance, use UL listed chemically charged ground rods. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager immediately. Exothermically weld all connections below grade. Exothermically weld connections above grade or use UL 467 approved connectors.

2.2.3.14 Efficiency

Overall efficiency of [65 percent] [90 percent] [_____] minimum when operated at full output.

2.2.3.15 Optional Rectifier Special Required Features

[1. An efficiency filter (choke) (may be required to improve the rectifiers efficiency). [capacitor] (A capacitor may also be required to be used in conjunction with the filter to further improve the efficiency and minimize noise.)

][2. Convenience Outlet mounted on Faceplate

][3. Safety shield panel covering Taps or all energized conductors on faceplate

][4. Stainless Steel Perforated screens on Air Cooled Rectifiers

][5. Heavy duty Draw-pull Stainless steel cabinet latch

][6. Separate Slide-out equipment racks for Transformer and Stack

][7. Additional [_____]coarse or [_____] fine voltage control link bar taps

][8. Quick-change, heavy-duty knobs for changing tap link bars Minimum 5/16" diameter

][9. Soldered tap changing studs 3/16" Grade XX

][10. Phenolic front panel

][11. Nickel Plated and double-nutted or soldered connections

][12. Terminal block for AC input wires

][13. Terminal block for Remote Monitoring Connections

][14. Primary tap change panel for dual input voltages (Single Phase models only)

]

2.2.3.16 Potable Water Storage Tanks

Provide CP and protective coatings for the interior submerged surfaces of potable water storage tanks, including bolted panel tanks in accordance with NSF/ANSI 61. Include requirements in the contract specifying that the contractor is responsible for providing an interior coating system and ensuring that the coating system is compatible with an impressed current CP

(ICCP) system, if specified, and NSF/ANSI 61. For bolted panel storage tanks, require the contractor to ensure all panels of a bolted panel storage tank are electrically continuous.

2.2.3.17 Fire Protection Water Storage Tanks

Fire protection water storage tanks are mission critical facilities and must be properly protected against corrosion. Provide an ICCP system for the interior submerged surfaces of all fire protection water storage tanks, including bolted panel tanks. When the backfill beneath an on-grade tank is corrosive, provide an ICCP system for the exterior bottom of the on-grade tank. Refer to UFGS Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM, NACE International SP0193 External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottoms. Include requirements in the contract specifying that the contractor is responsible for providing an interior coating system and ensuring that the coating system is compatible with the ICCP system. For bolted panel storage tanks, require the contractor to ensure all panels of a bolted panel storage tank are electrically continuous.

For Navy projects, allow ICCP or galvanic anode (GCP) systems for fire protection water storage tanks. See above references and UFGS Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM.

2.3 COMPONENTS

2.3.1 Junction Box Enclosures (Access and Physical Protection)

NEMA ICS 6, Type [3R] [4X] [_____] enclosure with [clamped cover] [Type [304] [316] stainless steel hinges and [clamped] [latched] cover] [and padlocked hasp]. Enclosure must be of [galvanized steel] [painted steel] [aluminum] [fiberglass] [non-metallic] construction with terminal board. Knockout for conduit must be the size and location as per design drawings.

2.3.2 Shunts for Junction Boxes

[MIL-I-1361.] [0.1] [0.01] [_____] ohm, [2] [8] ampere, accuracy plus or minus one percent, polycarbonate circuit board type, color coded for value recognition [red for 0.1 ohm shunt] [yellow for 0.01 ohm shunt] with Nickel plated brass posts and standard 0.25 inch holes on 1 inch centers to fit test stations and terminal boards 6 ampere, accuracy plus or minus one percent, manganin (Trade Mark/alloy).

2.3.2.1 Nameplates

Provide nameplate in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and ASTM D709. Provide laminated plastic nameplates for each enclosure as specified or as indicated on the drawings. Each nameplate inscription must identify the function. Nameplates will be melamine plastic, 0.125 inch thick, white with [black] [_____] center core. Surface will be matte finish. Corners will be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 25 inch by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.3.3 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic [1/8] [1/4] [_____] inch thick with dimensions as indicated. Insulated terminal boards must have the required number of terminals (one terminal required for each conductor). Install solderless copper lugs and copper buss bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, reference electrodes and coupons).

2.4 MATERIALS

2.4.1 Anodes

2.4.1.1 Dimensions and Weights

Bare anode weight [9] [17] [20] [32] [_____] pounds not including core.

2.4.1.2 High-Silicon Chromium Bearing Cast Iron

ASTM A518/A518M. Provide cast iron anodes with the following characteristics:

a. Electrical resistivity: 72 micro-ohm-centimeter at 20 degrees F (maximum).

b. Physical properties (nominal):

Tensile strength	15,000 psi
Compressive strength	100,000 psi
Brinell hardness	520
Density	7.0 grams per cubic centimeter
Melting point	2300 degrees F

c. Coefficient of expansion from 32 to 212 degrees F: 0.733 micrometers per degree F.

2.4.1.2.1 Chemical Composition (Nominal)

Element	Percent by Weight Grade 2
Silicon	14.20-14.75
Manganese	1.50 Max.
Carbon	0.75-1.15
Chromium	3.25-5.00
Iron	Balance

2.4.1.2.2 Electrical Resistivity

Seventy-two microhm-centimeter at 20 degrees F.

2.4.1.2.3 Physical Properties (Nominal)

Tensile strength	15,000 psi
Compressive strength	100,000 psi
Brinell hardness	520
Density	7.0 grams per cubic centimeter
Melting Point	2300 degrees F
Coefficient of expansion from 32 to 212 degrees F	0.733 micrometer per degree F

2.4.1.2.4 Anode Connecting Cables

Anodes must have connecting cables installed at the factory.

2.4.1.3 Aluminum Anodes

Provide aluminum anodes with composition and size conforming to NACE mandated requirements.

2.4.1.4 Precious Metal Anodes

Provide [precious metal anodes] [_____], [solid] [composite] [wire] [rod] [expanded mesh] [ribbon] in form. Anode core must be [copper] [niobium] [titanium] with [platinum] [mixed metal oxide] [_____] coating with thickness of [_____] [mils].[Precious metal anode assemblies must have factory sealed and tested electrical connections to the anodes.] Size and length as indicated by engineering design drawings.

2.4.1.5 Mixed Metal Oxide (MMO) Anodes

Titanium Wire anodes with a mixed metal oxide crystalline electrically conductive coating with [0.062 inches] [0.118 inches] diameter.

Nominal Wire Size		**Diameter Tolerance**		**Titanium**		**Active Surface Area**		**Weight**	
mm	**inches**	**mm**	**inches**	**Percent by Weight**	**Percent by Volume**	**m^2/m of Length**	**ft^2/ft of Length**	**g/m**	**lbs/ft**
	0.062		+0.007 -0.00	36.1	52.7		0.017		0.009
	0.118		+0.010 -0.00	17.1	29.0		0.033		0.042

Titanium Rod anodes with a mixed metal oxide crystalline electrically conductive coating with [0.125 inches STD] [0.125 inches XL] [0.25 inches STD] [0.55 inches] [0.75 inches STD] diameter and [24 inches XL] [48 inches XL] length for use in [freshwater or brackish water] [seawater]. STD is standard MMO coating thickness, XL is extended life (greater MMO coating thickness). Titanium tubular anodes with a mixed metal oxide crystalline electrically conductive coating with [___] diameter, [___] length.

Anodes	Diameter		Length		Surface Area		Weight	
mm	cm	inches	cm	inches	m^2	ft^2	kg	lbs
		0.063		39.4		0.78		0.47
		1.00		19.7		0.42		0.40
		1.00		39.4		0.84		0.77
		1.22		30.0		0.82		0.70
		1.22		48.0		1.30		1.10

2.4.1.6 Platinized Niobium [Titanium] Anode

Standard platinized niobium anode must be [20 percent][40 percent] niobium by cross-sectional area with a copper core and [single][double] platinum thickness. The following table shows examples of platinized niobium anodes. Other platinized niobium anodes and platinized titanium may be specified.

20 Percent Niobium				
Diameter	Niobium Thickness	Resistance	Platinum Thickness	
inches	inches	micro-ohm/ft	u-in.	u-in.
0.75	0.038	22	300	600
0.5	0.025	50	200	400
0.375	0.019	89	150	300
0.25	0.013	201	100	200
0.188	0.009	356	75	150
0.125	0.006	806	50	100
40 Percent Niobium				
0.375	0.038	113	150	300
0.25	0.025	256	100	200
0.188	0.019	453	75	150
0.125	0.013	1025	50	100
0.093	0.01	1822	38	75
0.063	0.007	4102	25	50

2.4.1.7 Anode Life Test

The anode wire material must sustain current densities of 9.29 amperes per square feet in an oxygen-generating electrolyte for 20 years. The manufacturer must certify that a representative sample taken from the same lot used to construct the anode, has been tested and meets the following criteria. The test cell must sustain a current density of 9.29 amperes per square feet in a 15-weight percent sulfuric acid electrolyte at 150 degrees F without an increase in anode to cathode potential of more than 1 volt. The cell containing the anode is to be powered with a constant current power supply for the 30-day test period. The representative sample must include a minimum of 5 inch in length taken from the lot of wire that is to be used for the anode.

2.4.2 Galvanic Anodes

2.4.2.1 Magnesium

[ASTM B843] Chemical composition as mandated by NACE.

Bare anode weight: [17] [20] [32] [_____] pounds [not including core].

2.4.2.2 Zinc

[ASTM B418, Type [I] [II].] [ASTM F1182.] [MIL-A-18001] Bare anode weight: [5] [15] [30] [_____] pounds [not including core].

Typical Zinc Bare Anode Sizes and Packaged Weight							
Bare Weight		Width		Height		Length	
kg	pounds	mm	inches	mm	inches	mm	inches
	5		1.4		1.4		10
	12		1.4		1.4		24
	15		1.4		1.4		30
	15		2.0		2.0		15
	18		1.4		1.4		36
	30		1.4		1.4		60
	30		2.0		2.0		30
	45		2.0		2.0		45
	60		2.0		2.0		60

2.4.3 Anode Wires and Cable

2.4.3.1 Anode Connecting Wire

Anode connecting wire must be No. [8] [_____] AWG stranded copper wire with type CP High Molecular Weight Polyethylene (HMWP) insulation, 7/64 inch thick, 600 volt rating. Cable-to-anode contact resistance must be 0.003 ohms maximum.

2.4.3.2 Anode Header Cable

Cable for anode header and distribution must be No. [_____] AWG stranded copper wire with type [CP HMWP, 7/64 inch thick insulation] [HMWPE protective jacketed cable with a fluoropolymer inner or primary insulation], 600-volt rating.

2.4.3.3 Polyethylene Insulation

Polyethylene insulation must comply with the requirements of ASTM D1248 and of the following types, classes, and grades:

2.4.3.3.1 HMWP

HMWP must be Type I, Class C, Grade E5.

2.4.3.3.2 High Density Polyethylene (HDPE)

HDPE must be Type III, Class C, Grade E3.

2.4.3.4 Attachment of Anode Lead Wire

Install anode lead wires at factory.

2.4.3.5 End-Connected Anode

[Drill] [Cast] a recess [6] [_____] inches deep in one end of the anode. Attach the lead wire to the anode with an anchor device. Not more than 1/2 inch of bare wire must protrude from the anchor device. Attachment must withstand a 325 pound pull without loosening the wire or anchor device. Fill the recess with an epoxy sealing compound [, leaving sufficient space for a plug]. [Provide non-metallic plug flush with the anode end surface.] [Install a heat shrinkable anode cap over the attachment. Cap must extend not less than 2 1/2 inches on the lead wire and 3 inches on the anode.] Cable-to-anode contact resistance must not exceed 0.02 ohms.

2.4.3.6 Center-Connected Anode

Attach the lead wire to the center of the anode with an anchor device suitably fastened to the wire. Not more than one inch of bare wire must protrude from the anchor device. Encapsulate [each side of] the connection point with [a minimum of 6 inches [_____] of] high voltage insulating compound mastic and 4 inches [_____] of epoxy resin. Attachment must withstand [900] [1500] [_____] pounds pull without loosening the wire or anchor device. Provide a non-metallic [plug flush with the anode end] [end cap] to prevent chaffing of the anode lead wire. Cable-to-anode contact resistance must not exceed 0.02 ohms.

2.4.3.7 Mixed-Metal-Oxide-Anode Lead Wires

[[Solidly crimp] [and solder] the connection between the anode rod or ribbon and the lead wire. Seal the connection [with two layers of half lapped mastic tape covered with a heat shrinkable sleeve] [in cast epoxy].]

[Tin and anneal the copper wire and hydraulically swage the tubular anode onto copper bushings in contact with the wire. Place a 1 1/8 inch copper sleeve, inner diameter slightly larger than the tubular anode outer diameter, over the tube prior to swaging.] Cable to anode contact resistance must not exceed 0.02 ohms.

2.4.4 Permanent Reference Electrodes

Permanent reference electrodes must be [copper/copper-sulfate] [silver silver-chloride] [zinc] [Hydrocarbon-Proof Palladium (Pd/$PdCl_2$)] specifically manufactured for submersible use, [1 1/4] [_____] inch diameter, by [8] [10] [_____] inches long, [plastic] [_____] tube with a minimum surface sensing area of [_____] [_____] square inches. Must never need recharging, maintenance, or recalibration. Must have impregnated membrane which keeps electrode electrolytes from drying out or getting the reference electrode electrolyte contaminated. Must have ion trap to prevent reference electrode damage from hydrogen sulfide or excess chloride ions. Provide electrodes with No. [10] [12] [_____] AWG, Rubber Heat (resistant) Wire (RHW) [RHW] Thermoplastic Heat and Water-resistant Nylon-coated (THHN) [THHN] [_____] cable of sufficient length to extend to the [rectifier] [junction box] without splicing. No splices are allowed below the high-water level. Reference electrodes will have a minimum 20-year life, stability of plus or minus 5 millivolts under 3 microamp load. The manufacturer must calibrate the PRC to 316 mV plus or minus 10mV referenced to a standard hydrogen electrode (SHE) and provide a calibration certificate detailing the results of the calibration. Procedures for evaluating the accuracy annually must be included in the Operation and Maintenance Manual.

2.5 ACCESSORIES

2.5.1 Shunt Resistors

[0.01] [_____] ohm, [6] [_____] amp, with an accuracy of plus or minus one percent. [Shunts must conform to MIL-I-1361 [rating as shown]].

2.5.2 Conduit

[UL 6, rigid galvanized steel.] [Outlet boxes: UL 514A and Fitting: UL 514B, threaded hubs.] [Metallic conduit and fittings to be polyvinyl-chloride coated in accordance with [NEMA RN 1, Type A40] [NEMA TC 2, Type EPC-40-PVC]]. Provide non-metallic conduit conforming to NEMA TC 2. Provide conduit support in accordance with NFPA 70.

2.5.3 Wires and Cables (other than Anodes)

Provide copper wire conforming to ASTM B3 and ASTM B8. Wires terminating in a rectifier, junction box or test station must have a cable identification tag.

2.5.3.1 AC Power Supply Wiring

[UL 83, Type [THW] [THWN] [THHN]] [UL 44, Type RHW,] [UL 854, Type USE], stranded [solid] copper conductors, gauge (AWG) and color coded as indicated.

2.5.3.2 Reference Electrode Wire

[UL 83, Type [THW] [THWN] [THHN]] [UL 44, Type RHW,] stranded [solid] copper conductors, gauge (AWG) and color coded as indicated.

2.5.4 Wire Connectors

Safety Standard for Wire Connectors must conform to UL 486A-486B.

2.5.5 Splices

[Splices are not permitted in submerged sections of anode lead wire or anode header cable.] Provide splices with a compression connector on the conductor, and insulation and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

(1) Provide cast-type splice insulation by means of molded casting process employing a thermosetting epoxy-resin-insulating material applied by a gravity-poured method or pressure-injected method. Provide component materials of the resin insulation in a packaged form ready for convenient mixing without removing from the package.

(2) Gravity poured method must employ materials and equipment contained in and approved commercial splicing kit which includes a mold suitable for the cables to be spliced. When the mold is in place around the joined conductors, prepare the resin mix and pour into the mold.

(3) Provide [heavy wall] heat-shrinkable splice insulation by means of a thermoplastic adhesive sealant material which must be applied with a clean burning propane gas torch per manufacturer's instructions.

2.5.6 Insulating Tape

Safety Standard for Insulating Tape must conform to UL 510.

2.5.7 Bolting

ASTM A307, Grade B for bolts; ASTM A194/A194M, Grade 2 for nuts. Dimensions: ASME B18.2.1 for bolts, ASME B18.2.2 for nuts. Threads: ASME B1.1, Class 2A fit for bolts, Class 2B fit for nuts. Bolts must extend completely through the nuts and may have reduced shanks of a diameter not less than the diameter at the roof of threads.

2.5.8 Cable and Wire Identification Tags

[Laminated plastic material with black letters on a yellow background] [[Brass] [Stainless steel] material with stamped or engraved letters.] Print letters and numbers a minimum 3/16 inch in size. Provide identifier legend [in accordance with the drawings] [_____].

2.5.9 Clevis Assemblies

Provide clevis assemblies, 1/4 inch flat steel with a spool opening of 2 1/8 inch, 4 1/2 inch long to the centerline of the spindle. Provide porcelain spools, with an outside diameter of 2 1/4 inch and an overall height of 2 1/8 inch.

2.5.10 Pin Insulators

Provide pin insulator assemblies, 4 inches long overall and 1/4 inch diameter aluminum bolt 3/4 inch long attached to the flat end with an aluminum nut and lock washer. Provide porcelain insulator of non-conducting material with hard glazed finish. Provide insulator with a hole through the bottom at least 1/2 inch diameter.

2.5.11 Hand-hole Assemblies

Provide aluminum hand-hole covers, 7 inches in diameter and 1/16 inch thick and connected to insulating rubber gasket, 7 inches in diameter and 1/8 inch thick. Cut handholes 6 inches in diameter. Provide hand-hole assemblies with 1/2 inch bolts and 1/4 inch plate clamping bars.

2.5.12 Exothermic Weld Kits

Provide exothermic weld kits specifically designed by the manufacturer for welding the types of materials and shapes provided.

2.5.13 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.5.14 Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device, as specified or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 0.125 inch thick, white with [black] [_____] center core. Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be one by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.5.15 Cathodic Protection System Operation and Maintenance Manual

A Cathodic Protection System Operation and Maintenance Manual must outline the step-by-step procedures required for system startup, operation, adjustment of current flow, and shutdown. The manual must include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. The manual must list routine maintenance procedures, recommendations for maintenance testing, possible breakdowns and repairs, and troubleshooting guides. The manual must include single line diagrams for the system as installed, instructions in making tank-to-reference electrode potential measurements and frequency of monitoring. The instructions must include precautions to ensure safe conditions during troubleshooting and repair of the CP system.

PART 3 EXECUTION

3.1 SAFETY PRECAUTIONS AND HAZARDOUS LOCATIONS

Any operations that will generate heat, sparks, or flame include, but are not limited to, grinding, soldering, welding, cutting, brazing and exothermic welding. Ensure that hot work equipment is in good repair and used according to manufacturer's recommendations. A thorough safety inspection of the area must be conducted. Remove flammable gasses and liquids from the area. Combustibles in the work area must be moved or covered with fire-retardant blankets. One or more 20-pound ABC-type fire extinguisher(s) must be inspected before each planned use, and be readily available. A qualified fire watch must be present and remain 30 minutes after completion of the task(s). If work is being conducted in an area where explosive vapors could accumulate, adequate ventilation must be provided and air monitoring must be conducted.

3.2 INSTALLATION

3.2.1 Anode Installation

[IEEE C2] [NFPA 70].

3.2.1.1 Icing Climate Requirements

Suspend anodes in a manner similar to that in non-icing climates, except provisions must be made to prevent the anodes and suspending cables from being damaged by freezing or falling ice or by suspended floating flexible anode rings from the tank walls.

3.2.1.2 Anode Placement

Arrange anodes in the tank [and riser pipe] as shown in the drawings [so that protection can be provided to surfaces without exceeding potentials [in the vicinity of the anodes] that will be detrimental to coatings]. Suspend anodes from [roof] [wall] [plate] [structure] by means of factory-installed connecting wire designed to support the anodes in air [before submergence] without failure of the electrical wire insulation or the electrical conductors. Prevent contact between anode and tank surfaces such as man-access hatches, ladders, heater pipes, and stay rods.

3.2.1.3 Anode Hangers

Anode hangers must electrically insulate the anode suspending wire from the tank steel.

3.2.1.4 Handholes

Provide a handhole having a diameter of 6 inches in the tank roof for each anode string to permit replacement or inspection of anodes.

3.2.2 Anode Connection

3.2.2.1 Anode Lead Wires

Electrically connect anodes to the positive D.C. header cable with compression connectors or split bolts, or the header cable may terminate in a junction box for connection with all anode cables. Use a minimum of two split bolts for each connection if split bolts are used. Mark each of the wires terminating in the junction box.

3.2.2.2 Anode Header Cable

Provide header cable on the [underside of the roof] [wall] with electrically insulating hangers which enter the tank near the roof line from an externally mounted junction box. External wiring must be in conduit. Mark each of the wires terminating in the junction box.

3.2.2.3 Splices and Terminations

Locate under-roof electric wire splices above the high water line and seal water-tight using cast-type splice, gravity-poured method or heat shrinkable splice insulation as described in Section 2. Splices are not permitted in submerged sections of the anode lead wire or anode header cable.

3.2.3 Rectifiers

3.2.3.1 Rectifier Installation

Location and mounting as indicated. Assemble and attach equipment enclosures to [wall] [post] [pad] in accordance with the manufacturer's instructions. Handle wires to prevent stretching or kinking the conductors or damaging the insulation. Use lubricants when pulling wires into conduits. Bond the equipment enclosures to a grounding electrode.

3.2.3.2 Rectifier Grounding

Locate ground rod(s) as indicated in drawings. Measure resistance to earth. If resistance to earth is more than 25 ohms, install additional ground rod(s) at a distance of 12 feet or more and retest. Repeat if required. Low-resistance backfill, certified for use in grounding systems, may be required in exceptionally high soil resistivities using manufacturer's recommendations.

3.2.3.3 Wire-To-Tank Connections

Connect the structure wire to the tank [_____] [by use of an exothermic weld kit] [by brazing]. Clean the structure surface by scraping, filing, or wire brushing to produce a clean, bright surface. [Weld connections using the exothermic weld kits in accordance with the manufacturer's instructions. Test the integrity of the weld, prior to coating, by striking with a 2 pound hammer.] [Cover connections and surrounding cleaned surface with an electrically insulating coating compatible with the existing coating.]

3.2.4 Permanent Reference Electrodes

3.2.4.1 Permanent Reference Electrode Verification

Verify permanent reference electrodes against a portable electrode in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager before installation. Verify in a non-metallic container of water with the same composition as the tank to be protected. Permanent electrode must measure a reference potential agreeing with that measured by the portable electrode within plus or minus 0.010 volt when the sensing windows of the two electrodes being compared are not more than 0.07 inch apart but not touching. Remove permanent reference electrodes not within this potential range from the construction site by the end of the day and replace at the contractor's expense. The testing provision applies to replacement permanent reference electrodes as well.

3.2.4.2 Installation

Provide permanent reference electrodes at points in the tank [and riser pipe] which monitor minimum and maximum [tank] [/riser]-to-water [potentials], regulate the automatic control system [_____], and maintain continuous immersion. Sensing windows of reference electrodes must be equidistant to and located within one inch of the steel tank/riser pipe surface and be fixed in position, preventing contact with tank wall or appurtenances.

3.3 BOLTED AND RIVETED TANKS

Ensure electrical continuity of joining components.

3.4 GASEOUS EVOLUTION

Provide for possible evolution of gases from anode reaction and ventilation requirements.

3.5 FIELD QUALITY CONTROL

Field tests must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager or their designated representative. Advise the Contracting Officer or Contracting Officer's Representative [5] [_____] days prior to performing each field test. Quality control for the cathodic protection system must consist of the following:

a. Initial field testing by the contractor upon construction.

b. Government field testing after contractor has submitted initial field test report.

c. Warranty period field testing by the contractor.

d. Final field testing by the contractor after one year of service.

3.6 TESTS AND MEASUREMENTS

3.6.1 Native Potentials

Notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of five (5) working days prior to each test. Base potential tests: At least [one week] [24 hours] [_____] after [installation of structure to be protected] [initial operation of structures containing fluids] and installation of the anodes, but before connection of anodes to the structure, measure base (native) structure-to-electrolyte potentials of the [structure]. Perform measurements at anode junction boxes, test stations and other locations suitable for test purposes. The locations of these measurements must be identical to the locations specified for potential measurements with anodes connected. Use the same measuring equipment that is specified for measuring protected potential measurements.

3.6.2 Protected Potentials

Systems must be tested and inspected by the contractor's corrosion engineer in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager corrosion protection engineer or an approved representative. Notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of five working days prior to each test. At least [one week] [24 hours] [_____] after native potential testing and connection of anodes to the structure, measure protected structure-to-electrolyte potentials. The locations of these measurements must be identical to the locations specified for native potential measurements. Use the same measuring equipment that is specified for measuring protected potential measurements. Record test data, including date, time, and locations of testing and submit report to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Contractor must correct and retest, at the contractors and Technical Experts expense, deficiencies in the materials and installation observed by these tests and inspections.

3.6.3 Reference Electrode Potential Measurements

Upon completion of the installation and with the entire CP system in operation, electrode potential measurements must be made using a copper/copper sulfate reference electrode and a potentiometer-voltmeter, or a direct-current voltmeter having an internal resistance (sensitivity) of not less than 10 megohms per volt and a full scale of 10 volts. The locations of these measurements must be identical to the locations used for baseline potentials. The values obtained and the date, time, and locations of measurements must be recorded. No less than eight (8) measurements will be made.

3.6.4 Holiday Test

Any damage to the protective coating during installation must be repaired before completion. After repair-coating has been applied, the entire structure, tank, wall or pipe must be inspected by an electric holiday detector with impressed current in accordance with NACE SP0188. The holiday detector will be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Holidays in the protective coating must be repaired upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager to determine suitability of the detector. Labor, materials, and equipment necessary for conducting the inspection must be furnished by the contractor. The coating system must be inspected for holes, voids, cracks, and other damage during installation.

3.6.5 Rectifier Testing (impressed current systems only)

The purpose of the rectifier operational inspection is to determine the serviceability of all components required to impress current to the anodes of the impressed current system. The inspection must be thorough to ensure dependable current until the next inspection.

a. Before energizing the rectifier, visually check all rectifier components, shunt box components, safety switches, circuit breakers, and other system power components.

b. Tighten all accessible connections and check temperature of all the components.

c. Ensure all permanent reference electrode caps are removed and placed inside the rectifier cabinet for verification of removal and for use during tank cleaning.

d. Startup testing of the rectifier must include voltage and current testing at all tap settings up to the level of protection or maximum of the rectifier rated current, whichever is the lowest. Do not apply excessive current to the tank. For automatic rectifiers, record each tap setting (if available) before switching to automatic potential control.

e. Using a dependable hand-held meter, measure the output voltage and current, and calibrate the rectifier meters, if present. For rectifiers with more than one circuit, measure the output voltage and current for each circuit using a dependable hand-held meter, and calibrate the rectifier meters, if present.

f. For systems with permanent reference electrodes, using a calibrated reference electrode, measure the potential difference to each installed permanent reference electrode by placing both electrodes together in the electrolyte with CP current off (may be tested before installation). If the difference is more than 10 mV, replace the permanent reference electrode. For rectifiers with potential voltmeters, using a dependable hand-held meter, measure the potentials for each voltmeter, and calibrate that rectifier meter.

g. Calculate the CP system circuit resistance of each circuit by dividing the rectifier DC voltage output of each circuit by the rectifier DC ampere output for that circuit.

h. Calculate the rectifier efficiency.

3.6.6 Initial Cathodic Protection System Testing

Initial field testing must be completed by the contractor upon completion of construction. Field testing must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager or their designated representative. Advise the Contracting Officer or Contracting Officer's Representative [5] [_____] days prior to performing each field test. Field testing must include native and protected potentials, anode current testing and permanent reference electrode testing.

The contractor must submit an initial field test report of the CP system. Tank-to-electrolyte measurements, including initial potentials, protected potentials, anode outputs, rectifier and other required testing must be recorded on applicable forms. Identification of test locations, test station and anode test stations will coordinate with the as-built drawings and be provided on system drawings included in the report. The contractor must locate, correct, and report to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager any short circuits encountered during the checkout of the installed CP system.

3.6.7 Government Field Testing

The government corrosion [engineer] [program manager] must review the contractor's initial testing report. Approximately four weeks after receipt of the contractor's initial test report, the system will be tested and inspected in the contractor's presence by the government corrosion [engineer] [program manager]. The contractor must correct, at the contractor's expense, materials and installations observed by these tests and inspections to not be in conformance with the plans and specifications. The contractor will pay for all retesting done by the government engineer made necessary by the correction of deficiencies.
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3.6.8 One-Year-Warranty-Period-Testing

The contractor must inspect, test, and adjust the CP system [quarterly] [semi-annually] [_____] for one year, [4] [2] [_____] interim inspections total, to ensure its continued conformance with the criteria outlined below. The performance period for these tests will commence upon the completion of all CP work, including changes required to correct deficiencies identified during initial testing, and preliminary acceptance of the CP system by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Copies of the One Year Warranty Period Cathodic Protection System Field Test Report, including field data, and certified by the contractor's corrosion engineer must be submitted to the Contracting Officer or Contracting Officer's Representative, the activity, and the geographic EFD corrosion [engineer] [program manager] [Contracting Officer] [Contracting Officer's Representative] [Technical Expert] [Project Manager].

3.6.9 Final Acceptance Field Testing

Conduct final acceptance field testing of the CP system utilizing the same procedures specified under the Initial Field Testing of the CP systems. The contractor will inspect, test, and adjust the CP system after one year of operation to ensure its continued conformance with the criteria outlined below. The performance period for these tests will commence upon preliminary acceptance for the CP system by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Copies of the Final Cathodic Protection System Test Report, certified by the contractor's corrosion engineer must be submitted to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager and the geographic EFD corrosion [engineer] [program manager] for approval, and as an attachment to the Operation and Maintenance Manual in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. The government corrosion [engineer] [program manager] must review the contractor's final field testing report.

3.7 CLOSEOUT ACTIVITIES

3.7.1 Reconditioning of Surfaces

3.7.1.1 Concrete

Concrete must be 3000 psi minimum ultimate 28-day compressive strength with one inch minimum aggregate conforming to [ASTM C94/C94M] [Section 03 30 00 CAST-IN-PLACE CONCRETE].

3.7.1.2 Restoration of Sod

Restore unpaved surfaces disturbed during the installation to their original elevation and condition. In areas where grass cover exists, it is possible that sod can be carefully removed, watered, and stored during construction operations, and replaced after the operations are completed. Where the surface is disturbed in a newly seeded area, re-seed the area with the same quality and formula of seed as that used in the original seeding. Seeding must be done as directed, in all unsurfaced locations where sod and topsoil could not be preserved and replaced. The use of sod in lieu of seeding will require approval by the Contracting Officer or the Contracting Officer’s Representative, Technical Expert and Project Manager.

3.7.1.3 Restoration of Pavement

Repair pavement, sidewalks, curbs, and gutters where existing surfaces are removed or disturbed for construction. Saw cut pavement edges. Graded aggregate base course must have a maximum aggregate size of 1 1/2 inches. Prime base course with [liquid asphalt, ASTM D2028/D2028M, Grade RC-70] [_____] prior to paving. Match base course thickness to existing but must be atleast 6 inches. Asphalt aggregate size must be 1/2 inch [_____], asphalt cement must [conform to ASTM D3381/D3381M, Grade AR-2000] [_____]. Match asphalt concrete thickness to existing but must not be less than 2 inches. Repair Portland cement concrete pavement, sidewalks, curbs, and gutters using 3,000 psi concrete conforming to [ASTM C94/C94M] [Section 03 30 00 CAST-IN-PLACE CONCRETE.] Match existing pavement, sidewalk, curb, and gutter thicknesses. Final surface must be the same level as the existing surface.

3.7.1.4 Cleanup

The contractor is responsible for cleanup of the construction site. All paper bags, wire clippings, must be disposed of as directed. Paper bags, wire clippings and other waste will not be put in bell holes or anodes excavation.

3.7.2 Training

3.7.2.1 Instruction to Government Personnel

During the warranty testing or at a time designated by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager, make available the services of a technician regularly employed or authorized by the manufacturer of the CP system for instructing Government personnel in the proper operation, maintenance, safety, and emergency procedures of the CP system. The period of instruction must be atleast [two] [four] [_____] hour[s] and at most [two] [_____] 8-hour working day[s]. Conduct the training at the jobsite or at another location mutually satisfactory to the government and the contractor. The field instructions will cover all of the items contained in the Operation and Maintenance Manual.

-- End of Section --

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SECTION 26 42 19.10

CATHODIC PROTECTION SYSTEMS (IMPRESSED CURRENT) FOR LOCK MITER GATES
11/08

PART 1 GENERAL

1.1 UNIT PRICES

Measurement and payment requirements will be specified for work subject to extreme variation in estimated quantity when unit price bidding is required.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

If the Contractor desires, for any reason, to deviate from or utilize publications other than those designated below, submit to the Contracting Officer, for review and approval, the requested deviation and/or the publication proposed for use. This submission shall clearly state the requested deviation and the reasons for it, including a complete comparison and cross-reference in sufficient detail to prove compliance to the applicable portions of the publications referred to herein and listed below.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1 (1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASTM INTERNATIONAL (ASTM)

ASTM A518/A518M (1999; R 2018) Standard Specification for Corrosion-Resistant High-Silicon Iron Castings

ASTM D789 (2015) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)

ASTM D1248 (2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

NACE INTERNATIONAL (NACE)

NACE SP0169 (2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1 (2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)

NEMA 250 (2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ST 1	(1988; R 1994; R 1997) Specialty Transformers (Except General Purpose Type)
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

U.S. ARMY CORPS OF ENGINEERS (USACE)

CERL Tech Rep FM-95/05	(1994) Field Evaluation of Cathodic Protection Systems Using Ceramic-Coated Anodes for Lock and Dam Gates
EM 1110-2-2704	(2021) Engineering and Design -- Cathodic Protection Systems (CPS) for Civil Works (CW) Structures

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

1.3 SYSTEM DESCRIPTION

1.3.1 General Description

Furnish, install, test and place in service a complete cathodic protection system for the lock miter gates consisting of all equipment, wiring, and wiring devices necessary to produce a continuous flow of direct current from the anodes in the water electrolyte to the gate surfaces to, adequately and efficiently, protect the surfaces of the metal structures against corrosion where the surfaces are in contact with the water. The metallic surfaces of the gates need only be protected to upper pool stages, except that the downstream side of the lower gate shall be protected to lower pool level. This is in addition to the protective coating on the gates.

a. Provide, prior to system installation, detailed design calculations, bill of materials lists and drawings of the cathodic protection system. The detailed drawings shall show the system installation including arrangement and locations of all anodes, terminal boxes, conduit routing and test facilities to be installed for corrosion control on the submerged surfaces of the gates. Six copies each of detail drawings of the proposed cathodic protection system installation, proposed bill of materials, and Contractor design calculations within [30] [45] [90] [_____] days after receipt of notice to proceed, and before commencement of any work. The drawings shall provide dimensions and show anode arrangement for both elevated and sectional views of the gates, rectifier details and locations, terminal box details and locations, mounting details, wiring diagram, conduit layout locations, types and transitions and any other pertinent information considered necessary for the proper installation and performance of the system.

b. The Contractor's furnished materials list, design calculations and drawings shall be approved by the Contracting Officer prior to purchasing, delivering or installing any of the cathodic protection system. These specifications together with the approved materials list, design calculations and drawings shall provide the minimum requirements of this contract.

c. The cathodic protection system shall be furnished complete and in operating condition as further defined later in this specification.

1.3.2 Performance Requirements

Final test and adjust the system such that the cathodic protection system is providing corrosion control for the submerged surfaces of the lock miter gates in accordance with the following paragraphs taken from Section 6 of NACE SP0169.

1.3.2.1 First Criterion

A negative (cathodic) voltage of at least a minus 850 millivolts "instant-off" potential, as measured with respect to a calibrated, saturated copper-copper sulfate reference electrode (CSE) over 90 percent of each gate leaf face, and at least minus 800 millivolts "instant-off" at all other locations. These requirements do not necessarily include those areas within 2 ft of the sill, quoin and miter of each gate (refer to Paragraph 1.3.3.2 of NACE SP0169). The above criteria shall be achieved without the "instant-off" potential exceeding minus 1100 millivolts at any location. Determination of this voltage shall be made with the cathodic protection system in operation. Correction shall be made for IR drop using "instant-off" potential measurements (all operating cathodic protection systems shall be simultaneously interrupted). If digital meters are used to obtain these measurements, the second reading displayed on the digital voltmeter after interruption of the rectifier current shall be interpreted as the "instant-off" reading.

1.3.2.2 Second Criterion

A second criterion may be used for those gate submerged surfaces within 2 ft of each gate sill, quoin, and miter to ensure that the operating conditions are providing cathodic protection. This criterion is a minimum cathodic polarization voltage decay of 100 millivolts provided that a potential of at least minus 750 millivolts "instant-off" potential as measured with respect to a calibrated, saturated copper-copper sulfate reference electrode (CSE) is also obtained. Polarization shift measurements shall be made within 1 ft of the sill plate at the quoin, at 2 ft intervals along the gate bottom, and at the miter on each gate leaf face. This criterion cannot be used until the criterion in paragraph 1.3.3.1 of NACE SP0169 for the remaining gate submerged surfaces have been maintained for a minimum 1-week period. This allows time for the cathodic protection system to polarize the gate metal. The "instant-off" potential shall be measured between the structure surface and a saturated copper-copper sulfate reference cell immersed in the electrolyte directly adjacent to the structure. Interrupting the protective current and measuring the polarization decay thereafter shall determine this polarization voltage shift. When the protective current is initially interrupted, an immediate voltage shift will occur. The second voltage reading observed after the immediate voltage shift shall be recorded and used as the base reading from which to measure polarization decay. Readings shall then be taken each 10 minutes thereafter and the voltage readings and time intervals recorded. The total time for achieving this decay shall be 4 hours or less.

1.3.3 Contractor Quality Control

1.3.3.1 General

Establish and maintain quality control for all operations to assure compliance with contract requirements and maintain records of this quality control for all construction operations, including, but not limited to, the following:

a. Design
b. Materials
c. Assembly and workmanship
d. Installation
e. Testing

1.3.3.2 Reporting

The original and two copies of these records and tests, as well as corrective action taken, shall be furnished [daily] [_____] to the Contracting Officer.

1.3.4 Modification of Design

No modifications of the design of the cathodic protection system as specified and shown on the Contractor's approved drawings shall be made except with the express written approval of the Contracting Officer. Submit all Contractor identified discrepancies in the design or any change proposals with sufficient details for complete evaluation by the Contracting Officer. The minimum design requirements specified herein shall be met. All such proposed modifications shall be fully described and submitted to the Contracting Officer for approval. The Contractor is responsible for the satisfactory performance of the furnished complete systems. Modifications or changes proposed shall be identified as a "MODIFICATION" or "CHANGE" and shall be submitted to the Contracting Officer for approval within 15 days after the need for such modification or change is determined.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a

code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Drawings; G[, [_____]]

SD-03 Product Data

Materials and Equipment; G[, [_____]]
Training Course; G[, [_____]]
Protective Angle Irons; G[, [_____]]
Modification of Design; G[, [_____]]

SD-06 Test Reports

Factory Test Data
System Commissioning; G[, [_____]]

SD-07 Certificates

Qualifications; G[, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G[, [_____]]

1.5 QUALITY ASSURANCE

1.5.1 Qualifications

The cathodic protection system installation, including all testing, energizing and placing of system in service, shall be performed by an organization that has had a minimum of 5 years' experience in this type of work. The Corrosion Expert whose credentials meet or exceed those provided for below shall supervise the installation and testing of this system. Submit certified Corrosion Expert(s) qualifications for all personnel who may be used to fulfill this position on the project. Installation of the cathodic protection system will also be witnessed by the Contracting Officer. Provide certified information with their submittals evidencing their compliance with this organization experience requirement.

1.5.2 Contractor's Responsibilities

Provide the services of a Corrosion Expert to design, supervise installation, test and final adjust the miter gate cathodic protection system for operation in accordance with these specifications. Inspect all work associated with the system installation, certify all work prior to system energization and be present and participate in all system testing and final adjusting.

1.5.3 Corrosion Expert

"Corrosion expert," as used in this specification, is a person, who, by reason of thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of submerged metal structures. Such a person shall be accredited or certified by the National Association of Corrosion Engineers (NACE) as a NACE Accredited Corrosion Specialist or a NACE certified Cathodic Protection (CP) Specialist or be a registered professional engineer who has certification or licensing that includes education and experience in corrosion control submerged metallic structures, if such certification or licensing includes 5 years' experience in corrosion control on metallic structures of the type under this contract.

1.5.4 Pre-Installation Meeting

A pre-installation meeting shall be conducted at the project site office which shall be attended by the Contractor's project superintendent and corrosion expert. This meeting shall be held after all pre-construction submittals have been made and approved by the Contracting Officer prior to the start of any work on this project. The meeting shall include discussions of Safety, Communication and Work Plans, as well as any other issues which may have risen as a result of the submittal review.

1.6 DELIVERY, STORAGE, AND HANDLING

The Contracting Officer will arrange to provide an unsecured area onsite for the Contractor to store the system materials and installation equipment. The area's size will be limited to approximately [_____] square feet. Provide storage means to secure the equipment against loss due to theft and/or weather, fire or floods.

1.7 PROJECT/SITE CONDITIONS

Coordinate and properly relate the work to the site and to all trades. The location and dimensions of the gate structures to receive protection are available from the Contracting Officer. The cathodic protection system design is based on a water resistivity of [_____], a total area, in square feet, of [_____], a minimum coating efficiency of 50 percent, a minimum current density requirement for effective cathodic protection of [_____] amperes/bare square foot of submerged steel and a 20-year life expectancy.

1.8 WARRANTY

The materials, equipment, and workmanship furnished under this section of the specifications shall be guaranteed for a period of 1 year from the date of acceptance. Prior to expiration of the warranty period, the Government will conduct a System voltage and current output test of the cathodic protection system including each anode output installed on the lock gate structure as well as detailed "On" and "Instant-Off" structure to electrolyte potential measurements to determine if the system and equipment are performing in accordance with the plans and specifications and that no significant deterioration of the system or components therein has occurred during the first year of operation. Acknowledge responsibility under these guarantee provisions by letter, stating that the equipment, materials, and workmanship referred to herein are guaranteed to continue to perform as installed and to continue to provide effective corrosion control in accordance with the criteria elsewhere in these specifications and specifically indicating the inclusive dates of the guarantee period starting at the date of final acceptance of the correctly working system approved by the government and for a period of 1 year thereafter.

1.9 SYSTEM COMMISSIONING

1.9.1 General

The Contractor's Corrosion Expert shall perform the following system energizing and commissioning tests. Perform all energizing and commissioning tests in the presence of the Project Corrosion Engineer, recorded and submitted to the Contracting Officer within [_____] days following completion of the test. Submit all installation and energization measurements and test data in tabulated form. Notify the Contracting Officer 30 days in advance of the date of the test so that a representative can be present. All instruments used in conducting the tests shall have been calibrated by an accredited testing laboratory within 1 year prior to the test. Certification shall be provided to the Contracting Officer for approval.

1.9.2 Insulation Testing

After installation of the button anode on the gate, but prior to connection to the rectifier and submergence, an insulation test shall be made to demonstrate that no metallic contact or short circuit exists between the anode and the structure. These tests shall be made using a Megger apparatus or other device specifically designed for this purpose. Any insulation found to be shorted shall be replaced. Each button anode shall have a minimum resistance of 500,000 ohms isolation from the gate. If the button anode fails to indicate 500,000 ohms isolation, make the necessary corrections and/or modifications to the anode installation to achieve the minimum reading.

1.10 EXTRA MATERIALS

a. Furnish spare rod, sausage and button-type anodes (the type used in the original installation) to the Contracting Officer with a minimum of five of each type installation component required for the original installation of the sausage and button anodes. Sufficient neoprene gaskets, mounting hardware, and epoxy cement shall be furnished for installation of the silicon button anodes. Supply a minimum of two of each type of anode rod or string assemblies each for the upstream and downstream gates (anode assembly complete with factory attached 100 ft anode lead cable and a minimum of five disk or button anodes with 100 ft of factory attached cable). Cement, epoxy, polychloroprene gaskets, etc. and any other material needed for installation shall be supplied in sufficient quantity to install these spare components.

b. Furnish a complete set of special tools, provided in a steel or plastic toolbox, for use in installing all types of anodes used in the installation. Tools used in making the original installation, provided they are in good working condition, will be acceptable. One tool shall be a torque wrench device capable of 40 psi.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

All cathodic protection system materials and equipment furnished shall be designed for a minimum 20-year service life when operating at the system maximum rated output. The components to be used shall be based on the Contractor's Cathodic Protection System Specialist's design which shall be in accordance with these specifications. Submit a complete list in triplicate of materials and equipment to be incorporated in the work, within [30] [45] [90] [_____] days after date of receipt of notice to proceed, and before commencement of installation of any materials or equipment. The list shall include cuts, diagrams, and such other descriptive data as may be required by the Contracting Officer. Partial lists submitted from time to time will not be considered. Submit, as a minimum, the following:

a. Water resistivity as measured on site.

b. Complete system design calculations which, as a minimum, shall be as provided in Appendix "K" of CERL Tech Rep FM-95/05 including calculations for total current required for each gate side, each anode circuit resistance, rectifier current and voltage output requirements and life of each anode type and location within the system.

c. Complete list of materials for all cathodic protection system components including all replaceable components in the rectifier units, terminal boxes and anodes materials with mounting equipment including part numbers and source name, address and phone number for each component.

d. Conductor types and sizes including copper grade, number of strands, insulation, and resistance for each wire type and size to be used.

e. Anodes, layout of anodes, and detailed description of anode installation procedure.

f. Layout of rectifiers and anode terminal boxes, rectifier and terminal box details including method of control including wiring diagram and schematic, output measurement means, cabinet materials and construction, ammeters and voltmeters, shunt resistors, variable resistors, and AC & DC lightning and surge protection.

g. All connections, supports, and seals for conductors, conduit, and plastic and steel protector pipes, pipe caps, angle iron, [_____].

h. All watertight connections and connection protection means.

i. Resistor and anode terminal cabinet details and mounting locations. Identified connections and conductors in the terminal cabinet shall be shown on a drawing.

j. Certified experience and qualification data of installing firm, as specified in paragraph QUALIFICATIONS.

2.1.1 Direct Current Cables

2.1.1.1 Anode Lead Cables

Direct current cable from the terminal cabinet to each anode disk, ribbon, button or rod assembly shall consist of 7-strand No. 8 AWG stranded copper wire with type CP high molecular weight polyethylene insulation (HMPE), 7/64 inch thick, 600-volt rating, in accordance with ASTM D1248, Type I, Class C, Grades E-5 and J-1. Each anode lead shall be continuous without splices from its point of connection in the terminal cabinet to the anode disk, ribbon, button, or rod assembly. The cable-to-anode connection shall be assembled by the manufacturer and the area shall be sealed with a waterproof epoxy. Cable-to-anode contact resistance shall be 0.003 ohm maximum. HSCI string anode assemblies (assembled in link sausage manner to the anode cable lead) shall also be assembled by the manufacturer. The conductor for the HSCI sausage strings only shall be 7-strand, No. 4 AWG copper wire with CP high molecular weight polyethylene insulation (HMPE), 7/64 inch thick, 600-volt rating, in accordance with ASTM D1248, Type I, Class C, Grades E-5 and J-1, and shall not be cut or spliced within the anode or assembly and shall be routed without splicing to the anode terminal box. The cable HMPE insulation does not adhere well to some epoxies and shall be roughed in the sealant area prior to application of the sealant to the anode connections. Anode leads, terminal board connections, and corresponding jumpers on the front of the terminal board shall be marked with the anode number, as specified.

2.1.1.2 Rectifier and Terminal Cabinets Connection Cables

Conductors shall be soft drawn copper and shall have the number of conductors as shown on the drawings. Cables connecting the terminal cabinet to the lock wall outlet and cables between the lock wall outlet and the rectifier dc terminals shall be No. 10 AWG insulated copper wire, and have a neoprene jacket. Cables between the resistor and anode terminal cabinets on each gate shall consist of 7-strand No. 8 AWG stranded copper wire with type CP HMPE, 7/64 inch thick, 600-volt rating, in accordance with ASTM D1248, Type I, Class C, Grades E-5 and J-1. One conductor shall be included for each dc plus (+) circuit and one conductor for each negative (-) connection. Each cable shall be continuous without splices from its point of connection in one terminal cabinet to its point of connection in the other terminal cabinet.

2.1.2 Cable in Conduit

Cathodic protection cables shall consist of soft drawn copper conductors with Class B stranding and a [low-density, high-molecular-weight black polyethylene] [RHW-USE Style RR Hypalon] covering serving as both insulation and jacket. Cables shall meet or exceed the requirements specified above. Flexible cable connections between the ac power outlet on the lock wall and the ac input terminals of the rectifier shall be made with No. 10 AWG copper conductors in flexible portable power cables, UL type SO.

2.2 RECTIFIERS AND AUXILIARY EQUIPMENT

2.2.1 General

Provide a rectifier unit for [each upstream and downstream face of each gate leaf] [each of the four gate leaves of the lock]. The cathodic protection system power circuit shall consist of a step-down transformer with secondary taps for output adjustment, primary circuit breaker, rectifier transformer, rectifier, secondary fuses, and rectifier terminal panel. The rectifier units shall be located [in the control houses] [outside at the specified locations]. They shall be designed [for removal during periods when flood waters overtop the lock wall] [to be free-standing].

2.2.2 Cabinets

The rectifier cabinet shall house the rectifier transformer, rectifier stacks, circuit breaker, terminals, and the control and instrument panel. In installations requiring the use of a step-down transformer, the cabinet shall be designed such that the rectifier equipment specified above can be installed in the lower section of the cabinet with the step-down transformer in the upper portion. Cabinets shall be [convection air cooled] [oil immersed cooled] constructed of 14-gauge minimum sheet stainless steel, ASTM grade 304. The cabinets shall be designed for use outdoors; NEMA 250, enclosure 3R, and appropriate structural shapes shall be used in the construction of the cabinet to provide rigidity and to prevent bending or flexing of the cabinet while being transported. Louvers for air-cooled units shall be provided in the hinged doors and on the sides of the cabinets for ventilation. All ventilation openings shall be covered with ASTM grade 304 stainless steel insect screen arranged so as to be easily replaceable. All doors shall be hinged using post hinges designed to allow easy removal of all doors for unit servicing and shall be provided with a hasp and lock for padlocking. Locks used shall be keyed alike such that all cabinets can be opened with one key. Furnish the keys and turn them over to the Contracting Officer.

2.2.3 Wheeled Rectifier Cabinets (Alternate 1)

The rectifier cabinet shall be mounted on wheels and provided with handles for moving during floods. The wheels, axles, and bearings shall have sufficient capacity to support a weight of at least three times the weight of the complete rectifier. Studs for the clamps to be used for securing the rectifier to the pipe rail, as shown on the drawings, shall be welded to a reinforced back section of the cabinet at the factory before finishing. All components shall be ASTM grade 304 SS or equal.

2.2.4 Stationary Cabinets (Alternate 2)

The rectifier cabinet shall be mounted on structures as shown on the drawings. Welding of ASTM grade 304 SS or equal clamps, brackets, or cabinet-back reinforcement, shall be accomplished at the factory before finishing.

2.2.5 Circuit Breakers

A 120/240-volt, [10] [_____] ampere-interrupting-capacity, double-pole, molded-case circuit breaker conforming to UL 489 shall be installed in the primary circuit of the rectifier transformer and shall disconnect both conductors. The breaker shall be provided with instantaneous and inverse time trips. [10] [_____] ampere cartridge-type fuses conforming to NEMA FU 1 with suitable fuse holders shall be provided in each leg of the dc circuit.

2.2.6 Step-down Transformers

Step-down transformers shall be of the two-winding, insulating dry type conforming to NEMA ST 20 and shall be rated for 480-120/240 volts, single-phase, 60-Hertz. Transformers shall be provided with 2 to 5 percent full capacity primary taps below rated voltage. Transformers shall be rated for not less than a temperature rise of 176 degrees F above a 104 degrees F ambient and shall be provided with Class B or H insulation.

2.2.7 Rectifier Transformers

The rectifier transformer shall be two-winding, [convection air-cooled] [oil immersed cooled], with a primary operating voltage of 120/240 volts, single phase, and shall conform to the requirements of NEMA ST 1. The transformer secondary shall be provided with five "coarse" and five "fine" taps on each dc circuit, to permit variations of the dc output voltage in 25 uniform increments of the rated output voltage, from zero to a maximum rated voltage of [_____] volts. Voltage steps shall be adjustable by rotating solid brass tap bars. Each control shall be identified by suitable permanent, engraved marking such as "coarse" or "fine" and shall have an arrow to indicate the type and direction of adjustment. Individual steps of adjustment shall be marked with numbers in consecutive order for fine control and with letters in alphabetical order for coarse control. All primary alternating current terminals shall be mounted behind the panel. The coils of all transformers manufactured for cathodic protection use shall be dipped in preheated varnish and baked dry for maximum moisture and corrosion resistance.

2.2.8 Rectifiers

Rectifier stacks shall be [air-cooled] [oil-immersed] units, consisting of silicon stacks to provide full-wave, bridge-type rectification, within the manufacturer's ratings. The rectifier shall be suitable for operation over an ambient temperature range of 0 to 120 degrees F. Output ratings shall be as designed by the Corrosion Expert and shall be for continuous duty operation.

2.2.9 Ammeter and Voltmeter

A dc ammeter and voltmeter of the semi flush, 3-1/2 inch round or rectangular panel board type, conforming to the applicable requirements of ANSI C39.1, shall be provided in each dc circuit, or as otherwise indicated on the drawings. Instruments shall be of the sealed, taught band type have a guaranteed accuracy of 1 percent of full-scale deflection, zero adjustment, and a minimum scale length of 2.4 inch. Full load reading shall be indicated by means of a red mark on the meter scale and shall incorporate at least 80 percent of the meter scale length. Each meter shall be provided with a momentary contact switch, either integral with the meter or separately mounted, for momentary reading. A single meter having dual scales may be furnished in lieu of separate meters, provided that the scales are distinct and easily read, and that a switch is provided to select the desired function and to prevent simultaneously energizing more than one function.

2.2.10 Current Monitoring Shunt

A separate current monitoring shunt resistor shall be provided on the rectifier unit face plate to facilitate using an external digital milli-voltmeter to confirm the current output displayed by the unit ammeter. This shunt resistor shall have a calibrated accuracy of plus or minus 1 percent and shall have a 1 ampere/millivolt drop rating.

2.2.11 Ammeter and Voltmeter Switches

The switches used for switching the meters in and out of the dc circuit shall be lever action sealed toggle, quick make-or-break type switches. The switches shall be [[single-pole] [double-throw]] [[double-pole] [double-throw]] and shall be wired so that do not interrupt the output circuit.

2.2.12 Control and Instrument Panel

The control and instrument panel shall be of the dead-front type and shall be installed in the rectifier cabinet. Primary connection shall be made by means of a panel-mounted terminal block with screw connection protected by a removable metal or molded plastic cover. Incoming power lines shall be terminated in such a manner as to prevent accidental contact by personnel using the rectifier.

2.2.12.1 Tap Bars

Tap bars serving the rectifier transformer secondary adjustment shall be permanently identified by means of engraving on the non-metallic control panel face plate denoted "coarse" and "fine" and shall have the individual tap positions identified by letters, "A," "B," "C," etc., and numerals, "1," "2," "3," etc., respectively.

2.2.12.2 DC Output Terminals

Rectifier dc output terminals shall be identified by means of engraving on the non-metallic control panel face plate indicating polarity of the terminal and point of connection to the system, i.e., "+ANODES" and "-STRUCTURE."

2.2.12.3 Components Identification

All other components on the rectifier panel face plate shall be identified by means of engraving on the non-metallic control panel face plate.

2.2.13 Anode Cable Leads

Anode cable leads shall be identified at the resistor and anode terminal cabinet by means of plastic sleeves or tags showing the anode lead number as indicated on the drawings. They shall be of sufficient length so that splicing between the anode and the anode terminal box is not necessary. No splices of the anode lead wires will be permitted between the anode and the anode terminal box.

2.2.14 Surge Arresters

MOV surge arresters shall be provided for all AC & DC power circuits. In addition, for AC voltages above 120-volt, a single pole valve-type surge arrester shall be used for each input line. It shall be located ahead of the ac breaker feeding the rectifier transformer. Surge arresters shall be rated for continuous load currents up to [10] [_____] amps minimum and shall limit the voltage to 200 volts peak. The response clamping activation time shall be 5 nanoseconds maximum.

2.2.15 Wiring Diagram

A complete wiring diagram of the rectifier unit showing both the ac supply and the dc outputs to the resistor and anode terminal cabinets shall be encased in clear rigid plastic and mounted on the inside of the rectifier cabinet door. All components shall be shown and labeled.

2.2.16 Resistor and Anode Terminal Cabinet Wiring Diagram

A complete wiring diagram showing the anode numbers in the terminal cabinets and a complete wiring diagram of the entire cathodic protection system shall be provided. Each conductor and each termination shall be identified.

2.3 CONDUIT AND FITTINGS

2.3.1 Nonmetallic Conduit

Nonmetallic conduit shall be type 80, extra heavy-wall, PVC, rigid-plastic conduit. Conduit shall conform to the requirements of NEMA TC 2. PVC conduit utilized as rod or string anode protective pipe is the only PVC conduit allowed by these specifications. The Contractor's designer shall design the plastic pipe such that its inside diameter (I.D.) is at least 2 inch greater than the anode outside diameter (O.D.). The Pipe shall be perforated on the side opposite the angle iron protective channel except for the area within 2 inch of the pipe couplings at each girder web which shall not be perforated. The total open area provided by these perforations shall be at least equal to the surface area of the anode material contained within the PVC pipe.

2.3.2 Rigid Metal Conduit

Rigid metal conduit shall conform to the requirements of ANSI C80.1, and shall be of the size indicated on the drawings. The conduit shall be galvanized both inside and outside using the hot-dip method.

2.3.3 Conduit Fittings and Outlets

Conduit fittings and outlets for rigid metal conduit shall conform to the requirements of NEMA FB 1.

2.4 RESISTOR AND ANODE TERMINAL CABINETS

Terminal cabinets shall be provided for each rectifier output circuit. Cabinets shall be NEMA type 4X, weather-resistant construction. Cabinets shall be constructed of ASTM grade 304 stainless steel. Cabinets shall be of ample size to accommodate all anode and power input lead wires and [_____] standard brass or copper heavy duty screw terminals to facilitate individual connection of each anode assembly lead wire through a 0.01 ohm type RS shunt resistor to a common copper bus bar. All terminals, bus bars, shunts, and other DC conducting components shall be mounted to an extra strong, non-metallic panel. All conductors shall be identified in the cabinet by means of plastic or metal tags or plastic sleeves to indicate the anode number. Each terminal shall be identified with permanent engraved identification of the anode number, or other corresponding conductor numbers, or function. Cabinets shall be securely mounted on the top of the corresponding gate in the manner proposed by the Contractor and approved by the Contracting Officer. A removable, hinged front door facing a direction after installation that is easily accessible shall be provided.

2.5 IMPRESSED CURRENT ANODES AND MATERIALS

2.5.1 General Requirements

For details on various types of anodes, anode designs and typical anode configurations for preparation of project drawings, the Corrosion Expert designing the system shall refer to CERL Tech Rep FM-95/05.

2.5.2 Ceramic Precious Metal Oxide Coated Anodes

Ceramic Precious Metal Oxide Coated Anodes shall conform to the following requirements:

2.5.2.1 Conductive Precious Metal Oxide Ceramic Coating

The electrically conductive ceramic coating shall contain a mixture consisting primarily of iridium, tantalum, and titanium oxides. Although the exact composition of the conducting layer can vary, the average composition shall generally be a 50/50 atomic percent mixture of iridium and titanium oxides with small amounts of tantalum. The coating resistivity shall be certified by the manufacturer to have an electrical resistivity of less than 0.002 ohm-centimeters, a bond strength to the substrate metal greater than 50 MPa, and a current capacity of 100 DC amperes per square meter of anode surface area when operated in an oxygen-generating electrolyte at 150 degrees F for 20 years.

2.5.2.2 Anode Substrate Material

The anode substrate shall be fabricated from high purity alloy titanium.

2.5.3 Hi-Silicon Cast-Iron Anodes

Hi-Silicon Cast-Iron Anodes shall conform to the following requirements:

2.5.3.1 Chemical Composition (Nominal)

ELEMENT	PERCENT BY WEIGHT
Silicon	14.20 - 14.75
Manganese	1.50 Max
Carbon	0.75 - 1.15
Chromium	3.25 - 5.00
Iron	Balance

2.5.3.2 Electrical Resistivity

Electrical Resistivity shall be 72 micro-ohm-centimeter at 20 degrees F maximum.

2.5.3.3 Physical Properties (Nominal)

PROPERTY	VALUE
Tensile Strength	15,000 psi
Compressive Strength	100,000 psi
Brinnell Hardness	520
Density	0.253 lb/cu in.
Melting Point	2,300 deg F
Coefficient of Expansion Between 32 deg F and 212 deg F	0.00000289 in/deg F

2.5.4 Ceramic Coated Titanium Anodes (Disk Type)

2.5.4.1 General

Ceramic coated titanium disk anodes shall be conductive ceramic coated titanium disks similar to that shown in Figure 2, "Typical Ceramic Coated Flat Disk Anode" of CERL Tech Rep FM-95/05, November, 1994. Anodes shall conform to the requirements in Section 2.6.1 and shall be suitable for cathodic protection use, shall be highly resistant to corrosion, and shall have good electrical properties. Anodes disk shall be at least 5 inch diameter factory mounted in a 12 inch diameter FRP reinforced Polyurethane protective shield to prevent shorting of the anode to the skin plate and over voltage damage to the adjacent coating. It shall be provided with a integral titanium mounting rod with gold plated connector socket. Each disk anode shall be provided with a gold plated connector plug and PVC cable connector that shall be assembled by the manufacturer. Submit certified Factory Test Data on anode connections showing anode-to-contact resistance. This test data shall provide a measured resistance of less than 0.003 ohm (or the connection shall be redone). Provide a certified report on these factory tests within two weeks after fabrication by the manufacturer.

2.5.4.2 Impact Protection for Disk Anode Cables

A 6 inch diameter by 8 inch long steel schedule-40 pipe with threaded pipe cap shall be welded to the gate in back of each disk anode. A hole shall be drilled in the side of this pipe and a thread-o-let fitting shall be welded to the 6 inch diameter pipe at this point to receive the anode lead wire and conduit routed to the anode terminal box at the top of the gate leaf. The pipe and conduit are provided for impact protection of the anode cables and the anode bolt. The pipes shall be galvanized and painted with 7 mil of paint.

2.5.4.3 Number of Ceramic Coated Titanium Disk Anodes

The actual number of ceramic coated titanium disk anodes shall be in accordance with the corrosion engineer's approved design calculations based on the system circuit resistance, current requirements ,current distribution and anode life, in accordance with EM 1110-2-2704 and Appendix "A" in CERL Tech Rep FM-95/05, "Detailed Cathodic Protection Design Procedures for Pike Island Auxiliary Lock" as long as the minimum number of button anodes provided shall equal or exceed one each for every 200 square feet of submerged steel surface area (for some typical anode configurations, refer to Figures 4, 5, 6, 7, C3, and F2 in CERL Tech Rep FM-95/05). The minimum number of anodes and an indication of their mounting locations should be shown in the design drawings.

2.5.5 Hi-Silicon Cast Iron Button Anodes

2.5.5.1 General

Anodes shall be high-silicon cast iron conforming to ASTM A518/A518M.

2.5.5.2 High-Silicon, Cast-Iron Anodes (Button Type)

High-silicon, cast-iron "button-type" anodes shall be an alloy of silicon, carbon, manganese, and iron. Anodes shall be similar in all respect to the Button anode design shown in Figure 1, "HSCBCI "Sausage" and "Button" Anode Designs of CERL Tech Rep FM-95/05. Anodes shall conform to the requirements in paragraph IMPACT PROTECTION FOR RODS AND SAUSAGE-STRING

ANODES and shall be suitable for cathodic protection use, shall be highly resistant to corrosion, and shall have good electrical properties. Anodes button castings shall have a nominal weight of 18 lb and shall be 6 inch diameter by 3 inch deep and shall be provided with a 3/4 inch diameter by 2 inch deep conical terminal connection cavity in the back of the anode and 1 by 2 inch stepped mounting hole provision through the center of the anode as shown in above referenced Figure 1. A polychloroprene or neoprene gasket material to be installed behind the button anode shall be not less than 1/8 inch thick by 8 inch diameter. The gasket adhesive shall be 100 percent silicone waterproof caulking material similar to GE 100 percent Silicone Caulk suitable for continuous immersion service. Plastic seal plugs shall be molded or fabricated from an approved polystyrene. The flanged sleeve shall be fabricated from nascent oxygen and chlorine resistant rigid plastic material. Button anodes and cable shall be assembled by the manufacturer.

2.5.5.3 Anodes Number

The actual number high-silicon, cast-iron "button-type" anodes shall be in accordance with the corrosion engineer's approved design calculations based on the system circuit resistance, current requirements, current distribution and anode life, in accordance with EM 1110-2-2704 and Appendix "A" in CERL Tech Rep FM-95/05, "Detailed Cathodic Protection Design Procedures for Pike Island Auxiliary Lock" as long as the minimum number of button anodes provided shall equal or exceed one each for every 200 square feet of submerged steel surface area (for some typical anode configurations, refer to Figures 4, 5, 6, 7, C3, and F2 in CERL Tech Rep FM-95/05. The minimum number of anodes and an indication of their mounting locations should be shown in the design drawings.

2.5.5.4 Assembly

The manufacturer shall be responsible for assembling the conductor to the anode after the conductor has been tinned. Connections shall be made with caulked tellurium lead, and then sealed with epoxy around the connection. All tinned wire shall be completely covered by lead. Reference Figure 1, "HSCBCI "Sausage" and "Button" Anode Designs of CERL Tech Rep FM-95/05 for mounting component details.

2.5.5.5 Impact Protection for Button Anode Cables

A 6 inch diameter by 8 inch long steel schedule-40 pipe with threaded pipe cap shall be welded to the gate in back of each button anode. A hole shall be drilled in the side of this pipe and a thread-o-let fitting shall be welded to the 6 inch diameter pipe at this point to receive the anode lead wire and conduit routed to the anode terminal box at the top of the gate leaf. The pipe and conduit are provided for impact protection of the anode cables and the anode bolt. The pipes shall be galvanized and painted with 7 mil of paint.

2.5.6 Ceramic Coated Titanium Segmented Rod Anodes

a. Ceramic coated titanium segmented rod anodes shall be conductive ceramic coated titanium rods similar to that shown in Figure 3, "Typical Ceramic Coated Flat Disk Anode" of CERL Tech Rep FM-95/05. Anodes shall conform to the requirements in Section 2.6.1 and shall be suitable for cathodic protection use, shall be highly resistant to corrosion, and shall have good electrical properties. Each anode rod shall be solid titanium and at least 1/8 inch diameter by 48 inch long with integral factory fabricated 1/2 inch diameter ceramic coated titanium screw couplings at each end. One anode for each assembled length shall be provided with a screw coupled sealed PVC cable connector which shall be assembled by the manufacturer. Each such connector/cable assembly shall be provided with sufficient lead length so that no splices are necessary between the anode/cable connector and the anode terminal box.

b. The actual number of segmented rod assemblies and the number of strings per chamber shall be in accordance with the corrosion engineer's approved design calculations based on the current required for protection in accordance with EM 1110-2-2704 and Appendix "A" in CERL Tech Rep FM-95/05, "Detailed Cathodic Protection Design Procedures for Pike Island Auxiliary Lock" as long as the number of segmented rod anode assemblies provided shall equal or exceed 1 linear foot of 1/8 inch diameter (minimum) ceramic coated titanium rod material for each 100 square feet of submerged steel surface area and at least one full height assembly in each chamber (for some typical anode configurations, refer to Figures 4, 5, 6, 7, C3, and F2 in CERL Tech Rep FM-95/05). Each assembly shall extend at least 6 inch above the normal highest water line to within 6 - 12 inch of the bottom most girder plate.

2.5.7 Hi-Silicon Cast Iron Sausage Anode Strings

a. High-silicon, cast-iron anodes shall be an alloy of silicon, carbon, manganese, and iron conforming to ASTM A518/A518M. Anodes shall be similar in all respect to the "Sausage" anode design shown in Figure 1, "HSCBCI "Sausage" and "Button" Anode Designs of CERL Tech Rep FM-95/05. Anodes shall be suitable for cathodic protection use, shall be highly resistant to corrosion, and shall have good electrical properties. "Sausage" anode castings shall have a nominal weight of 6-1/2 lb each and shall with an irregular surface terminal connection cavity in the center interior of the tubular shaped anode as in CERL Tech Rep FM-95/05. Anodes shall be 2-3/16 inches in diameter by 12 inch long, designed for tandem mounting in "link-sausage" manner on the anode lead cable. Cable and anodes shall be connected all in a manner similar to the "Sausage" anode design shown in the above referenced Figure 1. Anode strings shall be assembled by the manufacturer and the anode lead cable shall not be spliced in the anode. The anode shall be assembled by removing insulation from the anode cable and connecting the anode to the cable inside the anode.

b. The actual number and spacing of the individual "sausage" segments and the number of strings per chamber shall be in accordance with the corrosion engineer's approved design calculations based on the current required for protection in accordance with EM 1110-2-2704 and Appendix "A" in CERL Tech Rep FM-95/05, "Detailed Cathodic Protection Design Procedures for Pike Island Auxiliary Lock" as long as the number of "sausage" anodes provided shall equal or exceed one each for every 200 square feet of submerged steel surface area and at least one string in each chamber (for some typical anode configurations, refer to Figures 4, 5, 6, 7, C3, and F2 in CERL Tech Rep FM-95/05). Each assembly shall extend from 6 inch above the normal highest water line to within 6 - 12 inches of the bottom most girder plate.

2.6 IMPACT PROTECTION FOR RODS AND SAUSAGE-STRING ANODES

2.6.1 PVC Pipe and Metal Couplings

PVC pipe, to be used for protection of the rod and sausage-string anodes, shall be installed through each girder web in the center of each chamber which shall have an inside diameter (I.D.) that is at least 1-1/2 inch greater than the anode outside diameter (O.D.). The Pipe shall be Schedule 80 PVC minimum and perforated on the side opposite the angle iron except for the area within2 inch of the pipe couplings at each girder web. The total open area provided by these perforations shall be at least equal to the surface area of the anode material contained within the PVC pipe. Metal couplings shall be installed through the girder webs on the compartment side of the gate (and where compartments are used on the skin plate side), where the PVC pipe penetrates the web. The steel coupling selected should have an I.D. that will allow the plastic pipe and its associated couplings to pass through the coupling. These steel couplings shall be aligned vertically for each anode string to serve as vertical troughs for the plastic pipes. The full sections of the plastic pipe shall be solvent welded together end to end. The plastic pipe shall have holes drilled in it as shown on the drawings. The steel coupling, angle iron, channel iron and all areas affected by the welding shall be prepared for painting and coated with the same paint system as the adjacent gate surfaces, in accordance with Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES.

2.6.2 Protective Angle Irons

Submit anode disk, button, strip, rod and string details including ice and debris damage protection means for each anode type and alternative location.

2.6.2.1 PVC Piping

The protective PVC piping is subject to damage from floating ice and/or driftwood. Therefore, protective angle irons shall be installed in front of the protective PVC pipe. These angle iron sections shall be at least 1/4 inch thick with angle legs whose height equal to at least 75 percent but not more than 100 percent of the plastic pipe coupling outside diameter. This angle iron shall be welded to each girder passage pipe coupling from the top of the highest girder to the bottom most girder plate. At each girder, which is penetrated by the PVC pipe, the angle irons shall also be welded to the girder to reduce stress concentrations in the girder web caused by this penetration. The entire assembly, consisting of the perforated PVC pipe containing the sausage anodes and the angle irons, shall be installed as shown on the drawings. When plastic pipes only are used for sausage anode protection, the girder penetration shall be the same, but the angle iron shall be installed in the impact area only.

2.6.2.2 Painting

The steel couplings, angle iron, and channel iron shall be prepared for painting and coated with the same paint system as the adjacent gate surfaces, in accordance with Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES. Each component shall have the same minimum mil thickness (where 1 mil = 0.001 inch) of paint after couplings, angle irons, and channels are welded to the structure. The welded area shall be cleaned to bare metal and painted in this same manner. The paint shall be of the same type used on the lock gate.

2.7 MARKINGS

2.7.1 General

Markings, when required by the drawings and when specified herein, shall be accomplished by means of metal or plastic sleeves as specified, stamped or engraved as indicated herein or on the drawings.

2.7.2 Rectifier Cabinets

Rectifier cabinets shall be identified by means of suitable stainless steel plates attached to the outside of the rectifier cabinet by means of bolts or screws.

PART 3 EXECUTION

3.1 EXAMINATION

Visit the premises and thoroughly become familiar with all details of the work and working conditions, verify existing conditions in the field, note the exact locations for materials and equipment to be installed on the gates for cathodic protection, and advise the Contracting Officer of any discrepancies before performing any work.

3.2 INSTALLATION

Furnish all materials, equipment, and labor necessary to provide a complete and workable cathodic protection system conforming to the drawings and specifications. All electrical work and materials shall conform to NFPA 70 and requirements specified herein. Pipe shall be 6 inchdiameter Schedule 40 steel pipe. Fittings for rigid metal conduit shall conform to NEMA FB 1. Conduit used shall be straight; no kinks or bends will be permitted. All conduit shall be RGS except the 6 inch pipe required for protecting the HSCI button anodes and PVC schedule-80 perforated protective pipe used to protect the ceramic rod and HSCI sausage string anodes.

3.3 WIRING

3.3.1 Gate Structure at Control Room

Cables, of the type specified in paragraph DIRECT CURRENT CABLES, shall be installed between the rectifier cabinet located in the control room and the dc receptacle located adjacent to each lock gate. This cable shall be installed in conduit conforming to the requirements of paragraph CONDUIT AND FITTINGS.

3.3.2 Rectifier on the Lock Wall

Type SO cable shall be run exposed from the ac receptacle on the lock wall to the rectifier cabinet and from this cabinet to the dc receptacle. Type SO cable shall also be run exposed from the dc receptacle to the watertight bushing on the gate. Watertight insulating bushings shall have a cable seal fitting that makes a watertight conduit connection and a watertight seal between the cable jacket or insulation and the fitting. At all locations at which a conduit penetrates a watertight member, a watertight packing gland constructed as shown on the drawings shall be installed.

3.3.3 Wiring on the Gate Structure

All dc circuit wiring and anode lead wiring on the gate structures shall be installed in rigid galvanized steel conduit, except for sausage anode strings, which shall be installed as shown on the drawings, and as specified. Conduit installed on the gate structure shall be installed, where possible, in the recesses of the gate and flush with the wall skin plate to reduce the probability of physical damage from floating debris. Each anode shall be provided with sufficient lead length, without splice, to reach the terminal cabinets located on the top of each gate leaf. Watertight insulating bushings shall have a cable seal fitting that seals between the cable jacket or insulation and the fitting. At all locations at which a conduit penetrates a watertight member, a watertight packing gland constructed as shown on the drawings shall be installed.

3.4 ROD AND SAUSAGE ANODE INSTALLATION

3.4.1 Metal Pipe Couplings for PVC Pipee

Metal pipe couplings (guides for PVC pipe used with sausage anodes) shall be permanently welded on the gate structure. Rod or Sausage-type anodes shall not be used without these PVC pipe guides. PVC schedule-80 pipe (with holes) containing the sausage anode strings shall be installed through the couplings with the holes oriented away from the protective steel angle channel (toward the back of the chambers). Anode rod or string assemblies shall be capable of being withdrawn at any time for inspection and repair. The metal pipe couplings used for PVC pipe guides shall be installed plumb, with an alignment tolerance of plus or minus 1/4 inch over the entire height of the gate. When in place, the metal pipe couplings shall be welded to the girder. Protective angle irons shall be positioned at the previously specified locations to protect the PVC pipe and anode strings contained therein, exposing as much anode surface area as possible.

3.4.2 Assembly of Titanium Rod Anode

The ceramic coated titanium rod anode shall be sequentially assembled as it is lowered into the PVC pipe by screw coupling each to the next anode element. The coupling shall be tightened to a torque equal to that specified by the anode manufacture. The topmost element shall have the factory fabricated anode-to-cable connector attached in a similar manner. The HSCI sausage anode assemblies are lowered into place inside the plastic pipe. Take care in handling these HSCI anode strings since the material is very brittle and subject to cracking if dropped or bounced against a hard surface. If any single anode element in the HSCI "sausage" string is cracked, replace the entire string with a new string. No cracked anodes shall be installed in the system. Anode centering devices shall be installed on each rod or string anode element to assure that the anode in maintained in a centered position within the pipe in a manner so that no portion of the anode is closer than 1/2 inch of the pipe interior surface. Each anode lead shall be continuous without splices from its point of connection to the anode to the terminal cabinet on the gate structure. Anode leads shall be marked with anode string or anode number at the point of connection to the terminal box. A minimum of 6 inch of excess cable shall be coiled in the anode terminal box before cutting and connection the cable to the corresponding anode terminal in the terminal box. This connection shall then be coated with a suitable oxidation preventing electrical contact paste.

3.4.3 Suspension of Anode Rod or String Assemblies

Support means for each anode rod or string shall be done in a manner to permit easy raising, lowering, removal and/or reinstallation of the anode strings in the anode guides. The anode assemblies shall be suspended from anode connecting cables using "Kellum" or equal grips to provide uniform and non-deforming gripping of the wire insulation.

3.5 DISK AND BUTTON ANODE INSTALLATION

3.5.1 General

Install the Disk or Button-type anodes at the locations shown on the approved Contractor's corrosion engineer design drawings.

3.5.2 Impact Protection Pipes Installation

The impact protection pipes for the disk or button anode connection cables shall be installed prior to installation of the anodes. A 6 inch diameter by 8 inch long galvanized steel schedule-40 pipe with threaded pipe cap shall be fully seal welded to the gate in back of each button anode. A hole shall be drilled in the side of this pipe and a thread-o-let fitting welded to the 6 inch diameter pipe at this point to receive the anode lead wire and conduit routed to the anode terminal box at the top of the gate leaf. The pipe and conduit provide impact protection of the anode cables and the anode support means. The pipes shall be prepared for painting and coated with the same paint system as adjacent gate surfaces, in accordance with Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES.

3.5.3 Disk Anode Installation

Deleiver the disk anode as a complete assembly by the manufacturer. A 1-1/8 inch diameter hole shall be drilled through the skin plate at each disk anode location shown on the approved system design drawings. Remove the FRP nut and washer from the disk support shaft. Apply 100 percent silicone waterproof caulk to the skin plate side of the anode composite shield in sufficient quantity to completely seal the shield at its outer perimeter and adjacent to the shaft where it passes through the skin plate. The disk shall then be inserted through the gate skin plate and held firmly in place while the washer and then nut are placed on the support shaft from the opposite side of the gate and tightened using an automatic torque wrench set to 25 ft-lb of torque. The cable connector shall then be attached to the integral threaded socket on the end of the anode support shaft and tightened to the torque specified by the manufacturer. This cable shall then be routed through the pipe protecting thread-o-let fitting and then via conduit to the anode terminal box. Each disk anode lead shall be continuous without splices from its point of connection to the anode to the terminal cabinet on the gate structure. Anode leads shall be marked with anode string or anode number at the point of connection to the terminal box. A minimum of 6 inch of excess cable shall be coiled in the anode terminal box before cutting and connection of the cable to the corresponding anode terminal in the terminal box. This connection shall then be coated with a suitable oxidation preventing electrical contact paste.

3.5.4 Button Anode Installation

a. The polychloroprene or neoprene gasket material shall be not less than 1/8 inch in thickness and shall provide a minimum of 500,000 ohms of resistance between the button anode and gate. Plastic plugs, molded or fabricated from an approved polystyrene to fit securely in the anode opening, shall be furnished and installed in accordance with the approved submittal drawings. After assembly, the anode support bolt shall be completely insulated on the button side of the gate by forcing epoxy cement through a passage provided for that purpose, around the insulating sleeve, into the bolt-head cavity, and out the vent hole in the plastic plug. The plastic plug shall be placed in the bolt-head cavity such that the vent hole is at the highest point.

b. Epoxy cement shall be of an approved type, shall have a suitable dielectric strength, shall be water-resistant, and shall not generate enough heat to damage or react with the plastic plug, the insulating bushings, or the gaskets. The epoxy shall provide a minimum electrical resistance of 10 megohms between the anode and the gate.

c. The flanged sleeves shall be fabricated from nylon conforming to the requirements of ASTM D789, or a similar approved rigid plastic material. It shall be of proper size and length so that it will penetrate the skin plate enough to provide electrical isolation between the anode and skin plate. The sleeve shall enter the skin plate at least 3/16 inch. Refer to CERL Tech Rep FM-95/05 - Figure 1, "HSCBCI "Sausage" and "Button" Anode Designs for mounting component details.

d. Also isolate the bolt from the anode and skin plate. A metal washer shall be used behind the skin plate to connect the bolt to the gate so that the bolt will receive cathodic protection and not corrode. Apply the epoxy cement (resin) to provide a watertight seal in all areas of the bolt and anode bolt cavity. This will isolate the anode from the gate.

e. The surfaces of the gates to be covered by the polychloroprene or neoprene gasket and the anode shall be sandblasted to clean metal to provide a bonding surface for the epoxy cement. The metal washer shall not exceed the flange diameter of the nylon sleeve and the nylon flanges shall be at least 1/8 inch in diameter smaller than the diameter of the button anode hole bolt-head cavity. The anchoring bolt shall have slots that are large enough and adequate to transfer epoxy. Bolts shall be machined and holes drilled to transfer epoxy. The bolt shall be of sufficient length to allow threads to be visible past the nut. Structural thickness shall be considered. The neoprene gasket shall be attached to the gate and the anode using an approved cement to make a watertight seal. The bolt shall be used to torque the anode to a watertight seal on the gate. The bolt shall not be over-torqued, causing the metal anode to contact the gate or the polychloroprene gasket to turn out from the skin plate. The anodes shall not be handled or carried by the conductor. Each anode lead shall be continuous without splices from its point of connection to the anode to the terminal cabinet on the gate structure. Anode leads shall be marked with anode string or anode number at the point of connection to the terminal box. A minimum of 6 inch of excess cable shall be coiled in the anode terminal box before cutting and connection of the cable to the corresponding anode terminal in the terminal box. This connection shall then be coated with a suitable oxidation preventing electrical contact paste.

3.6 RECTIFIER CABINET INSTALLATION

Secure wheeled rectifier cabinets, when provided, to the lock wall pipe rails using the clamp provided as a part of the rectifier. Secure stationary rectifier cabinets to the structures as shown on the approved submittal drawings.

3.7 RESISTOR AND ANODE TERMINAL CABINETS INSTALLATION

Install resistor and anode terminal cabinets at locations convenient for maintenance and testing purposes and to provide ready access to the terminals therein. Securely mount the cabinets to the gate structure with welded angle iron supports holding the cabinet in place.

3.8 REPAIR OF EXISTING WORK

The work shall be carefully laid out in advance, and where cutting, channeling, chasing, or drilling of the gate structure or girder web, or other surfaces is necessary for the proper installation, support, or anchorage of the cabinets, conduit, raceways, or other electrical work, this work shall be carefully done, and any damage to the gate structure or equipment shall be repaired by skilled mechanics of the trades involved, at no additional cost to the Government.

3.9 SYSTEM COMPONENT CIRCUIT RESISTANCE MEASUREMENT

Within 1 week following the filling of the lock, the resistance of each anode, reference electrode, system ground, and reference ground shall again be measured and recorded using four separate test lead wires and a Nilsson Model 400 AC impedance meter or other similar AC impedance instrument acceptable to the Contracting Officer. The measurement shall be made by disconnecting the component lead at the appropriate terminal in the terminal box and connecting two of the four AC impedance test leads individually to the lead wire. The other two AC impedance test leads shall be individually connected to the structure component to which the component is mounted or connected. Should the resistance between the lead wire and the structure (immerse anode and reference elements in water) be less than 50 percent or more than 200 percent of the calculated (expected) resistance, make the necessary corrections and/or modifications necessary to achieve the anticipated value(s).

3.10 STRUCTURE-TO-REFERENCE CELL POTENTIAL MEASUREMENTS

Following completion of the installation of the cathodic protection system and prior to placing the impressed current cathodic protection system in operation, structure-to-reference cell potential measurements shall be made. The testing equipment shall be a calibrated copper-copper sulfate reference electrode with waterproof connector to insulated test lead wire suitable for immersion testing and of suitable length so that no splices are necessary in the test lead wire and a high-resistance digital voltmeter, Fluke Models 865 or 867 or equal. The copper-copper sulfate reference electrodes shall contain a saturated reagent copper sulfate in distilled water. Prior to first system energization, native "OFF" potential measurement shall be recorded using the same meter and calibrated reference electrode to be used during system energization and adjustment. These native "OFF" potentials shall be measured and recorded at all the specified locations.

3.11 RECTIFIER ADJUSTMENT

Rectifier adjustment shall be accomplished as follows:

a. Adjust the output of the rectifier so that the gate-to-water potential measured using a reference cell indicates that the negative potential has stabilized and is at least minus 0.85 volt and not more than 1.2 volts. These measurements shall be made with current applied. Corrections for IR drop shall be made. This shall be accomplished by adjusting the rectifier to obtain the aforementioned "instant-off" potentials. This IR drop correction shall be made by interrupting the current output of the rectifier either manually or automatically using a 90 percent minimum "ON" and 10 percent maximum "OFF". If more than one rectifier is energized at the same time, all such rectifiers shall be interrupted simultaneously. The "OFF" time period shall not exceed 1 second. During this "OFF" period, the Fluke 865/867 meter shall be used to automatically read the minimum DC voltage that is the polarized protective potential on the gate.

b. Perform a complete structure-to-water potential survey of the gate leaf face.

3.11.1 Locations of Structure-to-Reference Cell

Locate the reference cell in the water, 0.5 to 3 inch from the gate structures. The reference cell shall be connected with a waterproof screw coupled connector to a conductor on a reel. The cell shall be lowered to depths in the water as indicated below. The reference cell conductor shall be connected to the positive terminal of the digital voltmeter. A second conductor shall be connected from the gate structure to the voltmeter negative terminal. The measurement procedure shall be repeated and recorded for each measurement location. Measurements shall be made every 3 ft vertically (minimum) from normal pool elevation to the bottom of the gate. These same measurements shall be made at a minimum of five locations across the width of the gates on both the skin plate and chamber sides. In addition, one set of measurements shall be made at the quoin end and one at the miter end on both sides of the gate. All measurement positions should be permanently marked on the handrail of the gates directly above where the measurement is made.

3.11.2 Polarization Decay

a. Polarization decay measurements are only necessary if the gate surfaces adjacent to the sill plate, quoin and miter fail to meet the above criteria of providing negative protection potential of at least minus 0.85 volts.

b. A minimum negative (cathodic) polarization voltage shift of 100 millivolts shall be measured between the structure surface and the reference electrode cell above contacting the electrolyte. This polarization voltage shift is to be determined by interrupting the protective current and measuring the polarization decay. When the current is initially interrupted, an immediate voltage shift will occur. The second voltage reading displayed after the immediate shift shall be used as the base reading from which to measure polarization decay. Polarization measurements shall be made at minimum 10-minute intervals for a maximum of 4 hours. This measurement cannot be made until the gate has had a chance to become polarized.

c. Location of the structure with respect to the reference cell for polarization decay measurements shall be 1 ft from the bottom gate at the quoin, miter, and at 2 ft intervals along the bottom of the gate. Measurements shall be made on each gate leaf face.

3.12 RECORDING OF MEASUREMENTS

All system component circuit resistances, structure-to-water potential measurements, including native potentials, shall be assembled in computer generated tabular form using Microsoft Excel or similar approved spreadsheet and submitted in six copies together with a copy of the data disk (3-1/2 inch floppy disks), with each location identified on the as-built drawings. Locate, correct, and report to the Contracting Officer any unusual data or problems encountered during checkout of the installed cathodic protection system. Structure-to-water potential measurements are required on structures as necessary to affirm that protection has been achieved on all submerged surface of the lock gates. All tests shall be witnessed by the Contracting Officer and the completed test measurements data shall be submitted to him for his review and approval.

3.13 OPERATION AND MAINTENANCE INSTRUCTIONS

Submit Weekly, Monthly and Annual Test Procedure to be part of the operations and maintenance instruction manual. This test plan shall conform to all applicable NACE International Recommended Practices.

3.13.1 Operating Instructions

Furnish to the Contracting Officer twelve (12) complete copies of operating instructions detailing the step-by-step procedures required for system start-up and adjustment of the rectifier to achieve the criteria of protection. This shall include native system and component test data (data before system energization), test set up, test equipment diagrams showing voltmeter and reference cell connections, test locations, and a description of the procedure for measuring "on" and "off" potentials. Detailed steps shall show use of the equipment used in the training course and cover test and measurement of the cathodic protection systems for the gate leafs. Submit the Operation and Maintenance manual to the Contracting Officer for approval 30 days prior to the training course. Information on the equipment shall include the manufacturer's name, model number, service manual, parts list, and a brief description of all equipment and its basic operating features.

3.13.2 Maintenance Instructions

Furnish to the Contracting Officer eight complete copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and trouble-shooting guides. The instructions shall include diagrams for the system as installed, instructions in making gate-to-reference electrode measurements, and frequency of monitoring.

3.14 TRAINING COURSE

Conduct a training course for operating staff, as designated by the Contracting Officer, on the cathodic protection system. The training period shall consist of a total of 8 hours of training and shall start after the system is functionally complete, but prior to final acceptance tests. Provide course material, including testing data and records, for a minimum of [12] [_____] Government attendees. Submit this course material to the Contracting Officer for approval 30 days prior to the scheduled start of the training course. Submit life of the anodes and outline of course and handout sheets with testing and measurements from the instruction manual and description of the use of equipment for completing test and measurements for students. The training course shall include demonstrations of the procedure for measuring the minus 850 millivolts "off" potentials and NACE International protection criteria of a minimum negative (cathodic) polarization voltage shift of 100 millivolts. Provide a digital voltmeter (Fluke 865 or similar and approved equal) and an insulated cable (minimum 100 ft length) on a reel with a saturated copper-copper sulfate reference cell attached by a factory assembled waterproof connector for these demonstrations. This equipment will become the property of the Government and shall be turned over to the Contracting Officer upon completion of the training course.

-- End of Section --

SECTION 26 51 00

INTERIOR LIGHTING
05/20, CHG 2: 11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2019) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A1008/A1008M	(2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B633	(2019) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM D4674 REV A	(2002; R 2010) Standard Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

ANSI/IES LM-79	(2019) Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products
ANSI/IES LM-80	(2020) Approved Method: Measuring Luminous Flux and Color Maintenance of LED

	Packages, Arrays and Modules
ANSI/IES LS-1	(2020) Lighting Science: Nomenclature and Definitions for Illuminating Engineering
ANSI/IES TM-15	(2020) Technical Memorandum: Luminaire Classification System for Outdoor Luminaires
ANSI/IES TM-21	(2021) Technical Memorandum: Projecting Long-TermLuminous, Photon, and Radiant Flux Maintenance of LED Light Sources
ANSI/IES TM-30	(2020) Technical Memorandum: IES Method for Evaluating Light Source Color Rendition
IES Lighting Library	IES Lighting Library

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 77	(2017) Temporal Light Artifacts: Test Methods and Guidance for Acceptance Criteria
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2017) Electric Lamps— Specifications for the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination
NEMA SSL 7A	(2015) Phase-Cut Dimming for Solid State Lighting: Basic Compatibility
NEMA WD 1	(1999; R 2020) Standard for General Color

	Requirements for Wiring Devices
NEMA WD 7	(2011; R 2016; R 2021) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 101	(2021) Life Safety Code
NFPA 110	(2022) Standard for Emergency and Standby Power Systems

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 20	(2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches
UL 94	(2013; Reprint Apr 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 844	(2012; Reprint Oct 2021) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations
UL 916	(2015; Reprint Oct 2021) UL Standard for Safety Energy Management Equipment
UL 917	(2006; Reprint Aug 2013) UL Standard for Safety Clock-Operated Switches
UL 924	(2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment
UL 1472	(2015) UL Standard for Safety Solid-State Dimming Controls

UL 1598	(2021; Reprint Jun 2021) Luminaires
UL 1598C	(2014) Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 8750	(2015; Reprint Sep 2021) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and accessories that are mounted in exterior environments and not attached to the exterior of the building are specified in Section 26 56 00 EXTERIOR LIGHTING. Emergency lighting requirements are specified in Section 26 52 00.00 40 EMERGENCY LIGHTING.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings, must be as defined in IEEE 100 and ANSI/IES LS-1.

b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in ANSI/IES LM-80.

c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.

d. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Occupancy/Vacancy Sensor Coverage Layout; G; S

Lighting Control System One-Line Diagram; G

Sequence of Operation for Lighting Control System; G

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Local Area Controller; G

Lighting Relay Panel; G

Lighting Control Panel; G

Gateway; G

Lighting Contactor; G

Switches; G

Digital Switch Timers; G

Wall Box Dimmers; G

Scene Wallstations; G

Occupancy/Vacancy Sensors; G

Photosensors; G

Time Clocks; G

Power Packs; G

Power Hook Luminaire Hangers; G

Mini Inverters; G

Exit Signs; G

Emergency Drivers; G

Energy Star Label For Residential Luminaires; S

Linear LED Lamps; G

SD-05 Design Data

Luminaire Design Data; G

Photometric Plan; G

SD-06 Test Reports

ANSI/IES LM-79 Test Report; G

ANSI/IES LM-80 Test Report; G

ANSI/IES TM-21 Test Report; G

ANSI/IES TM-30 Test Report; G

Occupancy/Vacancy Sensor Verification Test; G

Photosensor Verification Test; G

SD-07 Certificates

LED Driver and Dimming Switch Compatibility Certificate; G

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G

Lighting Control System, Data Package 5; G

Maintenance Staff Training Plan; G

End-User Training Plan; G

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES Lighting Library as applicable, for the lighting system specified.

1.5.1 Luminaire Drawings

Include dimensions, accessories installation details, and construction details. Photometric data, including CRI, CCT, LED driver type, aiming diagram, zonal lumen data, and candlepower distribution data must accompany shop drawings.

1.5.2 Luminaire Design Data

a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified in accordance with the NFPA 70. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

b. Provide long term lumen maintenance projections for each LED luminaire in accordance with ANSI/IES TM-21. Data used for projections must be obtained from testing in accordance with ANSI/IES LM-80.

1.5.3 ANSI/IES LM-79 Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data in IES format as outlined under "14.0 Test Report" in ANSI/IES LM-79.

1.5.4 ANSI/IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in ANSI/IES LM-80.

1.5.5 ANSI/IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in ANSI/IES TM-21.

1.5.6 ANSI/IES TM-30 Test Report

Submit color vector graphic in accordance with ANSI/IES TM-30 on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Include spectral distribution of test LED light source.

1.5.7 LED Driver and Dimming Switch Compatibility Certificate

Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices without flickering and to specified dimming levels.

1.5.8 Photometric Plan

1.5.8.1 Computer-generated Photometric Plans

Computer-generated photometric plans for each space are required to verify proposed luminaires and locations meet the required performance criteria of the design using the applicable light loss factor (LLF).

Target illumination levels are provided for each Interior Application. Depending on the application and the recommendations provided by the IES, values are given as one of the following:

a. Minimum: No values anywhere on the calculation grid may be less than this value, within a 10 percent margin of error.

b. Minimum Average: An average, taken over the entire task area for the application, may not be less than this value, within a 10 percent margin of error.

c. Maximum: No values anywhere on the calculation grid may be greater than this value, within a 10 percent margin of error.

d. Maximum Average: An average, taken over the entire task area for the application, may not be greater than this value, within a 10 percent margin of error.

e. Uniformity: Unless otherwise noted, uniformity is calculated as a ratio of the average calculated illuminance over the minimum calculated illuminance of the calculation grid.

1.5.8.2 Schematic Photometric Plan Calculations

Schematic photometric plan calculations must include:

a. Horizontal illuminance measurements at workplane or other designated height above finished floor, taken at a maximum of every one foot across the task area.

b. Average maintained illuminance level.

c. Minimum and maximum maintained illuminance levels.

d. Lighting power density (Watts per square foot).

e. LLF. Recommended LLF is 0.81 for LED luminaires but LLF varies based on environment and application.

1.5.8.3 Final Photometric Plan Calculations

Final photometric plan calculations must include:

a. Horizontal illuminance measurements at workplane or other designated height above finished floor, taken at a maximum of every one foot across the task area.

b. Where applicable, vertical illuminance measurements at designated surface, taken at a maximum of every one foot across task area.

c. Minimum and maximum maintained illuminance levels.

d. Average maintained illuminance level.

e. Average to minimum and maximum to minimum ratios for horizontal illuminance.

f. Lighting power density (Watts per square foot).

g. LLF. Recommended LLF is 0.81 for LED luminaires but LLF varies based on environment and application.

1.5.9 Occupancy/Vacancy Sensor Coverage Layout

Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.10 Test Laboratories

Test laboratories for the ANSI/IES LM-79 and ANSI/IES LM-80 test reports must be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program for both LM-79 and LM-80 testing.

b. One of the qualified labs listed on the Department of Energy - LED

Lighting Facts Approved Testing Laboratories List for LM-79 testing.

c. One of the EPA-Recognized Laboratories listed for LM-80 testing.

1.5.11 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.12 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design, and workmanship. Products must have been in satisfactory commercial or industrial use for six months prior to bid opening. The six-month period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the six-month period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.12.1 Alternative Qualifications

Products having less than a six-month field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.12.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than six months prior to date of delivery to site, unless specified otherwise.

1.6 WARRANTY

Support all equipment items by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

(1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

(2) Material warranty must include:

(a) All LED drivers and integral control equipment.

(b) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and assembly.

1.6.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:

(1) Software: Failure of input/output to execute switching or dimming commands.

(2) Damage of electronic components due to transient voltage surges.

(3) Failure of control devices, including but not limited to occupancy sensors, photosensors, and manual wall station control devices.

b. Provide a written five year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.

c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7 OPERATION AND MAINTENANCE MANUALS

1.7.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system for the building. Additional O&M Manual requirements for the Army are provided in Section 01 78 24.00 10 FACILITY DATA

REQUIREMENTS. Additional requirements for the Navy are provided in Section 01 78 24.00 20 FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI). Include the following:

a. Manufacturers' operating and maintenance manuals.

b. Luminaire shop drawings for modified and custom luminaires.

c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.7.2 Lighting Control System

Provide operation and maintenance manuals for the lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting control system for the building. Include the following:

a. Lighting control system layout and wiring plan.

b. Lighting control system one-line diagram.

c. Product data for all devices, including installation and programming instructions.

d. Occupancy/vacancy sensor coverage layout.

e. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the lighting control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

f. Sequence of operation descriptions for each typical room type, including final programming, schedules, and calibration settings.

g. "As-built" lighting control panel schedules.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and NL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the driver and light source provided.

Provide luminaire with Energy Star Label For Residential Luminaires in accordance with Energy Star.

2.2.1 Luminaires

UL 8750, ANSI/IES LM-79, ANSI/IES LM-80. For all luminaires, provide:

a. Complete system with LED drivers and light sources.

b. Housings constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.

c. ANSI/IES TM-21, ANSI/IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Recessed 1 by 4, 2 by 4, and 2 by 2	100 LPW
Recessed Downlight (fixed, adjustable, wallwash)	80 LPW
Linear, Accent (undercabinet, cove)	45 LPW
Linear, Ambient (indirect wall mount, linear pendent)	100 LPW
High Bay, Low Bay, and Industrial Locations	100 LPW
Food Service and Hazardous Locations	60 LPW
Other (track, residential diffusers)	50 LPW
Exterior Wall Sconce	50 LPW
Steplight	30 LPW
Parking Garage Luminaire	100 LPW

e. UL listed for dry or damp location typical of interior installations. Any luminaire mounted on the exterior of the building must be UL listed for wet location typical of exterior installations.

f. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.

g. Lenses constructed of heat tempered borosilicate glass, UV-resistant acrylic, or silicone. Sandblasting, etching and polishing must be performed as indicated in the luminaire description.

h. ANSI/IES TM-15. Provide exterior building-mounted luminaires that do not exceed the BUG ratings as listed in the luminaire schedule. If BUG ratings are not listed in the luminaire schedule, provide luminaires that meet the following minimum values for each application and mounting conditions:

Lighting Application	Mounting Conditions	BUG Rating
Exterior Wall Sconce	Above 4 feet AFF	B1-U0-G2
Exterior Wall Sconce	Below or at 4 feet AFF	B4-U0-G4
Steplight	Above 4 feet AFF	B1-U1-G2
Steplight	Below or at 4 feet AFF	B4-U1-G4
Parking Garage Luminaire	Ceiling mounted	B4-U4-G3

i. For all recessed luminaires that are identified to be in contact with insulation, provide luminaires that are IC-rated.

j. For all recessed luminaires that are to be installed in air plenums, require housings that are Chicago Plenum rated.

2.2.1.1 Luminaire Conversion Kits

Provide luminaire conversion kits that meet UL 1598C Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits.

2.2.2 Luminaires for Hazardous Locations

In addition to requirements stated herein, provide LED luminaires for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.

2.3 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type, delivered lumen output, and wattage as indicated in the luminaire schedule on project plans.

2.3.1 LED Light Sources

Provide LED light sources that meet the following requirements:

a. NEMA ANSLG C78.377. Emit white light and have a nominal CCT of 3500 Kelvin.

b. Minimum Color Rendering Index (CRI) of 95 with an R9 value of 95.

c. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

d. Light source color consistency by utilizing a binning tolerance within a 3-step McAdam ellipse.

2.4 LED DRIVERS

NEMA SSL 1, UL 8750. Provide LED drivers that are electronic, UL Class 1 or Class 2, constant-current type and that comply with the following requirements:

a. The combined driver and LED light source system does not exceed the minimum luminaire efficacy values as listed in the luminaire schedule provided.

b. Operates at a voltage of 120-277 volts at 50/60 hertz, with input voltage fluctuations of plus/minus 10 percent.

c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.

d. Maximum Total Harmonic Distortion (THD) less than 20 percent at full input power and across specified dimming range.

e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.

f. Withstands Category A surges of 2 kV without impairment of performance. Provide surge protection that is integral to the driver.

g. Integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.

h. 47 CFR 15. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

i. Class A sound rating.

j. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

k. Provide dimming capability as indicated in the luminaire schedule on project plans.

2.5 LIGHTING CONTROLS

Provide network certification for all networked lighting control systems and devices in accordance with the requirements of Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS. Provide lighting control systems that do not switch off battery-operated or emergency backup luminaires or exit signs in path of egress. Provide system with override of lighting control devices controlling luminaires in path of egress with activation of fire alarm system.

2.5.1 System

Provide lighting control system that operates the lighting system as described in the lighting control strategies in the project plans. Submit Sequence of Operation for Lighting Control System describing the operation of the proposed lighting control system and devices. Sequence of Operation must provide the strategies identified in the lighting control strategies.

2.5.1.1 Localized Control Systems

Provide room or area-wide lighting control system capable of manual control, time-based control, and receiving input from photosensors and occupancy/vacancy sensors.

2.5.1.1.1 Local Area Controller

Provide controller designed for single area or room with the following requirements:

a. Operates at a voltage of 120-277 volts at 50/60 hertz.

b. 2 zone, with 2 relays rated 20 amps each with one manual switch or dimmer per zone.

c. Provide inputs for occupancy/vacancy sensors, photosensors, and low-voltage wall switches.

2.5.1.2 Centralized Control Systems

Provide a centralized lighting control system capable of manual control, time-based control, receiving input from photosensors and occupancy/vacancy sensors, with the capabilities of controlling, monitoring, and programming changes from one centralized on-site location, and integration with other building systems.

2.5.1.2.1 Lighting Relay Panel

UL 924. Enclose panel hardware in a surface or flush-mounted, NEMA 1, 3R, or 4, painted, steel enclosure with lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door. Provide additional remote cabinets that communicate back to main control panel as required. Provide Lighting Control Panels that meet the following criteria:

a. Input voltage of 120-277 at 50/60 Hz, with internal low voltage power supply as required.

b. 16 single-pole latching relays rated at 20 amps, 120-277 volts. Provide provision for relays to close upon power failure. Provide relays designed for 10 years of use at full rated load.

c. Relay control module operates at 24 VDC and is rated to control a minimum of 16 relays.

2.5.1.2.2 Lighting Control Panel

UL 916, 47 CFR 15. Provide an electronic, programmable lighting control panel complete with microprocessor, capable of providing lighting control with input from internal programming, digital switches, time clocks, and other control devices.

Enclose panel hardware in a surface or flush-mounted, NEMA 1, 3R, or 4, painted, steel enclosure with lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door. Provide additional remote cabinets that communicate back to main control panel as required. Provide Lighting Control Panels that meet the following criteria:

a. Input voltage of 120-277 at 50/60 Hz, with internal low-voltage VDC power supply as required.

b. Solid-state, microprocessor-based, internal astronomical time clock. Microprocessor must have nonvolatile memory and must reset automatically after power interruptions of up to 90 days.

c. Interface for providing local programming and control capability, with physical key-locked cover or programmed security access code to prevent unauthorized use.

d. Dimming modules capable of 0-10V dimming.

e. Modules and control panels include multichannel output with required channels, with multiple inputs for manual control, photosensors, and occupancy/vacancy sensors.

2.5.2 Devices

2.5.2.1 Switches

Provide line-voltage toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. When used for non-digital loads, devices must be rated at 20 Amps inductive load, and be compatible with the lighting control systems.

2.5.2.2 Digital Switch Timers

Provide line-voltage toggle switches that allow manual control to ON and automatically switches lighting load to OFF. Device operates with the use of paddle, button, or toggle, and operates at 120-277 volts. Device allows for programming of auto off timer from 5 minutes to 1 hours.

2.5.2.3 Wall Box Dimmers

UL 1472, UL 20, IEEE C62.41, NEMA 77, NEMA SSL 7A. Dimmers must provide flicker-free, continuously variable light output throughout the dimming range of 10 percent to 100 percent. Devices must be capable of operating at their full rated capacity regardless of being single or ganged-mounted, and be compatible with three-way and four-way switching scenarios.

Provide wall-box dimmers that meet the following requirements:

a. Device operates as part of a lighting control system or an independent control device.

b. Device operates with the use of a vertical slider, paddle, rotary, button, or toggle with adjacent vertical slider.

c. Finish of device matches switches and outlets in the same area.

d. Back box in wall has sufficient depth to accommodate body of switch and wiring.

e. Dimmer is capable of controlling 0-10 volt LED drivers. Dimmers and the drivers they control must be provided from the same manufacturer or tested and certified as compatible for use together.

f. Radio frequency interference suppression is integral to device.

2.5.2.4 Scene Wallstations

Provide scene wallstations that are compatible with the other components of the lighting control system and capable of Class 1 or 2 wiring methods in accordance with the NEC and local codes. Provide devices that contain on/off group, preset scene functions, or dim up/dim down interface through front panel. Programming of new scenes or zone assignments must be accomplished by authorized personnel from the space being controlled. Provide labeling for each button, including laminated sheet with scene descriptions to be posted near each scene controller.

2.5.2.5 Occupancy/Vacancy Sensors

IEEE C62.41, NEMA WD 1, UL 94, UL 916, UL 508, ASTM D4674 REV A, NEMA WD 7. Provide occupancy/vacancy sensors with coverage patterns as indicated on manufacturer shop drawings. Provide occupancy sensor operation that requires movement to activate luminaires controlled and turns luminaires off after a set time of inactivity. Provide ceiling or wall-mounted occupancy/vacancy sensors that meet the following requirements:

a. Operating voltage of 120-277 volts.

b. Time delay of 30 seconds to 30 minutes with at least four intermediate time delay settings.

c. Sensors are ceiling mounted.

d. No minimum load requirement and be capable of switching from zero to 800 W at 120 VAC, 50/60 Hz and from zero to 1200 W at 277 VAC, 50/60 Hz.

e. Shielded or controlled by internal logic to adjust sensitivity to avoid false triggering due to ambient temperature, air temperature variations or HVAC air movement.

f. Sensor is equipped to automatically energize the connected load upon loss of normal power when located in a means of egress.

g. Occupancy and vacancy operation is field-adjustable and programmable with push-button or dip switch on the sensor device.

h. No leakage current to load when in the off mode.

i. Utilize zero-crossing circuitry to prevent damage from high inrush current and to promote long life operation.

2.5.2.5.1 Passive Infrared Sensors

Provide Passive Infrared Sensors (PIR) sensors that detect occupancy by sensing heat and movement in the area of coverage. Provide sensors are constructed of a housing of high-impact, injection-molded thermoplastic. Provide PIR sensors that are temperature compensated, with a dual element sensor and a multi-element fresnel lens of POLY IR4 material.

2.5.2.5.2 Ultrasonic Sensors

Provide ultrasonic sensors that detect occupancy by sensing a change in pattern of reflected ultrasonic waves in the area of coverage. Provide sensors that are constructed of a housing of high-impact, injection-molded thermoplastic. Provide ultrasonic sensors that operate at 40 kHz.

2.5.2.5.3 Dual Technology Sensors

Provide dual technology sensors that meet the requirements for PIR sensors and ultrasonic sensors indicated above. If either the PIR or ultrasonic sensing registers occupancy, the luminaires must remain on.

2.5.2.5.4 High Bay Sensors

Provide occupancy/vacancy sensors specifically designed for high-bay mounting applications for all ceiling-mounted sensors mounted above 35 feet using PIR technology. Provide high-bay sensors with interchangeable lenses for 360 degree open area coverage or narrow rectangular warehouse aisle coverage.

2.5.2.5.5 Integrated Sensors

Provide integrated occupancy/vacancy sensors that mount directly to the luminaires as indicated in project plans.

2.5.2.5.6 Power Packs

UL 2043. Provide power packs to provide power to lighting control sensors as required in accordance with the manufacturer's specifications. Provide power packs that meet the following requirements:

a. Operate at an input voltage of 120-277 VAC, with an output voltage 12-24 VDC at 225 mA.

b. Constructed of plenum-rated, high-impact thermoplastic enclosure.

c. Utilizes zero-crossing circuitry to prevent damage from inrush current.

d. Maximum load rating of 16 amps for electronic lighting loads.

e. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

2.5.2.6 Photosensors

Provide photosensors that meet the following requirements:

a. Detect changes in ambient lighting level and enable dimming as required by sequence of operation by operating in an open-loop or a closed-loop system as required.

b. Contain a detection cone, where the base of the cone may be circular or an elongated shape, and where the smallest angle between the edge and the axis of the cone is between 20 and 50 degrees. The cone axis may be tilted to the vertical when installed to give the sensor preferred directionality.

c. Sensors are ceiling-mounted with sensitivity, filtering, range and viewing angle to meet requirements of sequence of operation, scope of work and construction documents.

d. Time delay that is adjustable from 1 to 30 seconds ON delay, and 1 to 30 minutes OFF delay to prevent cycling, with deadband adjustment of 25 percent to 100 percent above lower setpoint.

e. Output dimming signal is linear to light level with less than 1 percent variation. Cadmium sulfide photo-resistors are not acceptable.

f. Sensor is not combined in the same housing or location with occupancy or vacancy sensors if the proper location for one function compromises the successful operation of the other function, or in any way reduces the system's ability to meet the design intent.

2.5.2.7 Time Clocks

UL 917, NEMA ICS 6. House time clock in a surface-mounted, lockable, NEMA 1, 3R, or 4 enclosure constructed of painted steel or plastic polymer. Provide electronic type time clock that meets the following criteria:

a. 7 day programming function, providing a total on/off set points as required.

b. 12 hour AM/PM type digital clock display format.

c. Power outage back-up for time clock utilizing lithium battery which provides coverage for a minimum of seven days.

2.6 EXIT AND EMERGENCY LIGHTING EQUIPMENT

2.6.1 Exit Signs

UL 924, NFPA 101. Provide wattage as indicated in the luminaire schedule on project plans. Provide LED Exit Signs that meet the following criteria:

a. Housing constructed of painted, die-cast aluminum.

b. UL listed for damp or wet location as required.

c. Configured for universal mounting.

d. 6 inch high, 3/4 inch stroke red lettering on face of sign with chevrons on either side of lettering to indicate direction.

e. Single or double face as indicated in project plans and luminaire schedule.

2.6.1.1 Exit Signs with Battery Backup

Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1-1/2 hours. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver. In lieu of battery, can use a nonradioactive photoluminescent plate.

2.6.1.2 Remote-Powered Exit Signs

Provide exit sign that contains provision for 120-277 VAC input from remote source.

2.6.2 Emergency Lighting Unit (ELU)

UL 924, NFPA 101. Provide emergency lighting units (ELUs) completely assembled with wiring and mounting devices, ready for installation at the locations indicated. Provide in painted, die-cast aluminum housing with UL damp label or UL wet label as required. Emergency lighting units must be rated for 12 volts, except units having no remote-mounted light sources and having no more than two unit-mounted light sources may be rated six volts. Equip units with brown-out sensitive circuit to activate battery when input voltage falls to 75 percent of normal. Equip with two LED light sources, automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 90 minutes. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver.

2.6.3 LED Emergency Drivers

UL 924, NFPA 101. Provide LED emergency driver with automatic power failure detection, test switch and LED indicator (or combination switch/indicator) located on luminaire exterior, and fully-automatic solid-state charger, battery and inverter integral to a self-contained housing. Provide self-diagnostic function integral to emergency driver. Integral nickel-cadmium battery is required to supply a minimum of 90 minutes of emergency power at 10 watts, 10-50 VDCcompatible with LED forward voltage requirements, constant output. Driver must be RoHS compliant, rated for installation in plenum-rated spaces and damp locations, and be warranted for a minimum of five years.

2.6.4 Self-Diagnostic Circuitry for LED Drivers

UL 924, NFPA 101. Provide emergency lighting unit with fully-automatic, integral self-testing/diagnostic electronic circuitry. Circuitry must provide for a one minute diagnostic test every 28 days, and a 30 minute diagnostic test every six months, minimum. Any malfunction of the unit must be indicated by LED(s) visible from the exterior of the luminaire. A manual test switch must also be provided to perform a diagnostic test at any given time.

2.6.5 Mini Inverters

UL 924, NFPA 101. Provide mini inverters that are designed to provide power to emergency luminaires. Provide mini inverters that are suitable for dry, damp or wet installations as equired, operate at a voltage of 120-277 volts at 50/60 hertz, and are capable of operating 0-10V dimming override. Provide mini inverters that supply a minimum of 90 minutes of emergency power.

2.6.6 Central Emergency Lighting System

UL 924, NFPA 101, NFPA 110 level 1, NFPA 70.. Provide a central power system providing emergency power at 120 volts, 60 hertz, for a minimum period of 90 minutes. Design the system to handle surges during loss and recovery of the voltage, and to deliver its full rated output to the designated lamp load. Provide batteries or backup ac source for power.

2.6.6.1 Operation

Provide system such that when the lighting system loses normal supply voltage, it automatically disengages itself from the normal input line, and switches to a self-contained inverter with built-in protection when the output is shorted or overloaded. Ensure that, when normal line voltage resumes, the emergency system automatically switches back to normal operation. Size the transfer switch for this function to handle 125 percent of full load. Provide the battery system with self-contained inverters with overload protection.

2.6.6.2 Charger

Provide a completely automatic battery charger that maintains the batteries in a fully charged condition and recharges the batteries to full capacity within 24 hours after full discharge in accordance with UL 924.

2.6.6.3 Batteries

Provide sealed nickel-cadmium batteries, maintenance-free for a period of not less than 10 years under normal operating conditions.

2.6.6.4 Accessories

Provide visual indicators to indicate normal power, inverter power, and battery-charger operation. Provide a low-voltage test switch to simulate power failure by interrupting the input line, voltage meter, electrolyte level detector to automatically disable the charging circuit in the event of a fault, and low-voltage cutoff to prevent extreme battery power dissipation.

2.6.6.5 Enclosure

Provide a free-standing cabinet with floor stand and constructed of 2.7 millimeter 12 -gage sheet steel with baked-on enamel finish and a locking latch.

2.7 LUMINAIRE MOUNTING ACCESSORIES

2.7.1 Suspended Luminaires

a. Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers.

b. Hangers must allow luminaires to swing within an angle of 45 degrees. Brace pendents 4 feet or longer to limit swinging.

c. Single-unit suspended luminaires must have twin-stem hangers. Multiple-unit or continuous row luminaires with a separate power supply cord must have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end.

d. Provide all linear pendent and surface mounted luminaires with two supports per four-foot section or three per eight-foot section unless otherwise recommended by manufacturer.

e. Provide rods in minimum 0.18 inch diameter.

2.7.2 Recess and Surface Mounted Luminaires

Provide access to light source and LED driver from bottom of luminaire. Provide trim and lenses for the exposed surface of flush-mounted luminaires as indicated on project drawings and specifications. Luminaires recessed in ceilings which have a fire resistive rating of one hour or more must be enclosed in a box which has a fire resistive rating equal to that of the ceiling. For surface mounted luminaires with brackets, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the luminaire rigidly in design position. Flanged part of luminaire stud must be of broad base type, secured to outlet box at not fewer than three points.

2.7.3 Luminaire Support Hardware

2.7.3.1 Wire

ASTM A641/A641M. Galvanized, soft tempered steel, minimum 0.11 inches in diameter, or galvanized, braided steel, minimum 0.08 inches in diameter.

2.7.3.2 Wire for Humid Spaces

ASTM A580/A580M. Composition 302 or 304, annealed stainless steel, minimum 0.11 inches in diameter.

ASTM B164. UNS NO4400, annealed nickel-copper alloy, minimum 0.11 inches in diameter.

2.7.3.3 Threaded Rods

Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

2.7.3.4 Straps

Galvanized steel, one by 3/16 inch, conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

2.7.4 Power Hook Luminaire Hangers

UL 1598. Provide an assembly consisting of through-wired power hook housing, interlocking plug and receptacle, power cord, and luminaire support loop. Power hook housing must be cast aluminum having two 3/4 inch threaded hubs. Support hook must have safety screw. Luminaire support loop must be cast aluminum with provisions for accepting 3/4 inch threaded stems. Power cord must include 16 inches of 3 conductor No. 16 Type SO cord. Assembly must be rated 120 volts or 277 volts, 15 amperes.

2.8 EQUIPMENT IDENTIFICATION

2.8.1 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.8.2 Labels

UL 1598. All luminaires must be clearly marked for operation of specific light sources and LED drivers. The labels must be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Note the following light source characteristics in the format "Use Only _____":

a. Correlated Color Temperature (CCT) and Color Rendering Index (CRI) for all luminaires.

b. Driver and dimming protocol.

All markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.9 FACTORY APPLIED FINISH

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum, meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

IEEE C2, NFPA 70.

3.1.1 Light Sources

When light sources are not provided as an integral part of the luminaire, deliver light sources of the type, wattage, lumen output, color temperature (CCT), color rendering index (CRI), and voltage rating indicated to the project site and install just prior to project completion, if not already installed in the luminaires from the factory.

3.1.2 Luminaires

Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires and secure in accordance with manufacturers' directions and approved drawings. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Luminaire catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a luminaire may be installed. Provide wires, straps, or rods for luminaire support in this section. Install luminaires with vent holes free of air blocking obstacles.

3.1.2.1 Suspended Luminaires

Measure mounting heights from the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain architect approval of the exact mounting height on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Support suspended luminaires from structural framework of ceiling or from inserts cast into slab.

a. Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level.

b. Locate so that there are no obstructions within the 45 degree range in all directions.

c. The stem, canopy and luminaire must be capable of 45 degree swing.

d. Rigid pendent stem, aircraft cable, rods, or chains 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation.

e. Suspended luminaires in continuous rows must have internal wireway systems for end to end wiring and must be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces.

f. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints.

g. Support steel luminaires to prevent "oil-canning" effects.

h. Match supporting pendents with supported luminaire. Aircraft cable must be stainless steel.

i. Match finish of canopies to match the ceiling, and provide low profile canopies unless otherwise shown.

j. Maximum distance between suspension points must be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.2.2 Recessed and Semi-Recessed Luminaires

a. Support recessed and semi-recessed luminaires independently from the building structure by a minimum of two wires, straps or rods per luminaire and located near opposite corners of the luminaire. Secure horizontal movement with clips provided by manufacturer. Ceiling grid clips are not allowed as an alternative to independently supported luminaires.

b. Support round luminaires or luminaires smaller in size than the ceiling grid independently from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around.

c. Do not support luminaires by acoustical tile ceiling panels.

d. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support each independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the luminaire.

e. Luminaires installed in suspended ceilings must also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

f. Adjust aperture rings on all applicable ceiling recessed luminaires to accommodate various ceiling material thickness. Coordinate cut-out size in ceiling to ensure aperture covers cut-out entirely. Install aperture rings such that the bottom of the ring is flush with finished ceiling or not more than 1/16 inch above. Do not install luminaires such that the aperture ring extends below the finished ceiling surface.

g. For luminaire recessed in plaster ceilings, provide plaster frames for setting. Install setting such that the bottom of the frame is flush with finished ceiling. Support luminaires with plaster frames utilizing yokes or leveling lugs. Do not mount luminaires or support elements to ducts or pipes. Yokes must support a luminaire by no fewer than two bolts each.

3.1.2.3 Field Applied Painting

Paint lighting equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Provide painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.3 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

3.1.4 Exit Signs

NFPA 101. Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

Connect exit signs on separate circuits and serve from an emergency panel. Provide only one source of control, which would be the circuit breaker in the emergency panel. Paint source of control red and provide lockout capability.

3.1.5 Lighting Controls

Refer to Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS for additional lighting control installation requirements.

3.1.5.1 Scene Wallstations

Submit labeling templates for all scene wallstations, ganged faceplates and other manual control cover plates. Label each scene control button with approved scene description.

3.1.5.2 Occupancy/Vacancy Sensors

a. Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage must provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways.

b. Locate ceiling-mounted sensors no closer than 6 feet from the nearest HVAC supply or return diffuser.

c. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations.

3.1.5.3 Photosensors

Locate and aim sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor set-point in accordance with the manufacturer's recommendations and for the indicated light level of the area of coverage, measured at the work plane.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

3.2.1.1 Lighting Control Verification Tests

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

a. Verify occupancy/vacancy sensors operate as described in sequence of operations. Provide testing of sensor coverage, sensitivity, and time-out settings in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit occupancy/vacancy sensor verification test.

b. Verify photosensors operate as described in sequence of operations. Provide testing of sensor coverage, aiming, and calibration in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit photosensor verification test.

c. Verify wall box dimmers and scene wallstations operate as described in sequence of operations.

3.2.1.2 Emergency Lighting Test

Interrupt power supply to demonstrate proper operation of emergency lighting. If adjustments are made to the lighting system, re-test system to show compliance with standards.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Commissioning

NFPA 101. Commission all components of the lighting system and lighting control system in accordance with Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING. Commission all components of the lighting system and lighting control system in accordance with Section 01 91 00.15 20 TOTAL BUILDING COMMISSIONING. Factory Trained Field Service Technician is responsible for calibration and programming sequences for input devices and systems in accordance with the requirements described in the sequence of operation.

3.3.2 Training

3.3.2.1 Maintenance Staff Training

Submit a Maintenance Staff Training Plan at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrates full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.2.2 End-User Training

Submit an End-User Training Plan at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide users with a list of control devices located within user-occupied spaces, such as photosensors and occupancy and vacancy sensors, including information on the proper operation and schedule for each device. Provide demonstration for each type of interface. Provide users with the building schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

Provide laminated instructions to the user at each scene wallstation. Provide only instructions relevant to the functionality of the specific scene wallstation. Provide a description of each labeled scene control button. If the room utilizes occupancy/vacancy sensors or photosensors, include a description of this functionality on the instruction sheet.

-- End of Section --

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SECTION 26 52 00.00 40

EMERGENCY LIGHTING
11/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 101	(2021) Life Safety Code

UNDERWRITERS LABORATORIES (UL)

UL 924	(2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Preinstallation Meetings

No later than 30 days after contract award, submit installation drawings for the Central Emergency Lighting Systems, indicating the location of installed fixtures.

Submit material, equipment, and fixture lists showing the manufacturer's style or catalog numbers, specification and drawing reference numbers, and a sample warranty. Also submit the manufacturer's catalog data and certificates of conformance for the following items:

a. Emergency Lighting Egress Units

b. Emergency Fluorescent Lighting

c. Central Emergency Lighting Systems

d. Accessories

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Central Emergency Lighting Systems; G

SD-03 Product Data

Material, Equipment, and Fixture Lists; G

Sample Warranty; G

Emergency Lighting Egress Units; G

Emergency Fluorescent Lighting; G

Central Emergency Lighting Systems; G

Accessories; G

SD-06 Test Reports

System Operational Tests; G

SD-07 Certificates

Certificates of Conformance

SD-11 Closeout Submittals

Warranty

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Furnish emergency lighting units completely assembled with wiring and mounting devices, ready for installation at the locations indicated. Equip fixtures with lamps. Ensure that emergency lighting units are suitable for operation on the ac supply circuit to which they are to be electrically connected.

2.1.1 Performance Requirements

Provide emergency lighting units conforming to UL 924 and NFPA 101.

2.2 MANUFACTURED UNITS

2.2.1 Emergency Lighting Egress Units

Provide a complete self-contained emergency lighting unit with batteries, battery charger, one or more local or remote lamp heads with lamps, undervoltage relay, indicator lights, on/off switch, and test switch, in accordance with UL 924 for Type I (emergency light set), Class I rechargeable storage-battery-powered unit , Style D nonrefillable nickel-cadmium battery , as indicated.

2.2.1.1 Batteries

Provide batteries rated 6-12 volts. Provide batteries with the capacity and rating to supply the lamp load while maintaining a minimum 87.5 -percent power for 1.5 hours, or the battery-lamp combination maintaining 60 -percent, minimum, illumination. Provide maintenance-free nickel-cadmium type batteries, with a minimum normal life of 10 years.

2.2.1.2 Battery Charger

Provide a battery charger with a dry full-wave rectifier with two charging rates: one to automatically maintain the battery in a fully charged state under normal conditions and the other to automatically recharge the battery to a fully charged state within 12 hours after a continuous discharge of 1-1/2 hours through the connected lamp load.

2.2.1.3 Unit Enclosure

Fabricate the unit enclosure with at least 18 -gage sheet steel. Design the cover to provide access to the battery and battery-charger compartments and to have a full-length piano hinge and a latching device. Protect component parts within the enclosure from dust, moisture, and oxidizing fumes from the battery. Coat the interior and exterior surfaces of the enclosure with a corrosion-resistant gray baked-enamel finish.

2.2.1.4 Lamp Heads, Lamps, and Indicating Lights

Mount the lamp heads on the top of the unit enclosure, or wall-mount the lamp heads. Except where otherwise indicated, ensure that the lamp heads are fully adjustable in the horizontal and vertical planes. Provide a steel lamp head assembly with nickel plating. Form the exterior housing of the lamp from nickel -plated sheet steel.

Provide sealed-beam lamps, PAR-36 or halogen, rated not less than 12 watts at the specified dc voltage.

Mount an amber "ready-for-use on alternating current" indicating light, a red "recharging on alternating current" indicating light, and a momentary-contact pushbutton test switch on the cover of the unit enclosure. The amber light, when illuminated, indicates that the unit is electrically connected to the normal ac supply source and that the battery is fully charged. The red light, when illuminated, indicates that the battery is being recharged. The momentary-contact pushbutton test switch transfers the unit from normal supply to battery supply and tests operation of equipment under simulated ac source power failure.

2.2.1.5 Relays and Switches

Provide a self-cleaning undervoltage relay that automatically connects the lampload to the battery supply upon failure of the ac supply. Mount an on-off toggle switch inside the unit enclosure to disconnect the battery from the lamp load when the unit is taken out of service. The relay energizes when the ac supply falls to 70 percent of normal voltage.

2.2.1.6 Mounting Shelves

Provide the emergency lighting units with angle iron mounting shelves and with a protective screen designed by the equipment manufacturer for this purpose. Coat the mounting shelf and screen with a corrosion-resistant finish in accordance with the manufacturer's standard practice.

2.2.2 Emergency Fluorescent Lighting

Provide each unit with an automatic power failure device, test switch, pilot light, and fully automatic high/low trickle charger in a self-contained solid-state, temperature-compensated power pack. Provide a sealed-wet or gelled-electrolyte battery with sufficient capacity to supply power to provide a minimum of 600 lumens using a 40 -watt rapid-start lamp. Provide a sealed and maintenance-free battery, with an active life of not less than 10 years under normal operating conditions.

2.2.3 Central Emergency Lighting Systems

Provide a central power system providing emergency power at 120 volts, 60 hertz, for a minimum period of 90 minutes. Design the system to handle surges during loss and recovery of the voltage, and to deliver its full rated output to the designated lamp load. Provide batteries or backup ac source for power.

2.2.3.1 Operation

Ensure that, when the system loses normal supply voltage, it automatically disengages itself from the normal input line, and switches to a self-contained inverter with built-in protection when the output is shorted or overloaded. Ensure that, when normal line voltage resumes, the emergency system automatically switches back to normal operation. Size the transfer switch for this function to handle 125 percent of full load. Provide the battery system with self-contained inverters with overload protection.

2.2.3.2 Charger

Provide a completely automatic battery charger that maintains the batteries in a fully charged condition and recharges the batteries to full capacity within 24 hours after full discharge in accordance with UL 924.

2.2.3.3 Batteries

Provide sealed nickel-cadmium batteries, maintenance-free for a period of not less than 10 years under normal operating conditions.

2.2.3.4 Accessories

Provide visual indicators to indicate normal power, inverter power, and battery-charger operation. Provide a low-voltage test switch to simulate power failure by interrupting the input line, voltage meter, electrolyte level detector to automatically disable the charging circuit in the event of a fault, and low-voltage cutoff to prevent extreme battery power dissipation.

2.2.3.5 Enclosure

Provide a free-standing cabinet with floor stand and constructed of 12 -gage sheet steel with baked-on enamel finish and a locking latch.

2.2.4 Self-Testing Module

Provide a self-testing module for the emergency lighting equipment that performs the following functions:

a. Continuous monitoring of charger operation and battery voltage with visual indication of normal operation and of malfunction.

b. Monthly discharge cycling of battery with monitoring of transfer circuit function, battery capacity, and emergency lamp operation with visual indication of malfunction. Conduct the battery capacity test using a synthetic load.

c. Manual test switch to simulate a discharge test cycle.

d. Low-voltage battery disconnect (LVD) and brown-out protection circuit.

PART 3 EXECUTION

3.1 INSTALLATION

Permanently fix in place the emergency lighting unit and install wiring for each unit in accordance with NFPA 70. Use the same panel bus or branch circuit as that serving the normal lighting in the area for the branch circuit feeding the unit equipment, and connect ahead of the area switches. Keep remotely connected emergency lighting circuit wiring independent of all other wiring and equipment, and do not enter the same conduit, cable, box, or cabinet with other wiring unless the fixture is supplied from two sources.

Mount emergency lighting units and remote lamps at a minimum of 7 -feet above the finished floor.

3.2 FIELD QUALITY CONTROL

Demonstrate emergency lighting units to operate satisfactorily in the presence of the Contracting Officer.

Perform and submit System Operational Tests in accordance with referenced standards in this section.

3.3 WARRANTY

Submit 2 copies of warranty, signed by an authorized representative, designating the Government as warrantee, to the Contracting Officer, 5 days before project closeout.

-- End of Section --

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SECTION 26 53 00.00 40

EXIT SIGNS
11/15

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2021) Life Safety Code

U.S. DEPARTMENT OF ENERGY (DOE)

DOE LT-4	(2005) How to Buy Energy-Efficient Exit Signs

UNDERWRITERS LABORATORIES (UL)

UL 924	(2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Pre-Installation Meetings

No more than 30 days after Contract Award, the Contracting Officer will schedule a Pre-Installation Meeting. Submit material, equipment, and fixture lists for the following showing manufacturer's product data, including style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site:

a. Exit Lighting Units

b. Contemporary Fixtures

c. Accessories

Submit exit lighting units outline drawings indicating overall physical features, dimensions, ratings, service requirements, and weights of equipment.

Submit certificates clearly indicating the energy efficiencies of each fixture type and conformance with 42 U.S.C. 8253(f) "Use of Energy and Water Efficiency in Federal Buildings, September 2012", and DOE’s Facility Energy Management Guidelines and Criteria for Energy and Water Evaluations in Covered Facilities, http://www1.eere.energy.gov/femp/technologies/procuring_eeproducts.html

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S"

classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists; G

SD-02 Shop Drawings

Exit Lighting Units; G

Exit Lighting Units Outline Drawings; G

SD-03 Product Data

Exit Lighting Units; G

Contemporary Fixtures; G

Accessories; G

SD-06 Test Reports

Operational Tests; G

SD-07 Certificates

Energy Efficiencies; G

1.4 WARRANTY

Provide a five year warranty for all components.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide emergency exit lighting fixtures conforming to UL 924, NFPA 101, and as specified.

Provide exit lighting fixtures completely assembled with wiring and mounting devices, ready for installation at the locations indicated. Ensure ceiling-mounted fixtures are designed to be supported independent of the ceiling and equipped with lamps.

Provide exit lighting fixtures having efficiencies in accordance with the recommended levels specified in DOE LT-4.

2.2 COMPONENTS

2.2.1 Contemporary Fixtures

Provide contemporary exit lighting fixtures having a fixture body with edge-lighted plastic exit-sign panels, face trims, lamps, lampholders, and mounting brackets for top, back, and end mounting to walls and ceilings in accordance with NFPA 101, as indicated.

Provide single or double face fixtures with thin wedge-shaped vertical cross sections. Ensure top edge of double-face fixtures is not more than 2-3/4 -inches thick, and top edge of single-face fixtures is not more than 2 -inches thick. Provide double-face fixtures with a bottom edge of not more than 1-3/4 -inches thick, and single-face fixtures not more than 1-1/4 -inches thick.

Provide plastic sign panels with acrylic with red translucent letters and directional arrows, as required. Ensure letters are 6 -inches high with stroke not less than 3/4 -inch wide.

Provide anodized sheet aluminum with a matte finish wireway cover and plastic sign backup plate, with face trims formed from sheet aluminum and shall have a brushed-satin finish . Ensure fixture bodies formed from sheet steel are not less than20 gage and painted.

Provide plastic sign panels which are edge-lighted from the top with at least two low-voltage miniature incandescent lamps that will illuminate the plastic sign panels and floor. Wire exit signs for two-circuit service at 120 volts and include a diode circuit that provides a minimum of 50,000 hours of lamp life.

Provide mounting plates and brackets formed from sheet aluminum or plate with a brushed-satin finish, not less than 4-1/2 -inches square and designed to secure the fixture to a 4 -inch square outlet box.

2.2.2 Emergency Power Loss Exit Lighting Units

Provide each self-contained unit with an automatic power failure device, test switch, pilot light, and fully automatic high/low solid-state trickle charger in a self-contained power pack. Provide with sealed-wet or gelled-electrolyte type battery, maintenance-free for a period of not less than 10 -years under normal operating conditions. Ensure normal operation is with 120 -volts. Connect to Emergency lighting panel.

2.2.3 Light Emitting Diodes (LEDs) Exit Lighting Fixtures

Provide single or double faced exit lighting fixtures with sheet metal enclosures, including frames, battery charger, batteries, red light emitting diodes (LEDs), and mounting brackets with mounting plates suitable for securing the fixture to a 4-inch outlet box. Ensure fixture features include:

a. Continuous charging

b. Automatic switching to standby batteries upon loss of power

c. Overload protection

d. Short circuit protection

e. Test switch

f. Low voltage disconnect

g. Switch controlled left and right LED directional arrows

h. Field connectable to operate from 115 volts

i. Brightness not less than ten (10) candlepower

Provide unit battery system with minimum operating time of three (3) hours for double faced fixtures and seven (7) hours for single faced fixtures.

PART 3 EXECUTION

3.1 INSTALLATION

Connect fixtures to the main panel bus through overcurrent protection. Use emergency lighting panel where available.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

Field test exit lighting to demonstrate satisfactory operation in the presence of the Contracting Officer.

Perform and submit operational tests in accordance with referenced standards in this section.

-- End of Section --

SECTION 26 55 53.00 40

SECURITY LIGHTING
11/14

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A575	(2020) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM A576	(2017) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM B2	(2013) Standard Specification for Medium-Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ILLUMINATING ENGINEERING SOCIETY (IES)

ANSI/IES RP-8	(2018; Addenda 1 2020; Errata 1-2 2021) Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C135.1	(1999) Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI ANSLG C78.42	(2009; R 2016) For Electric Lamps: High-Pressure Sodium Lamps
ANSI C78.40	(2011) American National Standard for Mercury Lamps--Specifications
ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C82.4	(2017) Lamp Ballasts - Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps
ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI C136.2	(2015) American National Standard for Roadway and Area Lighting Equipment: Luminaires Voltage Classification
ANSI C136.3	(2020) Roadway and Area Lighting Equipment - Luminaire Attachments
ANSI C136.6	(2004) American National Standard for Roadway Lighting Equipment - Metal Heads and Reflector Assemblies - Mechanical and Optical Interchangeability
ANSI C136.9	(2003) American National Standard for Roadway and Area Lighting Equipment - Socket Support Assemblies for Metal Heads - Mechanical Interchangeability
ANSI C136.11	(2011; R 2016; STBL 2021) Roadway Lighting Equipment - Multiple Parallel Wired Sockets

ANSI C136.15	(2020) American National Standard for Roadway and Area Lighting Equipment - Luminaire Field Identification
ANSI/ANSLG C78.43	(2013) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
ANSI/NEMA OS 1	(2013; R 2020) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 6 & 8	(2020) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA TC 9	(2020) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232	(1997f; R 2012) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 98	(2016) UL Standard for Safety Enclosed and Dead-Front Switches
UL 467	(2022) UL Standard for Safety Grounding

	and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 651A	(2011; Reprint Mar 2017) UL Standard for Safety Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit
UL 854	(2020) Standard for Service-Entrance Cables
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 1029	(1994; Reprint May 2017) UL Standard for Safety High-Intensity-Discharge Lamp Ballasts
UL 1203	(2013; Reprint Apr 2022) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 1598	(2021; Reprint Jun 2021) Luminaires

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting System; G

Detail Drawings; G

SD-03 Product Data

Equipment and Materials; G

Spare Parts; G

SD-06 Test Reports

CCTV Assessment Lighting; G

Operating Test; G

Ground Resistance Measurements; G

SD-07 Certificates

CCTV Assessment Lighting Test Procedures; G

Operating Test Procedures; G

SD-10 Operation and Maintenance Data

Operations and Maintenance Manuals; G

SD-11 Closeout Submittals

Record Drawings; G

1.3 QUALITY CONTROL

1.3.1 Standard Products

Provide materials and equipment which are the standard products of manufacturer regularly engaged in the manufacture of such products, and which essentially duplicate equipment that has been in satisfactory use at least two years prior to bid opening.

1.4 PROJECT/SITE CONDITIONS

Lighting equipment that is usable in their original configuration without modification may be reused with Government approval. Perform a field survey, including testing and inspection of existing lighting equipment and control lines intended to be incorporated into the lighting system, and furnish a report to the Government. For those items considered nonfunctioning, provide specification sheets, or written functional requirements to support the findings and the estimated cost to correct the deficiency with the report. As part of the report, include the scheduled need date for connection to all existing equipment.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Lighting System

Configure the lighting system as specified and shown. Include all fixtures, hardware, poles, cables, connectors, adapters and appurtenances needed to provide a fully functional lighting system.

a Design Requirements for CCTV Assessment Lighting

Configure the CCTV Assessment Lighting system as specified and shown. Ensure equipment conforms to NFPA 70 and IEEE C2. Provide sufficient light for optimum CCTV assessment of each zone in the configuration. Include all fixtures, hardware, poles, cables, connectors, adapters, and appurtenances needed to provide a fully functional lighting system.

2.1.1.1 Electrical Requirements

Provide equipment which operates from a voltage source as shown; plus or minus 10 percent, and at 60 Hz, plus or minus 2 percent.

a. Power Line Surge Protection

Provide transient voltage surge suppressors for all electronic equipment, meeting the requirements of IEEE C62.41.1 and IEEE C62.41.2, and UL listed as tested in accordance with UL 1449. Select surge suppressor ratings as indicated . Do not use fuses as surge suppression.

b. Interface CCTV Lighting and CCTV System

Interface infrared lights to the CCTV system and provide automatic, alarm actuated call-up of the light associated with the alarm zone.

2.1.2 System Design

Submit detail drawings for the complete system and for poles, lighting fixtures, bracket arms, cable boxes, handholes, transformers and controllers. Detail drawings for precast handholes include a design analysis to determine that strength is equivalent to indicated cast-in-place concrete handholes. Indicate in drawings bonding method for concrete encasement. Include in drawings design calculations showing adequate strength of screw foundations. For CCTV lighting, include in date:

a. Infrared light call-up response time.

b. Lamp strike and restrike times.

c. System startup and shutdown operations.

d. Manuals for CCTV Assessment Lighting equipment.

e. A typical zone layout showing light locations, isolux patterns, and lighting ratios.

Submit data published by the manufacturer of each item on the list of equipment and material, to permit verification that the item proposed is of the correct size, properly rated or applied, or is otherwise suitable for the application and fully conforms to the requirements specified.

2.2 EQUIPMENT

2.2.1 Interface Lighting System and Power Distribution

Provide conductors including all conductors extending from the load side of the primary and secondary power panels that serve assessment lighting equipment and as indicated.

2.2.2 Aerial Cable Hardware

Provide zinc coated aerial cable hardware conforming to IEEE C135.1, with steel hardware material conforming to ASTM A575 and ASTM A576, hot-dip galvanized in accordance with ASTM A153/A153M.

2.2.3 Cable Splices and Connectors

Provide cable splices and connectors conforming to UL 486A-486B. Provide underground splices and connectors conforming to the requirements of ANSI C119.1.

2.2.4 Cable Boxes

Provide cable boxes and covers made of cast iron with zinc coated or aluminized finish, of the sizes indicated on drawings. Provide minimum inside dimensions of not less than 12 inches square by 6 inches deep and not less than required to house the cable splice. Install a suitable gasket between the box and cover for a watertight seal. Install a sufficient number of screws to hold the cover in place along the entire surface of contact. Provide grounding lugs.

2.2.5 Manholes, Handholes, and Pullboxes

Provide manholes, handholes, pullboxes,and related frames and covers as indicated, with strengths conforming to the requirements of IEEE C2. Provide precast concrete manholes with the required strength established by ASTM C478. Provide frames and covers for manholes made of gray cast iron or cast steel. Provide a machine-finished seat to ensure a matching joint between frame and cover. Cast iron is to comply with ASTM A48/A48M, Class 30B, minimum. Provide handholes for low voltage cables installed in parking lots, sidewalks, and turf areas made from an aggregate consisting of sand and with continuous woven glass strands having an overall compressive strength of at least 10,000 psi and a flexural strength of at least 5,000 psi. Provide pullbox and handhole covers in parking lots, sidewalks, and turf areas of the same material as the box. Provide concrete pullboxes consisting of precast reinforced concrete boxes, extensions, bases, and covers. Install a sufficient number of tamperproof bolts to hold the cover firmly in place along the entire surface of contact; and include a tool for the tamperproof bolts.

2.2.6 Conduit, Ducts and Fittings

2.2.6.1 Conduit, Rigid Steel

Provide rigid steel conduit conforming to ANSI C80.1 and UL 6.

2.2.6.2 Conduit Coatings

Coat underground metallic conduit and fittings with a plastic resin system conforming to NEMA RN 1, Type 40. Epoxy systems may also be used.

2.2.6.3 Conduit Fittings and Outlets

a. Boxes, Metallic Outlets

ANSI/NEMA OS 1 and UL 514A.

b. Boxes, Nonmetallic, Outlet and Flush-Device Boxes and Covers

ANSI/NEMA OS 1 and UL 514C.

c. Boxes, Outlet for Use in Hazardous (Classified) Locations

UL 1203.

d. Boxes, Switch (Enclosed), Surface Mounted

UL 98.

e. Fittings for Conduit and Outlet Boxes

UL 514B.

f. Fittings for Use in Hazardous (Classified) Locations

UL 1203.

g. Fittings, PVC, for Use with Rigid PVC Conduit and Tubing

UL 514B.

2.2.6.4 Non-Metallic Duct

Provide non-metallic duct lines and fittings utilized for underground installation suitable for the application, consisting of thick-wall, single, round-bore type, using material of one type. Provide acrylonitrile-butadiene-styrene (ABS) duct conforming to NEMA TC 6 & 8 and NEMA TC 9, with high-density conduit conforming to UL 651A. Provide Schedule 40 polyvinyl chloride (PVC) conforming to UL 651. Provide schedule 40 polyvinyl chloride (PVC) conforming to UL 651.

Provide all plastic utility duct and fittings manufactured without a UL label or listing with a certification as follows: "The materials are suitable for use with 167 degree F wiring. No reduction of properties in excess of that specified for materials with a UL label or listing will be experienced if samples of the finished product are operated continuously under the normal conditions that produce the highest temperature in the duct."

2.2.7 Fixtures

Provide special fixtures as indicated on the drawings. Illustrations shown on these sheets or on the drawings are indicative of the general type desired and are not intended to restrict selection to fixtures of any particular manufacturer. Fixtures of similar design, equivalent light distribution and brightness characteristics, equal finish and quality is acceptable as approved.

2.2.7.1 Accessories

Provide accessories such as straps, mounting plates, nipples, or brackets for proper installation.

2.2.7.2 Special Fixtures

The types of special fixtures are designated by letters and numbers. For example, SP-1 denotes special Type 1.

2.2.7.3 In-Line Fuse

Provide an in-line fuse for each fixture, consisting of a fuse and a UL approved waterproof fuse holder rated as indicated, with insulated boots. Provide a fuse rating of 600 volts.

2.2.8 Transformers

Provide transformers conforming to UL 506. Provide rust-inhibiting treatment and standard finish by the manufacturer on all exterior transformer cases.

2.2.8.1 Outdoor Dry-Type Lighting Transformers

Provide single phase, 60 Hz, two winding, with two wire secondary and with a 240 or 480 volt primary to 120 volt secondary, 1 kVA transformers.

2.2.8.2 Buck-Boost Transformers

Provide transformers suitable for outdoor installation, with a 302 degree F insulation system for an 176 degree F rise; 60 Hz with 4 windings, 2 for primary and 2 for secondary, with all leads brought out to permit parallel or series connections of primary and secondary windings. Provide voltage ratings, kVA ratings, percent of boost and/or buck, and connections as indicated on drawings.

2.2.9 Wireway, Raintight, Support

Provide raintight wireway conforming to UL 870. When used for supporting floodlights on wood poles, provide 4 by 4 inches wide by 6 feet long wireway as indicated.

2.2.10 Nameplates

Provide each major component of equipment with a nonferrous metal or engraved plastic nameplate which shows, as a minimum, the manufacturer's name and address, the catalog or style number, the electrical rating in volts, and the capacity in amperes or watts.

2.2.11 Spare Parts

Submit spare parts data for each different item of material and equipment specified, after approval of detail drawings for materials and equipment, and not later than 4 months before the date of beneficial occupancy. Include in data a complete list of parts, special tools, and supplies, with current unit prices and sources of supply.

2.3 COMPONENTS

2.3.1 Protection of Security Lighting System Components

2.3.1.1 Components and Conductors

Protect Security lighting system conductors from damage. Install lighting system conductors in raceways or by means of direct burial, as shown. Where the conductors leave the underground systems, encase the conductors in rigid steel conduit of the indicated size. Provide wire guards to protect security lighting luminaries mounted below 20 feet. House exterior group-located electrical equipment such as time switches, safety switches, and magnetic contactors in a NEMA ICS 6, Type 4 enclosure. Provide an individual enclosure where only one piece of equipment is provided at a location.

2.3.1.2 Tamper Provisions

Provide enclosures, cabinets, housings (other than luminaire housings), boxes, raceways, conduits, and fittings having hinged doors or removable covers, and which contain any part of the security lighting system (including power sources), with corrosion-resistant tamper switches, connected to an Intrusion Detection System (IDS), that initiates an alarm signal when the door or cover is opened or moved. Make tamper switches inaccessible until the switch is activated. Conceal switch leads and mounting hardware from the exterior of the enclosure. For pull or junction boxes which contain no splices or connections the covers may be protected by 1/4 inch tack welds on four sides of each cover rather than by tamper switches. Affix labels to indicate they contain no connections. Do not indicate on labels that the box is part of the security system.

2.3.2 Cable

Provide all wire and cable not indicated as government furnished equipment, capable of withstanding the jobsite environment for a minimum of 20 years.

2.3.2.1 Insulated Cable

Provide USE type cable conforming to UL 854, with copper conductors and type RHW or XHHW insulation conforming to UL 44, including green ground conductor. Provide cable with insulation of a thickness not less than that given in column A or B of TABLE 15.1 of UL 854, rated 600 volts. Provide parts of the cable system, such as splices and terminations, rated not less than 600 volts. The size and number of conductors and the number of cables are as indicated. Strand conductors larger than No. 8 AWG.

2.3.2.2 Messenger Cable

Provide a messenger cable system to support aerial cable, including guys, hardware and appurtenances needed to install the messenger cable, and capable of supporting the weight of the lighting system cable with the required messenger cable tensioning without exceeding 30 percent of its breaking strength under 60 degrees F conditions of no ice and no wind. Size the messenger so that ice and wind loading normally encountered at the site does not cause the messenger to exceed 50 percent of its breaking strength. Size appurtenances, guys, and hardware to exceed the rated breaking strength of the messenger cable. Provide galvanized zinc coated steel or aluminum clad steel messenger cables.

2.3.2.3 Bare Copper Conductors

Provide medium-hard-drawn copper conductors conforming to ASTM B2 and ASTM B8.

2.3.3 Electrical Enclosures

Provide metallic enclosures as needed to house the security and CCTV lighting equipment conforming to NEMA ICS 6 and NEMA 250. Provide enclosures with lockable or padlock handles. Deliver keys for lockable enclosures to the Contracting Officer. Provide enclosures as specified or as shown on the drawings.

2.3.3.1 Interior Enclosures

Provide enclosures to house lighting equipment in an interior environment meeting the requirements of a NEMA 12 enclosure as defined in NEMA 250.

2.3.3.2 Exposed-to-Weather Enclosures

Provide enclosures to house lighting equipment in an outdoor environment meeting the requirements of a NEMA 4 enclosure as defined in NEMA 250.

2.3.3.3 Corrosion Resistant Enclosures

Provide enclosures to house lighting equipment in a corrosive environment meeting the requirements of a NEMA 4X enclosure as defined in NEMA 250.

2.3.3.4 Hazardous Environment Enclosures

Install equipment within a hazardous environment as described in paragraph Hazardous Locations.

2.3.4 Illumination

2.3.4.1 General Lighting

Provide luminaires, ballasts, lamps, and control devices required for general area lighting , including floodlighting as required.

2.3.4.2 Roadway Lighting

Provide luminaires, ballasts, lamps, and control devices required for roadway lighting.

2.3.5 Lamps and Ballasts, High Intensity Discharge (Hid) Sources

2.3.5.1 High-Pressure Sodium

Provide lamps conforming to ANSI ANSLG C78.42, and ballasts conforming to ANSI C82.4, or UL 1029. Provide clear high-pressure sodium lamps.

2.3.5.2 Mercury Vapor

Provide lamps conforming to ANSI C78.40, and ballasts conforming to ANSI C82.4.

2.3.5.3 Metal-Halide

Provide lamps made by a manufacturer with not less than 5 years experience in making metal-halide lamps, conforming to ANSI/ANSLG C78.43, with ballasts conforming to ANSI C82.4 or UL 1029.

2.3.6 Lamps, Incandescent

Provide incandescent lamps conforming to UL 1598 and rated for 120 volt operation unless otherwise specified.

2.3.7 Lamps, Fluorescent

Provide fluorescent lamps with standard cool-white color characteristics which do not require starter switches. Provide rapid-start type lamps.

2.3.8 Luminaire Components

Provide luminaire components conforming to the following:

a. Attachments, ANSI C136.3;

b. Voltage classification, ANSI C136.2;

c. Field identification marking, ANSI C136.15;

d. Interchangeability, ANSI C136.6 and ANSI C136.9; and

e. Sockets, ANSI C136.11.

2.3.9 Photometric Distribution Classification

Provide photometrics conforming to ANSI/IES RP-8.

2.3.10 Luminaires, Floodlighting

2.3.10.1 HID and Incandescent

Provide HID lighting fixtures conforming to UL 1598. Provide incandescent lighting fixtures conforming to UL 1598.

2.3.11 [Enter Appropriate Subpart Title Here]

2.4 MATERIALS

2.4.1 Corrosion Protection

2.4.1.1 Aluminum Materials

Do not use aluminum.

2.4.1.2 Ferrous Metal Materials

a. Hardware

Provide hot-dip galvanized ferrous metal hardware in accordance with ASTM A153/A153M and ASTM A123/A123M.

b. Equipment

Provide equipment and component items, including but not limited to metal poles and ferrous metal luminaires not hot-dip galvanized or porcelain enamel finished, with corrosion-resistant finishes which withstand 480 hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16-inch from the test mark, with a scribed test mark and test evaluation rated not less than 7 in accordance with TABLE 1, (procedure A) of ASTM D1654.

Coat cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel with a zinc rich paint conforming to the manufacturer's standard.

2.4.1.3 Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory, are as specified in Section 09 90 00 PAINTS AND COATINGS.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Current Site Conditions

Verify that site conditions are in agreement with the design package. Report all changes to the site or conditions that will affect performance of the system to the Government. Do not take any corrective action without written permission from the Government.

3.1.2 Existing Equipment

Connect to and utilize existing lighting equipment and devices as shown. Make written requests and obtain approval prior to disconnecting any control lines and equipment, and creating equipment downtime. Proceed with such work only after receiving Government approval of these requests. If any device fails after work has commenced on that device, diagnose the failure and perform any necessary corrections to the equipment. The Government is responsible for maintenance and repair of Government equipment.

3.2 INSTALLATION

Install all system components, including government furnished equipment, and appurtenances in accordance with the manufacturer's instructions, IEEE C2, and contract documents. Furnish necessary hardware, fixtures, cables, wire, connectors, interconnections, services, and adjustments required for a complete and operable system.

3.2.1 Enclosure Penetrations

Make enclosure penetrations from the bottom unless the system design requires penetrations from other directions. Seal all penetrations of interior enclosures involving transitions of conduit from interior to exterior, and penetrations on exterior enclosures with rubber silicone sealant to preclude the entry of water. Terminate the conduit riser in a hot-dipped galvanized metal cable terminator. Fill the terminator with an approved sealant as recommended by the cable manufacturer, and in such a manner that the cable is not damaged.

3.2.2 Prevention of Corrosion

3.2.2.1 Aluminum

Do not use aluminum in contact with earth or concrete, and where connected to dissimilar metal, protect with approved fittings and treatment.

3.2.2.2 Steel Conduits

Do not install steel conduits within concrete slabs-on-grade. Field wrap steel conduits installed underground or under slabs-on-grade, or penetrating slabs-on-grade, with 0.010 inch thick pipe-wrapping plastic tape applied with a 50 percent overlap, or provide with a factory-applied plastic resin, epoxy coating. Zinc coating may be omitted from steel conduit which has a factory-applied epoxy coating.

3.2.2.3 Cold Galvanizing

Coat field welds and/or brazing on factory galvanized boxes, enclosures, conduits, etc. with a cold galvanized paint containing at least 95 percent zinc by weight.

3.2.3 Cable Installation

Provide cable and all parts of the cable system, such as splices and terminations, rated not less than 600 volts, with the size and number of conductors and the number of cables as indicated. Provide stranded conductors if larger than No. 8 AWG. Identify each circuit by means of fiber or nonferrous metal tags, or approved equal, in each handhole and junction box, and at each terminal.

3.2.3.1 Splices

Make splices below grade with nonpressure-filled resin systems using transparent, interlocking, self-venting, longitudinally split plastic molds. Make splices above grade with sealed insulated pressure connectors and provide insulation and jacket equal to that of the cable. In order to prevent moisture from entering the splice, cut back jackets to expose the required length of insulation between the jacket and the tapered end of the insulation.

3.2.3.2 Installation in Duct Lines

Install ground and neutral conductors in duct with the associated phase conductors. Make cable splices in handholes only.

3.2.4 Direct Burial

Provide minimum cover depth from top of cable to finished grade 30-inches for direct buried cable, but not less than the depth of the frost line.

3.2.4.1 Trenching

Excavate trenches to the depths required to provide the minimum cable cover, with the bottom of the trench smooth and free of stones and sharp objects. Where the bottom of the trench consists of material other than sand or earth, remove an additional 3-inch layer and replace with a 3-inch layer of sand or stone-free earth compacted to the approximate density of the surrounding firm soil. Unreel the cables unreeled in place along the side of or in the trench and carefully placed on the sand or earth bottom. Pulling cables into a direct-burial trench from a fixed reel position is not permitted. Where cables cross, provide a separation of at least 3-inches, unless the cables are protected by nonmetallic conduit sleeves at the crossing. Make the radius of bends in cables not less than 12 times the diameter of the cable. Do not leave the cables under longitudinal tension. Install the first layer of backfill, 6-inches thick, consisting of sand or stone-free earth. Place one-inch untreated planks, not less than 8-inches in width, or approved equal protection, end to end along the cable run, approximately 3 inches above the cable. Place a 5-mil, brightly colored plastic tape not less than 3-inchesin width and suitably inscribed at not more than 10-feet on centers, or other approved dig-in warning indication, approximately 12-inches below finished grade levels of trenches. Provide selected backfill of sand or stone-free earth to a minimum depth of 3-inches above cables.

3.2.4.2 Requirements for Installation in Duct

Where indicated on drawing, install cable in duct lines. Install ground and neutral conductors in duct with the associated phase conductors. Install segments of direct-burial cable that cross under new railroad tracks, roads, or paving exceeding 5 feet in width, in plastic, or rubber duct encased in concrete in accordance with paragraph DUCT LINES. Pulling of cable into conduit from a fixed reel position is not permitted. At interfaces with direct-burial cable, center the direct-burial cable in the entrance to the duct, using an approved waterproof, nonhardening mastic compound to facilitate the centering. Where crossing existing railroad tracks, install coated rigid steel conduit under the tracks, in lieu of concrete-encased duct, in accordance with paragraph DUCT LINES in accordance with NFPA 70 and the regulations of the railroad.

3.2.4.3 Location of Cable Splices

Splices in direct-burial cable are not permitted in runs of 500 feet or less or at intervals of less than 500 feet in longer runs except as required for taps. Where cable splices in shorter intervals are required to avoid obstructions or damage to the cable, the location is as approved. Install cable splices in cable boxes or concrete handholes.

3.2.4.4 Markers

Locate cable and cable splice markers near the ends of cables, at each cable splice, approximately every 400 feet along the cable run, and at changes in direction of the cable run. Markers need not be placed along cables laid in relatively straight lines between lighting poles that are spaced less than 400 feet apart. Place markers approximately 2 feet to the right of the cable or cable splice when facing the longitudinal axis of the cable in the direction of the electrical load. Provide concrete markers with a 28 day compressive strength of 2500 psi in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Impress the letter "C" in the top of each marker.

3.2.4.5 Warning Tape

Place direct burial cable below a plastic warning tape buried in the same trench or slot. Place a 5 mil brightly colored plastic tape, not less than 3 inches in width and suitably inscribed at not more than 10 feet on centers with a continuous metallic backing and a corrosion-resistant 1 mil metallic foil core to permit easy location of the buried cable, approximately 12 inches below finished grade.

3.2.5 Messenger Cable

3.2.5.1 Installation

Attach messenger to poles with approved clamps,with not less than 5/8 inch through bolts. Do not exceed 30 percent of messenger cable rated tensioning rated breaking strength under 60 degrees F conditions of no ice and no wind. Stress messengers to a tension higher than the final tension in order to prestretch the cable, so that when the messenger is dead-ended under its final tension and sag, there is minimum variation from the calculated values.

3.2.5.2 Grounding and Bonding Connections

Ground messengers and guy at corners, dead-ends, and entrances to each facility. Ground at intervals not exceeding 1000 feet. Fusion weld connections below grade. Fusion weld connections above grade or use UL 467 approved connectors.

3.2.5.3 Grounding Conductors and Electrodes

Provide soft drawn copper ground conductors, having a current capacity of at least 20 percent of that of the messenger to which it is connected, no smaller than No. 6 AWG. Connect the ground conductor to a ground rod of copper clad steel conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. After installation is completed, ensure that the top of the ground is approximately 1 foot below finished grade. Protect the ground conductor by half-round wood, plastic, or fiber molding from the ground to a point at least 8 feet above the ground.

3.2.5.4 Ground Resistance Testing

Measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms maximum resistance under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes, interconnected with grounding conductors , to achieve the specified ground resistance. Provide additional electrodes up to three 10 feet long spaced a minimum of 10 feet apart . In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.2.6 Aerial Cable Splices

Make splices in aerial cable within 3 feet of a pole and place inside a watertight enclosure. Form drip loops at the cable entrance to the enclosure. Place lashing clamps within 12 inches of the enclosure.

3.2.7 Lashing Wire

Wind lashing wire tightly around both the communication cable and the messenger cable by machine methods, with a minimum of one turn per 14 linear inches and not less than the number of turns per linear foot that is recommended by the cable manufacturer for the distance between cable support points and the combined ice and wind loading and extreme wind loading shown or normally encountered for the installed location. Place lashing clamps at all poles and splices.

3.2.8 Stress Loops

Form loops in the aerial cable at all points of connection and at all poles to prevent damage from thermal stress and wind loading. Protect aerial cable from chafing and physical damage with the use of spiral cut tubing and PVC tape, or plastic sleeves.

3.2.9 Connections to Buildings

Extend cables into the various buildings as indicated and properly connect to the indicated equipment. Provide empty conduits to the indicated equipment from a point 5 feet outside the building wall and 2 feet below finished grade are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. After installation of cables, seal conduits to prevent moisture or gases from entering the building.

3.2.10 Duct Lines

3.2.10.1 Requirements

Provide the numbers and size of ducts as indicated, laying duct lines with a minimum slope of 4 inches/100 feet. Depending on the contour of the finished grade, the high point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short radius manufactured 90 degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius is 18 inches for ducts of less than 3 inches in diameter, and 36 inches for duct 3 inches or greater in diameter; for long sweep bends use a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends,with a maximum curve of 30 degrees using manufactured bends. Provide ducts with end bells when duct lines terminate in manholes or handholes.

3.2.10.2 Treatment

Keep ducts clean of concrete, dirt, or foreign substances during construction. Make field cuts requiring tapers with proper tools and match factory tapers. Use a coupling recommended by the duct manufacturer when an existing duct is connected to a duct of different material or shape. Store ducts to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Thoroughly clean ducts before installation. Store plastic ducts on a flat surface and protected from the direct rays of the sun.

3.2.10.3 Concrete Encasement

Provide ducts requiring concrete encasements in compliance with NFPA 70, except for electrical duct bank configurations for ducts 6 inches in diameter, which are determined by calculation and as shown on the drawings. Provide monolithic construction of duct line encasements. Where a connection is made to a previously poured encasement, bond or dowel the new encasement to the existing encasement. At any point, except railroad and airfield crossings, make tops of concrete encasements not less than the cover requirements listed in NFPA 70. At railroad and airfield crossings, encase duct lines with concrete and reinforce as indicated to withstand specified surface landings. Make tops of concrete encasement not less than 5 feet below tops of rails or airfield paving unless otherwise indicated. Where ducts are jacked under existing pavement, install rigid steel conduit. To protect the corrosion-resistant conduit coating, pre-drilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, use the pre-drilling method or the jack-and-sleeve method. Use separators or spacing blocks of steel, concrete, plastic, or a combination of these materials placed not more than 4 foot on centers. Securely anchor ducts to prevent movement during the placement of concrete, and stagger joints at least 6 inches vertically.

3.2.10.4 Non-encased Direct-Burial

Grade bottom of trenches toward manholes or handholes, smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches are comprised of materials other than sand, place a 3 inch layer of sand first and compact to approximate densities of surrounding firm soil before installing ducts. Vertically stagger joints in adjacent tiers of duct at least 6 inches, with the first 6 inch layer of backfill cover of compacted sand as previously specified. Backfill and compact the rest of the excavation in 3 to 6 inch layers. Hold duct banks in alignment with earth; however, use a wooden frame or equivalent forms to hold ducts in alignment prior to backfilling for high tiered banks.

3.2.10.5 Installation of Couplings

Make joints in each type of duct in accordance with the manufacturer's recommendation for the particular type of duct and coupling selected and as approved. Make duct joints by brushing a plastic solvent on insides of plastic coupling fittings and on outsides of duct ends, then slip each duct and fitting together with a quick 1/4 turn to set the joint tightly.

3.2.10.6 Concrete

Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE, with plain concrete strength of, 2500 psi at 28 days, and reinforced concrete strength of 3000 psi at 28 days. Provide monolithic duct line encasement construction. Where a connection is made to an existing duct line, bond the concrete encasement or dowel to the existing encasement.

3.2.10.7 Duct Line Markers

Provide duct line markers at the ends of long duct line stubouts or for other duct locations that are indeterminate because of duct curvature or terminations at completely below-grade structures. In addition to markers, place a 5 mil brightly colored plastic tape, not less than 3 inches in width and suitably inscribed at not more than 10 feet on centers with a continuous metallic backing and a corrosion-resistant 1 mil metallic foil core to permit easy location of the duct line, approximately 12 inches below finished grade levels of such lines.

3.2.11 Handholes

Determine the exact locations after carefully considering the locations of other utilities, grading, and paving. Secure approval of exact before construction is started.

3.2.11.1 Construction

Construct handholes as indicated on drawings, including appurtenances, with top, walls, and bottom consisting of reinforced concrete. Provide monolithic walls and bottom. Provide 3000 psi concrete at 28 days. Precast concrete handholes having the same strength and inside dimensions as cast-in-place concrete handholes may be used. In paved areas, make the top of entrance covers flush with the finished surface of the paving. In unpaved areas, set the top of entrance covers approximately 1/2 inch above the finished grade. Where finished grades are in cut areas, install unmortared brick between the top of handhole and entrance frame to temporarily elevate the entrance cover to existing grade level. Where duct lines enter walls, the sections of duct may be cast in the concrete or may enter the wall through a suitable opening. Caulk the openings around entering duct lines tight with lead wool or other approved material.

3.2.11.2 Appurtenances

Provide the following appurtenances for each handhole.

3.2.11.3 Cable Pulling-in Irons

Install a cable pulling-in iron in the wall opposite each duct line entrance.

3.2.11.4 Ground Rods

In each handhole, at a convenient point close to the wall, drive a ground rod conforming to paragraph GROUNDING CONDUCTORS AND ELECTRODES, into the earth before the floor is poured; with approximately 4 inches of the ground rod extending above the floor after pouring. When precast concrete units are used, the top of the ground rod may be below the floor; bring a No. 1/0 AWG copper ground conductor inside through a watertight sleeve in the wall.

3.2.12 Lighting

3.2.12.1 Lamps

Deliver lamps of the proper type, wattage, and voltage rating to the project in the original containers and install in the fixtures just before completion of the project.

3.2.12.2 Fixture Installation

Provide special fixtures as indicated on drawings. Illustrations shown on the drawings are indicative of the general type desired and are not intended to restrict selection of fixtures to any particular manufacturer. Fixtures of similar design, equivalent light-distribution and brightness characteristics, and equal finish and quality are acceptable as approved.

a. Accessories

Install accessories such as straps, mounting plates, nipples, or brackets as required for proper installation.

b. In-Line Fuses

Provide an in-line fuse for each fixture.

c. Special Fixtures

The types of special fixtures are designated by letters and numbers. For example, SP-1 denotes special type 1.

3.2.13 Transformer Installation

Install transformers for lighting fixtures on aluminum or steel or concrete poles in the transformer base. Provide a transformer base for poles that require transformers. Securely mount transformers to steel supporting plates and bolt to wood poles.

3.2.14 CCTV Alarm Interface

Furnish and install an alarm interface with the lighting control system, compatible with the CCTV alarm annunciation system. Monitor alarm closures for processing by the system CPU with the alarm. Provide alarm inputs to the alarm interface by relay contact or through an TIA-232 interface, modular and allowing for system expansion. Configure the alarm interface to be installed at the site to handle required alarm points, with an expansion capability of not less than 10 percent. Provide an output to actuate a video recorder.

3.3 FIELD QUALITY CONTROL

3.3.1 Test for CCTV Assessment Lighting

Submit CCTV assessment lighting test procedures and reports. After receipt by the Contractor of written approval of the test procedures, schedule the tests. Deliver the final test procedures report after completion of the tests.

Perform site testing and adjustment of the completed CCTV lighting, in conjunction with Section 28 10 05 ELECTRONIC SECURITY SYSTEM ACCEPTANCE TESTING. Provide personnel, equipment, instrumentation, and supplies necessary to perform testing. Give written notification of planned testing to the Government at least 14 days prior to the test. In the test procedures, explain, in detail, step-by-step actions and expected results demonstrating compliance with the requirements of the specification. Do not give notice until after receiving written approval of the specific test procedures. Use the test reports to document results of the tests. Deliver the reports to the Government within 7 days after completion of each test.

3.3.2 Operating Test

Submit operating test procedures and reports for the operating test to the Contracting Officer for approval. After receipt of written approval of the test procedures, schedule the tests. Deliver the final Operating Test procedures report after completion of the tests.

After the installation is completed and at such time as the Contracting Officer may direct, conduct an operating test for approval, in the presence of the Contracting Officer. Demonstrate that the equipment operates in accordance with the requirements specified. Furnish instruments and personnel required for the test The Government will furnish the necessary electric power.

3.3.3 Ground Resistance Measurements

Submit the measured resistance to ground of each separate grounding installation,in writing, indicating the location of the rods, the resistance of the soil in ohms per millimeter and the soil conditions at the time the measurements were made.

Measure the resistance to ground by the fall-of-potential method described in IEEE 81.

3.4 CLOSEOUT ACTIVITIES

3.4.1 Operations and Maintenance Manuals

Submit a draft copy of the operation and maintenance manuals, prior to beginning the tests for use during site testing. Submit final copies of the manuals as specified bound in hardback, loose-leaf binders, within 30 days after completing the field test. Update the draft copy used during site testing with any changes required, prior to final delivery of the manuals. Identify each manual's contents on the cover. Include names, addresses, and telephone numbers of each subcontractor installing equipment and systems, and nearest service representatives for each item of equipment for each system. Provide the manuals with a table of contents and tab sheets. Place tab sheets at the beginning of each chapter or section and at the beginning of each appendix. Include, upon delivery of the final copies, modifications made during installation checkout and acceptance.

3.4.2 Record Drawings

Maintain and keep up to date, a separate set of drawings, elementary diagrams and wiring diagrams of the lighting to be used for "record" drawings, showing all changes and additions to the lighting system. In addition to being complete and accurate, keep this set of drawings separate and do not use for installation purposes. Upon completion of the record drawings, a representative of the Government will review the as-built work with the Contractor. If the as-built work is not complete, the Contractor will be so advised and complete the work as required.

-- End of Section --

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SECTION 26 56 00

EXTERIOR LIGHTING
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS ANSI O5.1	(2017) Wood Poles -- Specifications & Dimensions

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO LTS	(2013; Errata 2013) Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA U1	(2022) Use Category System: User Specification for Treated Wood

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B108/B108M	(2019) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM G154	(2016) Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

ANSI/IES LM-79	(2019) Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products
ANSI/IES LM-80	(2020) Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules
ANSI/IES LS-1	(2020) Lighting Science: Nomenclature and Definitions for Illuminating Engineering
ANSI/IES RP-8	(2018; Addenda 1 2020; Errata 1-2 2021) Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting
ANSI/IES TM-15	(2020) Technical Memorandum: Luminaire Classification System for Outdoor Luminaires
ANSI/IES TM-21	(2021) Technical Memorandum: Projecting Long-TermLuminous, Photon, and Radiant Flux Maintenance of LED Light Sources
IES Lighting Library	IES Lighting Library

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C136.3	(2020) Roadway and Area Lighting Equipment - Luminaire Attachments
ANSI C136.13	(2020) Roadway and Area Lighting Equipment - Metal Brackets for Wood Poles
ANSI C136.21	(2014) American National Standard for Roadway and Area Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted Luminaires
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2017) Electric Lamps— Specifications for

	the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA C136.31	(2018) Roadway and Area Lighting Equipment - Luminaire Vibration
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA IEC 60529	(2004) Degrees of Protection Provided by Enclosures (IP Code)
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1728F-700	(2011) Specification for Wood Poles, Stubs, and Anchor Logs

UNDERWRITERS LABORATORIES (UL)

UL 773	(2016; Reprint Jul 2020) UL Standard for Safety Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2016; Reprint Jun 2020) UL Standard for Safety Nonindustrial Photoelectric Switches for Lighting Control
UL 924	(2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment
UL 1310	(2018; Reprint Jun 2022) UL Standard for Safety Class 2 Power Units
UL 1598	(2021; Reprint Jun 2021) Luminaires

UL 8750	(2015; Reprint Sep 2021) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section(s) 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Luminaires and accessories installed in interior of buildings or attached to the exterior of a building are specified in Section 26 51 00 INTERIOR LIGHTING.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings must be as defined in IEEE 100 and ANSI/IES LS-1.

b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in ANSI/IES LM-80.

c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.

d. Total Harmonic Distortion (THD) is the Root Mean Square (RMS) of all the harmonic components divided by the total fundamental current.

e. The "Groundline Section" of wood poles is that portion of the pole between one foot above, and 2 feet below the groundline.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Pole Drawings; G

Control System One-Line Diagram; G

Sequence of Operation for Exterior Lighting Control System; G

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Pole Warranty; G

Dimming Panel; G

Motion Sensors; G

Photosensors; G

Time Clock; G

Lighting Contactor; G

Poles; G

Brackets

Obstruction Marker Luminaires; G,

SD-04 Samples

Luminaire Samples; G

SD-05 Design Data

Luminaire Design Data; G

Photometric Plan; G

SD-06 Test Reports

ANSI/IES LM-79 Test Report; G

ANSI/IES LM-80 Test Report; G

ANSI/IES TM-21 Test Report; G

Pressure Treated Wood Pole Quality; G

Tests for Fiberglass Poles; G

SD-08 Manufacturer's Instructions

Poles

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G

Exterior Lighting Control System, Data Package 5; G

Maintenance Staff Training Plan; G

End-User Training Plan; G

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES Lighting Library as applicable, for the lighting system specified.

1.5.1 Drawing Requirements

1.5.1.1 Luminaire Drawings

Include dimensions, effective projected area (EPA), weight, accessories, and installation and construction details. Photometric data, including CRI, CCT, TM-15-11 BUG rating, LED driver type, aiming diagram, zonal lumen data, and candlepower distribution data per LM-79 must accompany shop drawings.

1.5.1.2 Pole Drawings

Include dimensions, wind load determined in accordance with ASCE 7-16, pole deflection, pole class, and other applicable information. For concrete poles, include: section and details to indicate quantities and position of prestressing steel, spiral steel, inserts, and through holes; initial prestressing steel tension; and concrete strengths at release and at 28 days.

1.5.2 Luminaire Design Data

a. Provide distribution data according to IES classification type as defined in IES Lighting Library and ANSI/IES RP-8.

b. B.U.G. rating for the installed position as defined by ANSI/IES TM-15 and shielding as defined by ANSI/IES RP-8.

c. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification in accordance with NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

d. Provide long term lumen maintenance projections for each LED luminaire in accordance with ANSI/IES TM-21. Data used for projections must be obtained from testing in accordance with ANSI/IES LM-80.

e. Provide wind loading calculations for luminaires mounted on poles. Weight and effective projected area (EPA) of luminaires and mounting brackets must not exceed maximum rating of pole as installed in particular wind zone area.

1.5.3 ANSI/IES LM-79 Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "14.0 Test Report" in ANSI/IES LM-79.

1.5.4 ANSI/IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in ANSI/IES LM-80.

1.5.5 ANSI/IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in ANSI/IES TM-21.

1.5.6 Tests for Fiberglass Poles

a. Ultraviolet resistance tests: Perform according to ASTM G154 using a UV-B light source having a 313 nanometer wavelength, operated at 130 degrees F, cycling the light source on for 4 hours and off for 4 hours for a total test period of 1500 hours minimum with the following results:

Fiber exposure:	None
Crazing:	None
Checking:	None
Chalking:	None
Color:	May dull slightly

b. Flexural strength and deflection test: Test loading must be as a cantilever beam with pole butt as fixed end and a force simulating wind load at the free end.

1.5.7 Pressure Treated Wood Pole Quality

Ensure the quality of pressure treated wood poles. Furnish an inspection report (for wood poles) of an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with AWPA U1 and RUS Bull 1728F-700 standards. The RUS approved Quality Mark "WQC" on each pole will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

1.5.8 Photometric Plan

For roadways, parking lots and intersections include computer-generated photometric analysis of the "designed to" values in accordance with ANSI/IES RP-8 for the "end of useful life" of the luminaire installation using a light loss factor of 0.81. Provide photometric plans that meet criteria in the Basis of Design in the project plans. Include the following in the submittal:

a. Horizontal illuminance measurements at finished grade, taken at a maximum grid size of 10 feet by 10 feet.

b. Vertical illuminance measurements at 5 feet above finished grade at all sidewalks and crosswalks, taken at a maximum of 10 feet.

c. Minimum and maximum footcandle levels.

d. Average maintained footcandle level.

e. Maximum to minimum ratio for horizontal illuminance only.

1.5.9 Test Laboratories

Test laboratories for the ANSI/IES LM-79 and ANSI/IES LM-80 test reports must be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program.

b. One of the qualified labs listed on the Department of Energy - Energy Efficiency & Renewable Energy, Solid-State Lighting web site.

c. One of the EPA-Recognized Laboratories listed at for LM-80 testing.

1.5.10 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory provisions of NFPA 70 unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.11 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for six months prior to bid opening. The six-month period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the six-month period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.11.1 Alternative Qualifications

Products having less than a six-month field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.11.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than six months prior to date of delivery to site, unless specified otherwise.

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

1.6.1 Aluminum Poles

Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

1.6.2 Steel Poles

Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

1.6.3 Wood Poles

Do not store poles on ground. Stack poles stored for more than 2 weeks on decay-resisting skids arranged to support the poles without producing noticeable distortion. Store poles to permit free circulation of air; the bottom poles in the stack must be at least one foot above ground level and growing vegetation. Do not permit decayed or decaying wood to remain underneath stored poles. Do not drag treated poles along the ground. Do not use pole tongs, cant hooks, and other pointed tools capable of producing indentation more than one inch in depth in handling the poles. Do not apply tools to the groundline section of any pole.

1.6.4 Fiberglass Poles

Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

1.6.5 Concrete Poles

Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation.

1.7 WARRANTY

Support all equipment items by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

   (1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

(2) Material warranty must include:

(a) All LED drivers and integral control equipment.

(b) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and installation.

1.7.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:

(1) Software: Failure of input/output to execute switching or dimming commands.

(2) Damage of electronic components due to transient voltage surges.

(3) Failure of control devices, including but not limited to photosensors and motion sensors.

b. Provide a written five year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.

c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7.3 Pole Warranty

Provide and transfer to the government the original pole manufacturers standard commercial warranty for each different pole manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Provide a written three year minimum replacement warranty for material, luminaire finish, and workmanship. Warranty service must be performed by a factory-trained engineer or technician.

1.8 OPERATION AND MAINTENANCE MANUALS

1.8.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system. Additional O&M Manual requirements for the Army are provided in Section 01 78 24.00 10 FACILITY DATA REQUIREMENTS. Additional requirements for the Navy are provided in Section 01 78 24.00 20 FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI). Include the following:

a. Manufacturers' operating and maintenance manuals.

b. Luminaire shop drawings for modified and custom luminaires.

c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.8.2 Exterior Lighting Control System

Provide operation and maintenance manuals for the exterior lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the exterior lighting control system. Include the following:

a. Control System One-Line Diagram

b. Product data for all devices, including installation and programming instructions.

c. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

d. Motion sensor coverage layout.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and XL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the LED driver and light source provided.

2.2.1 Luminaires

UL 8750, ANSI/IES LM-79, ANSI/IES LM-80. For all luminaires, provide:

a. Complete system with LED drivers and light sources.

b. Housing constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.

c. ANSI/IES TM-21, ANSI/IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Area and Roadway (pole mounted, arm mounted)	119 LPW
Pedestrian Post-Top (pole mounted, arm mounted)	97 LPW
Bollard	45 LPW
Accent (adjustable landscape, sign lighting)	35 LPW
Linear Accent (facade, wallwash)	80 LPW
Exterior Wall Sconce	50 LPW
Steplight	30 LPW
Parking Garage Luminaire	113 LPW

e. Product rated for operation within an ambient temperature range of minus 22 degrees F to 104 degrees F.

f. UL listed for wet locations. Optical compartment for LED luminaires must be sealed and rated a minimum of IP65 per NEMA IEC 60529.

g. IES Lighting Library. Light distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans.

h. Housing finish that is baked-on enamel, anodized, or baked-on powder coat paint. Finish must be capable of surviving ASTM B117 salt fog environment testing for 2500 hours minimum without blistering or peeling.

i. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.

j. ANSI/IES TM-15. Does not exceed the BUG ratings as listed in the luminaire schedule.. If BUG ratings are not listed in the luminaire schedule, provide luminaires that meet the following minimum values for each application and mounting conditions:

Lighting Application	Mounting Conditions	BUG Rating
Area and Roadway	All	B3-U0-G3

Lighting Application	Mounting Conditions	BUG Rating
Pedestrian Post-Top	All	B2-U1-G1
Exterior Wall Sconce	Above 4 feet AFF	B1-U0-G2
Exterior Wall Sconce	Below or at 4 feet AFF	B4-U0-G4
Steplight	Above 4 feet AFF	B1-U1-G2
Steplight	Below or at 4 feet AFF	B4-U1-G4
Parking Garage Luminaire	Ceiling mounted	B4-U4-G3

k. Fully assembled and electrically tested prior to shipment from factory.

l. Finish color is as indicated in the luminaire schedule or detail on the project plans.

m. Lenses constructed of clear tempered glass or UV-resistant acrylic.

n. All factory electrical connections are made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.

o. NEMA C136.31. Comply with 3G vibration testing.

p. Luminaire arm bolts constructed from 304 stainless steel or zinc-plated steel.

q. Wiring compartment on pole-mounted, street and area luminaires is accessible without the use of hand tools to manipulate small screws, bolts, or hardware.

r. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, LED drivers, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.

s. ANSI C136.3. For all roadway and area luminaires, provide products with an integral tilt adjustment of plus or minus 5 degrees to allow the unit to be leveled.

2.2.2 Obstruction Marker Luminaires

Provide obstruction marker luminaires for facilities as required by the FAA and in accordance with Section 26 56 20 AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS.

2.3 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type, lumen rating, and wattage as indicated in luminaire schedule on project plans.

2.3.1 LED Light Sources

Provide LED light sources that meet the following requirements:

a. NEMA ANSLG C78.377. Emit white light and have a nominal Correlated

Color Temperature (CCT) of 3500 Kelvin.

b. Minimum Color Rendering Index (CRI) of 70.

c. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

d. Light source color consistency by utilizing a binning tolerance within a 4-step McAdam ellipse.

2.4 LED DRIVERS

NEMA SSL 1, UL 1310. Provide LED Drivers that are electronic, UL Class 1 or Class 2, constant-current type and meet the following requirements:

a. The combined LED driver and LED light source system is greater than or equal to the minimum luminaire efficacy values as listed in the luminaire schedule provided.

b. Operate at a voltage of 120-277 volts at 50/60 hertz, with input voltage fluctuations of plus or minus 10 percent.

c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.

d. Maximum Total Harmonic Distortion (THD) less than or equal to 20 percent at full input power and across specified dimming range.

e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.

f. Meets the "Elevated" (10kV/10kA) requirements per IEEE C62.41.2 -2002. Manufacturer must indicate whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire. Provide surge protection that is integral to the LED driver.

g. Contains integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.

h. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

i. Class A sound rating for all drivers mounted under a covered structure, such as a canopy, or where otherwise appropriate.

j. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

k. UL listed for wet locations typical of exterior installations.

l. Non-dimmable.

m. Rated to operate between ambient temperatures of minus 22 degrees F and 104 degrees F.

2.4.1 Remote LED Drivers

Provide remote LED Drivers that are UL listed for wet locations typical of exterior installations.

2.5 LIGHTING CONTROLS

Provide a control system interface within each luminaire that is compatible with the energy management or control system used by the utility department in charge of the project area for control of site lighting. Provide network certification for all networked lighting control systems and devices in accordance with the requirements of Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.5.1 System

Provide exterior lighting control system that operates the exterior lighting system as described in the exterior lighting control strategies in the project plans. Submit Sequence of Operation for Exterior Lighting Control System describing the operation of the proposed exterior lighting control system and devices. Sequence of Operation must provide the strategies identified in the exterior lighting control strategies.

2.5.1.1 Relay Panel

Enclose panel hardware in a surface or flush-mounted, NEMA 1, 3R, or 4, painted, steel enclosure with lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door. Provide additional remote cabinets that communicate back to main control panel as required. Provide relay panel that meets the following criteria:

a. Input voltage of 120-277 at 50/60 Hz, with internal low voltage power supply as required.

b. UL 924. 16 single-pole latching relays rated at 20 amps, 120-277 volts. Provide provision for relays to close upon power failure. Provide relays designed for 10 years of use at full rated load.

c. Relay control module operates at 24 VDC and is rated to control a minimum of 16 relays.

2.5.2 Devices

2.5.2.1 Time Clock

NEMA ICS 6. House time clock in a surface-mounted, lockable NEMA 1 or 3R enclosure constructed of painted steel or plastic polymer. Provide electronic type time clock that meets the following criteria:

a. 24 hour7 dayastronomic programming function, providing a total of 56 on/off set points.

b. 12 hour AM/PM type digital clock display format.

c. Power outage back-up for switch utilizing lithium battery which provides coverage for a minimum of seven days.

d. Capable of controlling a minimum of 4 channels or loads.

e. Contacts are rated for 30 amps at 120-277 VAC resistive load in a configuration as required.

f. Contains function that allows automatic control to be skipped on certain selected days of the weekmanual bypass or remote override control.

2.5.2.2 Photosensors

UL 773, UL 773A. Provide Photosensors that meet the following requirements:

a. Hermetically sealed, light sensor type, rated at 40 watts, 120 volts, 50/60 Hz with single-pole, single or -throw contacts as required.

b. Turns ON at 1 to 3 footcandles and turns OFF at 3 to 15 footcandles.

c. Designed to fail to the ON position.

d. Housing is constructed of die cast aluminum, rated to operate within a temperature range of minus 40 to 158 degrees F.

e. Time delay that prevents accidental switching from transient light sources.

f. Directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

g. Designed for 20-year service to match life expectancy of long-life LED fixtures and exceed 15,000 operations at full load. Provide photosensors with zero-cross technology to withstand severe in-rush current and extend relay life.

h. Swivel base type housing with 1/2 in threaded base for mounting to a junction box or conduit.

i. Provide photosensors with metal oxide varistor (MOV) type surge protection.

2.5.2.3 Lighting Contactor

NEMA ICS 2. Provide a mechanically-held lighting contactor housed in a NEMA enclosure suitable for the environment conforming to NEMA ICS 6. Contactor must have silver cadmium oxide double-break contacts and coil clearing contacts for mechanically held contactors and must require no arcing contacts. Provide contactor with hand-off-automatic on-off selector switch.

2.6 POLES

AASHTO LTS. Provide round poles designed for wind loading of 110 miles per hour while supporting luminaires and all other appurtenances indicated. The effective projected areas (EPA) of luminaires and appurtenances used in calculations must be specific for the actual products provided on each pole. Provide poles that are anchor-base type designed for use with underground or overhead supply conductors. Poles, other than wood poles, must have oval-shaped hand hole having a minimum clear opening of 3 by 5 inches. Secure hand hole covers by stainless steel captive screws. Provide metal poles with an internal grounding connection accessible from the hand hole near the bottom of each pole. Install a means of wire disconnection accessible from the hand hole. Do not install square poles. Provide poles from a Manufacturer with a standard provision for protecting the finish during shipment and installation. Do not install scratched, stained, chipped, or dented poles.

2.6.1 Aluminum Poles

Provide aluminum poles with anodized finish unless otherwise noted in luminaire schedule on project plans. Do not paint aluminum poles. Provide poles that meet the following requirements:

a. AASHTO LTS. Manufactured of corrosion resistant aluminum alloys for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3,5) for cast alloys.

b. Seamless extruded or spun seamless-type with minimum 0.188 inch wall thickness.

c. Top of shaft is fitted with a round or tapered cover.

d. ASTM B108/B108M. Pole base is mounted by anchor bolts, made of cast 356-T6 aluminum alloy. Base must be machined to receive the lower end of shaft.

e. Joint between shaft and base is welded.

f. ASTM B108/B108M. Base cover is cast 356-T6 aluminum alloy.

g. All hardware other than anchor bolts are either 2024-T4 anodized aluminum alloy or stainless steel.

h. Grounding connection is designed to prevent electrolysis when used with copper ground wire.

2.6.2 Steel Poles

Provide steel poles with hot-dipped galvanized in accordance with ASTM A123/A123M factory finish. Provide poles that meet the following requirements:

a. Minimum 11-gage steel with minimum yield/strength of 48,000 psi

b. Pole is mounted by anchor bolts.

c. Consists of tapered tubular members, either round in cross section or polygonal.

d. Pole shaft is one piece and is of welded construction with no bolts, rivets, or other means of fastening except as specifically approved.

e. Base covers are of structural quality hot-rolled carbon steel plate, with a minimum yield of 36,000 psi.

f. Markings are approximately 3 to 4 feet above grade and includes manufacturer, year of manufacture, top and bottom diameters, and length.

g. Grounding connection is designed to prevent electrolysis when used with copper ground wire.

2.6.3 Wood Poles

ATIS ANSI O5.1, RUS Bull 1728F-700. Provide wood poles of Southern Yellow Pine or Douglas Fir. Provide poles that meet the following requirements:

a. AWPA U1. RUS Bull 1728F-700. Treated full length with chromated copper arsenate (CCA) or ammoniacal copper arsenate (ACA). Poles must be gained, bored, and roofed before treatment.

b. Branded by manufacturer with manufacturer's mark and date of treatment, height and class of pole, wood species, preservation code, and retention. Place the brand so that the bottom of the brand or disc is 10 feet from the pole butt for poles up to 50 feet long and 14 feet from the butt for poles over 50 feet long.

2.6.4 Brackets and Supports

ANSI C136.3, ANSI C136.13, and ANSI C136.21. Provide pole brackets that are not less than 1 1/4 inch galvanized steel pipe secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets must be coordinated to luminaires provided, and brackets for use with one type of luminaire must be identical. Brackets for pole-mounted street lights must correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 24 feet above street. Provide special mountings or brackets as indicated and of metal which will not promote galvanic reaction with luminaire head.

2.6.5 Pole Foundations

Provide anchor bolts consisting of a steel rod with a minimum yield strength of 50,000 psi; the top 12 inches of the rod must be galvanized in accordance with ASTM A153/A153M. Concrete must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.7 EQUIPMENT IDENTIFICATION

2.7.1 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.7.2 Labels

UL 1598. Luminaires must be clearly marked for operation of specific light sources and drivers according to proper light source type. Note the following luminaire characteristics in the format "Use Only _____":

a. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

b. Driver and dimming protocol.

Markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.8 FACTORY APPLIED FINISH

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Luminaires

Install all luminaires in accordance with the luminaire manufacturer's written instructions. Install all luminaires at locations and heights as indicated on the project plans. Level all luminaires in accordance to manufacturer's written instructions. Aim all luminaires in accordance with aiming diagram.

3.1.2 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

3.1.3 Field-Applied Painting

Paint lighting equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Provide painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.4 Wood Poles

Pole holes must be at least as large at the top as at the bottom and must be large enough to provide 4 inches of clearance between the pole and the side of the hole.

a. Setting depth: Provide pole setting depths as follows:

Length of Pole (feet)	Setting in Soil (feet)
20	5.0
25	5.5
30	5.5
35	6.0
40	6.0
45	6.5
50	7.0
55	7.5

60	8.0

b. Soil setting: "Setting in Soil" depths must apply where pole holes are in soil, sand, or gravel or any combination of these. At corners, dead ends and other points of extra strain, poles 40 feet long or more must be set 6 inches deeper.

c. Setting on sloping ground: On sloping ground, measure the depth of the hole from the low side of the hole.

d. Backfill: Tamp pole backfill for the full depth of the hole and mound the excess fill around the pole.

3.1.5 Concrete Poles

Install according to pole manufacturer's instructions.

3.1.6 Fiberglass Poles

Install according to pole manufacturer's instructions.

3.1.7 Aluminum and Steel Poles

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit bells, and ground rods must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.

3.1.8 Pole Setting

Poles in straight runs must be in a straight line. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 6 inch maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

3.1.9 Lighting Controls

Refer to Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS for additional lighting control installation requirements.

3.1.9.1 Photosensors

Aim photosensor according to manufacturer's recommendations.

3.1.9.2 Motion Sensors

Locate sensors in accordance with the manufacturer's recommendation. Locate sensors to achieve coverage of areas as indicated on project plans. Coverage patterns must be derated as recommended by manufacturer based on mounting height of sensor and any obstructions such as trees. Do not use gross rated coverage in manufacturer's product literature.

3.1.10 Grounding

Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Perform initial operational test, consisting of the entire system energized for 72 consecutive hours without any failures of any kind occurring in the system. All circuits must test clear of faults, grounds, and open circuits.

3.2.1.1 Lighting Control Verification Test

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Training

Provide on-site training to the Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide training that includes calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

3.3.1.1 Maintenance Staff Training

Submit a Maintenance Staff Training Plan at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrate full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.1.2 End-User Training

Submit a End-User Training Plan at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide demonstration for each type of user interface. Provide users with the curfew schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

-- End of Section --

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SECTION 26 56 20

AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS
02/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA ICS 2	(2000; R 2020) Industrial Control and

	Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA PB 1	(2011) Panelboards
NEMA WC 70	(2021) Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 70B	(2019) Recommended Practice for Electrical Equipment Maintenance

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS5351	(1987; Rev F; R 2006) Steel Castings, Sand, Corrosion and Moderate Hear Resistant, 13Cr, Normalized and Tempered

U.S. DEPARTMENT OF AGRICULTURE (USDA)

REA Bull 1753F-205	(1993) Filled Telephone Cables (PE-39)

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-535-01	(2017; with Change 3, 2021) Visual Air Navigation Facilities

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC 70/7460-1	(2016; Rev L; Change 2) Obstruction Marking and Lighting
FAA AC 150/5345-3	(2007; Rev F) Specification for L-821 Panels for Control to Airport Lighting
FAA AC 150/5345-5	(2006; Rev B) Specification for Airport Lighting Circuit Selector Switch
FAA AC 150/5345-7	(2013; Rev F) Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits

FAA AC 150/5345-10	(2014; Rev H) Specification for Constant Current Regulators Regulator Monitors
FAA AC 150/5345-12	(2005; Rev E) Specification for Airport and Heliport Beacon
FAA AC 150/5345-13	(2007; Rev B) Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits
FAA AC 150/5345-26	(2021; Rev E) FAA Specification for L-823 Plug and Receptacle, Cable Connectors
FAA AC 150/5345-27	(2021; Rev F) FAA Specification for Wind Cone Assemblies
FAA AC 150/5345-28	(2005; Rev F) Precision Approach Path Indicator (PAPI) Systems
FAA AC 150/5345-42	(2019; Rev J) Specification for Airport Light Bases, Transformer Housings, Junction Boxes and Accessories
FAA AC 150/5345-43	(2019; Rev J) Specification for Obstruction Lighting Equipment
FAA AC 150/5345-44	(2015; Rev K; Errata 2022) Specification for Runway and Taxiway Signs
FAA AC 150/5345-45	(2007; Rev C) Low-Impact Resistant (LIR) Structures
FAA AC 150/5345-46	(2016; Rev E) Specification for Runway and Taxiway Light Fixtures
FAA AC 150/5345-47	(2005; Rev B) Specification for Series to Series Isolation Transformers for Airport Lighting Systems
FAA AC 150/5345-51	(2005; Rev A) Specification for Discharge-Type Flashing Light Equipment
FAA AC 150/5345-53	(2012; Rev D) Airport Lighting Equipment Certification Program
FAA AC 150/5345-56B	(2011; Rev B) Specification for L-890 Airport Lighting Control and Monitoring System (ALCMS)
FAA AC 150/5370-10	(2018; Rev H; Errata 1 2019) Standard Specifications for Construction of Airports
FAA E-982	(2003; Rev J) PAR-56 Lampholder
FAA E-2519	(1972; Rev A) Types I and II
FAA E-2628	(1979; Rev B) Sequenced Flashing Lighting System, Elevated and Semiflush with Dimming and Monitoring

FAA FO 6850.19	(1978) Frangible Coupling

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 360	(2013; Reprint Aug 2021) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 797	(2007; Reprint Mar 2021) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 SYSTEM DESCRIPTION

Provide airfield and heliport lighting and visual navigation aids as indicated.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Protection plan; G

Training; G

SD-02 Shop Drawings

Lighting and visual navigation aids; G

Composite drawings showing coordination of work of one trade with that of other trades and with structural and architectural elements of the work. Provide sufficient detail to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Indicate where conflicts or clearance problems exist between the various trades.

Wave-off system; G

Landing signal officer (LSO) control panel; G

Approach Lighting Frangible Towers; G

Wind Cone Indicator Assembly Connection; G

Posted instructions; G

SD-03 Product Data

When equipment or materials are specified to conform to the standards or publications and requirements of AASHTO, ANSI, ASTM, AEIC, ETL, IEEE, IES, NEMA, NFPA, or UL, or to an FAA, FS, or MS, include proof that the items furnished under this section conform to the specified requirements. The label or listing in UL Electrical Construction or ETL or the manufacturer's certification or published catalog specification data statement that the items comply with applicable specifications, standards, or publications and with the manufacturer's standards will be acceptable evidence of such compliance. Provide manufacturer prepared certificates when the manufacturer's published data or drawings do not indicate conformance with other requirements of these specifications.

Simulated carrier deck lighting system components, complete; G

Pilot relay panel; G

Control transfer panel; G

Airfield lighting control and monitoring system components, complete; G

Approach lighting systems components, complete; G

Type L-823 Connectors; G

Precision approach path indicator system; G

Chase helicopter approach path indicator system

Runway edge lights; G

Runway threshold and end lights; G

Runway centerline lights, tailhook operations; G

Runway centerline lights, non-tailhook operations; G

Runway touchdown zone lights, tailhook operations; G

Taxiway edge lights; G

Taxiway centerline lights, each type; G

Runway hold position lights, each type; G

Guidance signs; G

Runway distance remaining signs; G

Arresting gear markers; G

Obstruction lighting; G

Wheels-up system components, complete; G

Wave-off system components, complete; G

Light bases, each type; G

Wind direction indicator; G

Airfield rotating beacon; G

Helipad/heliport beacon

List of airfield lighting materials and equipment with the FAA AC 150/5345-53 Appendix C review date.

Airfield identification/code beacon; G

Isolation transformers; G

Encapsulated isolation transformers; G

Isolation transformers for frangible towers; G

Constant current regulators, each size; G

Circuit selector switch; G

Control cable; G

Frangible couplings; G

Type P-605 Sealant; G

Type P-606 Sealant; G

Materials and equipment; G

SD-06 Test Reports

Visual inspection; G

Photometric testing; G

Airfield guidance signs; G

Discharge-type flashing light equipment; G

PAPIs; G

Progress testing for series lighting circuits; G

Counterpoise system test and inspection; G

Operating test; G

Distribution conductors, 600-volt class; G

Electrical acceptance tests; G

Low-voltage continuity tests; G

High-voltage insulation resistance tests; G

Constant current regulators, each size; G

SD-07 Certificates

Qualifications of contractor; G

Certified documentation of qualifications, as specified.

Qualifications of photometric tester; G

Special tools; G

List of special tools and test equipment required for installation, maintenance and testing of the products supplied by the Contractor. Items to be listed include, but are not limited to, the following:

4-Jack positioning jig, for in-pavement light bases.; G

Elevated light level; G

Crimping tool; G

Cable penciler

List of parts; G

A list of parts and components for the system by manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair necessary to ensure continued operation with minimal delays.

SD-08 Manufacturer's Instructions

Posted instructions; G

Submit proposed disgrams, instructions, and other sheets prior to posting.

SD-10 Operation and Maintenance Data

Constant current regulators, Data Package 5; G

Airfield rotating beacon, Data Package 3; G

Approach lighting systems components, Data Package 3; G

Wave-off system, Data Package 5; G

Maintenance and repair instructions; G

Instructions necessary to check out, troubleshoot, repair, and replace components of the systems, as specified.

Posted operations and maintenance instructions

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

As-built drawings

1.4 MAINTENANCE MATERIAL SUBMITTALS

1.4.1 Spare Parts

Provide spare parts as indicated in this specification as part of this contract. The spare parts must be provided at the end of construction. They must be in addition to any items consumed during construction or in testing.

1.5 QUALITY CONTROL

1.5.1 Regulatory Requirements

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.5.1.1 Code Compliance

Comply with the requirements and recommendations of NFPA 70 and IEEE C2 and local codes where required.

1.5.2 Standard Products

a. Use only approved equipment listed in FAA AC 150/5345-53 with addendum for the date of delivery the exception of Air Force threshold lights and Army heliport fixture colors and intensities. Inspect wire and cable for date of manufacture. Materials must be certified and listed as "Approved Airport Lighting Equipment" downloadable from: http://www.faa.gov/arp/pdf/534553ad.pdf. Do not use wire and cable manufactured more than one year before delivery to job site.

b. Provide materials and equipment listed by FAA, UL, or ETL, when such equipment is listed or approved. Do not use askarel, tetrachlorethylene and insulating liquids containing polychlorinated biphenyls (PCBs) in equipment.

c. Material and equipment must be a standard product of a manufacturer regularly engaged in the manufacture of the product and essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

d. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be products of the same manufacturer unless stated in this section.

1.5.3 Qualifications of Contractor

a. Provide documentation that the aviation lighting equipment contractor and installation electricians are experienced in installing, testing and maintaining aviation lighting systems of a similar complexity. Similar complexity, in increasing complexity, are the following: elevated edge lights and signs, in-pavement lights, and approach light systems. Include a list of government projects and 3 years of experience in constructing similar projects. Include written certification that systems have performed satisfactorily for not less than 18 months. Provide a list of airfield lighting schools or seminars attended in the last 5 years.

b. Submit certification containing the names and the qualifications of persons recommended to perform the splicing and termination of medium-voltage cables approved for installation under this contract. Indicate that any person recommended to perform actual splicing and termination has been adequately trained in the proper techniques and has had at least 3 recent years of experience in splicing and terminating the same or similar types of cables approved for installation. Any person recommended by the Contractor may be required to perform a dummy or practice splice and termination, in the presence of the Contracting Officer, before being approved as a qualified installer of medium-voltage power or series lighting cables. If that additional requirement is imposed, provide short sections of the approved types of cables with the approved type of splice and termination kits, and detailed manufacturer's instruction for the proper splicing and termination of the approved cable types.

1.5.4 Qualifications of Photometric Tester

Submit three copies of certification containing the names and the qualifications of persons recommended to perform Field Photometric Testing of Airfield Lighting Fixtures. The general goal of the field photometric testing is to test the airfield lighting fixtures in the field as constructed with respect to FAA AC 150/5345-46. Perform testing utilizing an independent, third-party firm unaffiliated with any lighting manufacturer or construction contractor. This firm must have demonstrated capability for the field measurement of the photometric performance of airfield lighting fixtures in comparison to FAA and UFC standards by having performed work similar to this contract successfully at no less than ten (10) air carrier airports (in the United States) in the past five (5) years.

Submit a list of equipment to be used for the photometric testing with a record of experience of similar projects with references for contact. Additionally, submit a list of equipment used to calibrate the photometric sensors as well as proof of the last date of calibration. The equipment must be calibrated within six months prior to commencement of testing.

1.5.5 Protection Plan

Submit detailed procedures to prevent damage to existing facilities or infrastructures. If damage does occur, the procedures must address repair and replacement of damaged property at the Contractor's expense.

1.5.6 Prevention of Corrosion

1.5.6.1 Metallic Materials

Protect metallic materials against corrosion as specified. Do not use aluminum in contact with earth or concrete. Do not use aluminum conductors.

1.5.6.2 Ferrous Metal Hardware

Ferrous metal hardware must be hot-dip galvanized in accordance with ASTM A123/A123M and ASTM A153/A153M.

1.6 DELIVERY, STORAGE, AND HANDLING

The Contractor must deliver, store and secure all airfield lighting materials an equipment in accordance with the manufacturers' requirements.

1.7 PROJECT/SITE CONDITIONS

Items furnished under this section must be specifically suitable for the following unusual service conditions:

1.7.1 Altitude

Any equipment must be suitable for operation up to an altitude of 10,000 feet.

1.7.2 Other

Material or equipment to be installed underground; in handholes, manholes, or underground vaults; or in light bases.

1.7.3 Environmental Requirements

The airfield for this project has the following requirements:

Location - Moody AFB
Altitude - 233 feet above mean sea level.
Maximum Exterior Temperature - 105 degrees F.
Minimum Exterior Temperature - 4 degrees F.
Maximum Relative Humidity - 96.5 percent non-condensing.

1.7.4 Existing Airfield Lighting Systems

Existing airfield lighting systems must remain in operating condition and interuptions must be held to a minimum. Where interuptions are necessary, they must be scheduled as approved in writing by the Contracting Officer. Prior to the scheduled time for each interuptions, all necessary materials and a sufficient labor force must be assembled to permit completing the work within the scheduled time interval. Under no circumstances must any of the existing airfield lighting circuits be left inoperative without making provisions for suitable temporary connections in the affected area or areas. All airfield lighting circuits covered under this contract must bereplaced in such a manner that they will be operational at dusk each day. The Contractor must submit to the Contracting Officer a plan for outages and maintaining lighting and lighting control..

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide airfield lighting and visual navigation aids as indicated on contract drawings.

2.1.1 Design Requirements

2.2 AIRFIELD LIGHTING CONTROL AND MONITORING SYSTEM (AFLCMS)

The FAA has determined that acceptable airfield lighting control and monitoring systems can be configured in three levels of features. They include personal computer (PC) based systems, programmable logic controller (PLC) based systems, and systems configured with pilot relay panels or basic PLC systems.

2.2.1 Pilot Relay Panel

Utilize one of more pilot relay panels as indicated or compliant with NEMA 250, NEMA ICS 2, and NEMA PB 1 for 120-volt control systems; or FAA AC 150/5345-13, Type L-841, for 48-V dc control systems.

2.2.2 Control Transfer Panel

Transfer panel, 120-volt, 60 Hz, with eight-pole, double-throw, continuous-duty, industrial control type relays, in NEMA Type 1 enclosure. Provide relay contacts with a rating of not less than 10 amp for continuous non-inductive loads. Transfer panel, 48-volt, dc, with double-pole, double throw relays in accordance with FAA AC 150/5345-13, Type L-841.

2.2.3 Control Panel

Quantity and color of lenses must conform to FAA AC 150/5345-3 and must correspond to the actual circuits indicated.

2.2.4 Airfield Lighting Control and Monitoring System

2.2.4.1 Computer Based (PC) Technology

Utilize computer based (PC) technology control systems as indicated on the drawings, compliant with FAA AC 150/5345-56B, L-890 Type as required. Include touchscreen type control panel. For the essential system PCs provide the following characteristics: 19 inch rack mount form factor, fully enclosed metal housing, redundant hot-swappable solid state software and data storage devices, redundant hot-swappable cooling system, redundant hot-swappable power supplies. Incorporate uninterruptible power supplies (UPS) for primary power to all system components required for normal operation for a duration of fifteen minutes.

2.2.4.2 Programmable Logic Controller (PLC) Technology

Utilize Programmable Logic Controller (PLC) technology, compliant with FAA AC 150/5345-56B, L-890, Type as required. Include touchscreen type control panel.

2.3 APPROACH LIGHTING SYSTEMS

2.3.1 High Intensity Approach Lighting System

Provide approach, centerline, crossbar, threshold bar, side row barrette, centerline barrette, bar lights, sequenced flashing lights, approach lighting frangible towers, and associated equipment and interconnecting wiring to provide a complete system as indicated on construction drawings.

2.3.1.1 Elevated High-Intensity Steady Burning Fixtures

Provide FAA E-982 unidirectional frangible mounted lights with PAR-56 200 W 300 W and 500 W lamps, and with aviation red filters at cross bar, centerline bars, and side row barrettes.

2.3.1.2 In-Pavement, High-Intensity Steady Burning Approach Lights

Use in-pavement, high-intensity, base-mounted lights in the overrun area and paved areas with traffic. Use fixtures conforming to FAA AC 150/5345-46 Type L-850E for unidirectional quartz lights with lamps, Type L-850E(L) for unidirectional LED lights with filters and transformers as indicated. Mounting must conform to the details indicated. Mount bases level and recess as required by thickness of fixture to provide installation in accordance with manufacturer's instructions.

2.3.1.3 Current Powered Sequenced Flashing Light (SFL) for High Intensity Approach Light System

FAA E-2628. Provide as a complete and integrated part of the approach system including individual power supply units, elevated flashing units, master timer, remote control and monitor units, interconnecting wiring, and support structures. Include master timer cabinet that provides timed flashing signals to 21-lamp power supplies. System must monitor individual lamp flashes and report via normally open contacts a condition of two, three, or more malfunctioning lamps or power supplies. The master timer cabinet can be a solid-state type. Provide the system with major components that are the product of a single manufacturer. Install junction boxes as indicated on concrete foundations and on the platform of elevated structures. Install conduit tappings in the bottom and top of the junction boxes as required to accommodate the incoming and outgoing power and control circuits for the flashing lights. Provide terminal strips in each junction box as indicated for termination and connection of the power and control circuits. Provide signal and monitor cables as recommended by the system manufacturer. Provide current transformers for current powered system.

2.3.1.4 Economy Approach REIL

FAA AC 150/5345-51Type L-849V current powered.

2.3.2 Medium-Intensity Approach Lighting Systems with Runway Alignment Indicator Lights (MALSR)

2.3.2.1 Elevated, Medium-Intensity, Steady-Burning Fixtures

Utilize FAA E-2325 PAR 38 lampholders with 150 watt PAR-38 spotlight lamps frangibly mounted on frangible supports. The peak intensity of the main beam, at 120V input, must not be less than 5,000 candelas and the intensity must not be less than 1,000 candelas at any angle up to 15 degrees from the beam axis.

2.3.2.2 In-Pavement, Medium-Intensity, Steady-Burning Fixtures

The peak intensity must be not less than 5,000 candelas within the main beam, and not less than 2500 candelas +/-5 degrees horizontally and +/-3.5 degrees vertically from the main beam axis, and not less than 500 candelas at +/-7 degrees horizontally and +/-5.5 degrees vertically from the main beam axis.

2.3.2.3 Encapsulated Stepdown Transformer

Provide 200-watt, 240-volt/30.3-volt transformer approved by the fixture manufacturer. Use connectors that comply with Type L-823 as indicated.

2.3.2.4 Voltage Powered Sequence Flashing Lights (SFL) for Medium Intensity Lights

These elevated SFL fixtures (RAIL) must meet the requirements of FAA AC 150/5345-51, Type L-849 with eight lights and must be as indicated on the contract drawings as an integrated part of the approach system. The SFL system must include the fixtures, the individual power supplies, master timer and power supply, remote control support structures, and interconnecting wiring. The SFL must flash twice per second in sequence towards the runway threshold.

2.3.3 Omnidirectional Approach Lighting System (ODALS)

The ODALS fixtures must meet the requirements of FAA AC 150/5345-51, Type L-859 Style F. The ODALS must include the 7 fixtures, the individual power supplies, the master timer and power supply, remote control, support structures and interconnecting wiring. The ODALS must flash twice per second in sequence towards the runway threshold.

2.3.4 Glide Slope Indicator System

Consists of four light units mounted in the area of the ground point of intercept of the glide slope and aimed in the direction of the approach.

2.3.4.1 Precision Approach Path Indicator System (PAPI)

FAA AC 150/5345-28 Type L-880 non-LED. Connect the four light units to 6.6 ampere series current circuit (Style B) via appropriate isolation transformers. Provide tilt switches and relays to de-energize all light units when one unit exceeds tilt requirements.

2.3.4.2 Chase Helicopter Approach Path Indicator System (CHAPI)

FAA AC 150/5345-28 Type L-881 non-LED with a filter that will provide a two-degree wide green sector in the center of the white over red beam. Connect the two light units to 6.6 ampere series current circuit (Style B) via appropriate isolation transformers. Provide tilt switches and relays to de-energize all light units when one unit exceeds tilt requirements.

2.3.5 Low-Impact-Resistant (LIR) Frangible Supports

Fiberglass reinforced conforming to FAA AC 150/5345-45. Provide anchor bolts, lowering devices and fixture mounting accessories as required by tower manufacturer.

2.4 RUNWAY LIGHTING SYSTEM

Include runway edge lights, runway threshold lights, runway centerline lights, runway touchdown zone lights, runway distance remaining signs and arresting gear markers, mounting structures, controls, and the associated equipment and interconnecting wiring to provide complete runway lighting systems as indicated. Use in-pavement light fixtures that withstand a minimum static single wheel load of 50,000 pounds. Where LED fixtures are used, provide fixtures that are compatible with the associated constant current regulators.

2.4.1 Runway Edge Lights

FAA AC 150/5345-46, Type L-850C, in-pavement, high-intensity white lights.

2.4.2 Runway Threshold and End Lights

FAA AC 150/5345-46, Type L-862, elevated high-intensity, bidirectional, [[Type L-861 SE][Type L-861(L) LED], elevated, medium-intensity, bidirectional] [[Type L-861][Type L-861(L) LED], elevated, medium-intensity, omnidirectional] [[Type L-852E][Type L-852(L) LED], in-pavement, medium-intensity, omnidirectional] [[Type L-850D][Type L-850D(L) LED], in-pavement, high-intensity, bidirectional] [[Type L-850C][Type L-850C(L) LED], in-pavement, high-intensity, unidirectional] [FAA E-982, PAR-56, elevated unidirectional outboard of runway edges,] [airfield and heliport lights as indicated]. For threshold lights use aviation green filter and for end lights use aviation red filters. Combine these lights in a single bidirectional fixture with the appropriate color filters as indicated.

2.4.3 Runway Touchdown Zone Lights, Tailhook Operations

FAA AC 150/5345-46, [Type L-852][Type L-852(L) LED], Class N (Navy), bidirectional, narrow beam, Type [V][VI][VII][VIII], [with shorting device for failed lamp,] modified to resist damage from aircraft tailhooks. Modify fixture as follows to resist damage from aircraft tailhooks. Stainless steel for top assembly must conform to SAE AMS5351 with Rockwell hardness of C40 plus or minus 5. Provide casting thickened from 3/8 to 1/2 inch, and optical plate thickened as required to maintain flushness. Height of fixture must be 1/2 inch above pavement in lieu of 3/8 inch. Light channel width must be 1 inch at the lens, with a divergence of 14 degrees on each side. Secure optical assembly with ceramic/metallic/fluorocarbon polymer coated steel bolts.

2.4.4 Runway Touchdown Zone Lights, Non-Tailhook Operations

FAA AC 150/5345-46, Type L-850B, with top casting having extra rib for protection against damage from aircraft tailhooks.

2.5 TAXIWAY LIGHTING SYSTEMS

Include edge lights, , hold position lights, and all associated equipment, power supplies and controls, mounting devices, and interconnecting wiring to provide complete systems. If LED fixtures are used, provide fixtures that are compatible with the associated constant current regulators.

2.5.1 Taxiway Edge Lights

FAA AC 150/5345-46, Type L-861T for elevated taxiway edge lights with 45-watt, 6.6A lamp and blue lens and FAA AC 150/5345-46, Type L-852E, Class [1][2] for semiflush taxiway edge lights with a 115-watt, 6.6A lamp and blue filter.

2.5.2 Taxiway Hold Lights

FAA AC 150/5345-46, Type L-852G unidirectional with yellow filter toward the taxiway.

2.5.3 Runway Hold Position Lights

FAA AC 150/5345-46, Type L-804, elevated, or Type L-852G, in-pavement, unidirectional, with aviation yellow filter and aimed toward the taxiway approach to the runway.

2.5.4 Limit Lights

FAA AC 150/5345-46, Type L-861 with red globes and 45-watt lamps or LEDs. Frangibly mount the lights on FAA AC 150/5345-42, Type L-867 light bases.

2.6 AIRFIELD GUIDANCE SIGN SYSTEMS

2.6.1 General

Provide guidance signs compatible with all L-828/L-829 regulators.

2.6.2 Photometric Requirements

Guidance signs must meet FAA minimum luminance requirements.

2.6.3 Taxiway Guidance Signs

FAA AC 150/5345-44, Type L-858Y for information and Type L-858R for mandatory signs. Provide signs of the size and with the information indicated. Sign must operate on a multistep 6.6 amp circuit.

2.6.4 Runway Distance Remaining Signs

FAA AC 150/5345-44, Type L-858B, Size 4, Style [3][5], with white numerals on a black background. Provide internally illuminated markers with illumination of the face not less than 50 percent of that at rated current when the series lighting circuit is operated at the lowest brightness step.

2.6.5 Arresting Gear Markers

Provide arresting gear markers that are the same as Runway Distance Remaining Signs, except arresting gear markers must have a 39 inch translucent yellow circle in place of numerals as specified above.

2.7 HELIPAD LIGHTING SYSTEMS

2.7.1 Helipad Perimeter Lights

2.7.1.1 Elevated Lights

FAA AC 150/5345-46, Type L-861 with aviation yellow globes, as indicated. Frangibly mount lights on FAA AC 150/5345-42, Type L-867 bases.

2.7.1.2 In-Pavement Lights

FAA AC 150/5345-46, Type L-852E with aviation yellow filters. Mount fixtures on FAA Type L-868 bases.

2.7.2 Helipad Floodlighting

Use helipad floodlights as indicated.

2.7.3 Helipad Landing Direction Lights

FAA AC 150/5345-46, Type L-861 with aviation yellow globes. For landing direction lights located in paved areas subject to aircraft or vehicular surface traffic, use FAA AC 150/5345-46, Type L-852E fixtures with aviation yellow filters.

2.7.4 Helipad Approach Direction Lights, Visual Meteorological Conditions

FAA AC 150/5345-46, Type L-861 fixtures with aviation white globes. For approach direction lights located in paved areas subject to aircraft or vehicular surface traffic, use FAA AC 150/5345-46, Type L-852E fixtures without filters.

2.7.5 Helipad Approach Direction Lights, Instrument Meteorological Conditions

FAA E-982 lampholder for Type PAR-56 lamps without filters.

2.8 HOVERLANE LIGHTS

FAA AC 150/5345-46, Type L-861 for elevated lights with aviation yellow or aviation green globes . For hoverlane lights located in paved areas subjected to aircraft or vehicle traffic, the fixtures must be FAA AC 150/5345-46, Type L-852E with aviation yellow or aviation green filters.

2.9 RUNWAY END IDENTIFIER LIGHTS (REIL)

FAA AC 150/5345-51, Type L-849, Style E- Unidirectional, three brightness steps. Include the master and slave fixture, the power supply, remote control, frangible mounts, and interconnecting wiring. The REIL units must flash in unison twice per second.

2.10 OBSTRUCTION LIGHTING AND MARKING

2.10.1 Obstruction Lights

Use obstruction marker lights emitting aviation red steady burning light. Use [multiple-socket assembly] [series socket assembly] FAA AC 150/5345-43, [Type L-810] [Type L-864] light fixtures. For multiple flashing lights on a circuit, flash the lights in unison. Use single- or double-unit type obstruction marker lights as indicated. Energize the obstruction lights circuits as indicated.

Do not use LED-based obstruction lights on military facilities.

2.11 LIGHT BASES

FAA AC 150/5345-42 Type L-867 or L-868 . Use steel bases, Class 1, Size B, C, D or A as required to accommodate the fixture or device installed. Use Size C where more than one distributed control module is installed in the light base. Where used as pull boxes in (single or multiple) can plazas use L-867D bases. Provide base plates, cover plates, and adapter plates to accommodate various sizes of fixtures.

Furnish each base with internal and external one-hole ground lugs for attaching ground or counterpoise cables.

Furnish each base with a 4 foot braided, #6 AWG equivalent ground strap with one-hole lug compression fittings. Utilize straps made for the purpose of grounding the light fixture to the base can interior grounding lug.

2.12 WIND DIRECTION INDICATOR

FAA AC 150/5345-27, Type [L-806, low mass supporting structure, size 1, 8 feet] [L-807, rigid supporting structure], [size 1, 8 feet][size 2, 12 feet], [Style (I-lighted] [II-unlighted], Size [1 to 8 feet] [2 to 12 feet]. Provide wind cones of the size and color as indicated, including wind cone indicator assembly connection, including wind cone indicator assembly connection..

FAA AC 150/5345-27, Type L-807, with a frangible support assembly, lighted with four lamps, and an orange 12 foot fabric cone. Provide wiring and controls. Supplemental wind cones, where used, must be Type L-806.

2.13 BEACON

The rotating beacons for airfield and heliport beacons are omnidirectional and color coded and are provided by rotating the beams in sequence to provide the color and intensity. For military facilities the beacon has a double-peaked white beam. Use beacons with flashes visible through 360 degrees.

2.13.1 Airfield Rotating Beacon

FAA AC 150/5345-12F, Type L-802M, Class [1] [2] for fixed wing aircraft. Provide a duplex type beacon with double-peaked white beam in a repeating white/white/green pattern. Use NEMA ICS 6 Type 3R enclosure of zinc-coated steel.

2.13.1.1 Power Supply

Provide weatherproof circuit-breaker panelboard having four single-pole 120-volt circuits, a ground bus and a solid neutral bus to provide separately protected circuits for the beacon lamps, motor, and obstruction lights. Provide cabinet with a NEMA Type 3R enclosure of zinc-coated steel. Locate panelboard at working height at ground level. Provide disconnect switches at the maintenance platform level

2.14 LAMPS AND FILTERS

Provide lamps of the size and type indicated, or as required by fixture manufacturer for each lighting fixture required. Include filters of colors as indicated and conforming to the specification for the light concerned or to the standard referenced.

2.15 EXPLOSION-PROOF FIXTURES FOR HAZARDOUS LOCATIONS

For explosive hazardous locations, use fixtures that meet the requirements of and be listed by UL Electrical Construction or ETL as defined in NFPA 70 for the hazard and application.

2.16 ISOLATION TRANSFORMERS

2.16.1 Encapsulated Isolation Transformers

FAA AC 150/5345-47, Type (G) L-830. Provide each transformer with rating as indicated. Insulation Level Primary voltage rating 5000 volts RMS, Secondary 600 V RMS. Operating Temperature range minus 131 degrees F to plus 149 degrees F. Resistant to UV exposure and ozone. Suitable for areas contaminated with oils, aircraft fuels, soil acids, alkalis, and deicing fluids. Compatible with FAA Style 2 and Style 9 connectors.

2.17 SURGE ARRESTERS

Provide surge arresters in accordance with IEEE C62.11, IEEE C62.41.1 and IEEE C62.41.2 as applicable with ratings as indicated. Provide surge arresters on the line side of the constant current regulator (CCR). Provide series circuit surge arresters for locations with a lightning flash density of 8 or more flashes per square kilometer per year.

2.18 SURGE PROTECTIVE DEVICES

As required in Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM.

2.19 CONSTANT CURRENT REGULATORS

2.19.1 Regulators

FAA AC 150/5345-10, [Type L-828, without monitoring] [Type L-829 with monitoring] dry-type system and with current rating or [6.6A][20A][6.6A and 20A][5.5A][_____]. Use regulators of ferroresconant design to reduce EMI, increase efficiency, and provide a power factor not less than 0.95. Provide regulators that operate on [60] [50] Hz, have internal primary switch [included] [excluded], have input voltage of [480][_____] and be controlled by [120 VAC][48VDC][_____] external control voltage. Provide [5][3][or][1] [_____] brightness steps, as indicated. [Provide monitors as indicated.] [Provide regulators with digital power meters.] [Provide regulators with insulation resistance monitoring systems.] [Provide regulators with integral or unit-mounted series circuit cutouts.] [Use stackable switchgear style regulators with a series circuit cutout cabinet.] Insure that constant current regulators are compatible with signs, [LED light fixtures] and other connected loads.

2.19.2 Basic Impulse Level (BIL)

Provide 60-kV series circuit BIL except that 4-kW, 7.5-kW and 10-kW regulator series circuits may have a BIL of 25 kV.

2.20 CIRCUIT SELECTOR SWITCH

FAA AC 150/5345-5, Type L-847, for [one] [two] [three] [four] circuit control [as indicated], Class [A, indoor] [B, outdoor], Rating [1, for 6.6 amperes] [2, for 20 amperes].

2.21 MATERIALS AND HARDWARE

2.21.1 Wire and Cable

Use copper conductors installed in conduit. Do not provide or install wire and cable manufactured more than one year before delivery to the job site.

2.21.1.1 Conductor Sizes

Conductor size conforming to American Wire Gage (AWG) or metric trade size. Use stranded conductors for sizes larger #8 AWG. Unless otherwise indicated #8 AWG and smaller may be solid or stranded.

2.21.1.2 Low Voltage Wire and Cable

a. [UL 83, Type [_____][THWN-2] UL 44 Type XHHW-2 [_____].]

b. [UL 83, Type [_____][THWN-2]] [UL 44, Type [XHHW-2] [_____] must be used for secondary series lighting circuits to be installed in pavement.]

2.21.1.3 Wire and Cable for Series Lighting Circuits

a. FAA AC 150/5345-7, Type L-824 for [crosslinked polyethylene Type C] [Type B] 5000-volt cable. Use unshielded cable for series airfield and heliport lighting.

2.21.1.4 Safety (Equipment) Grounding System

Safety (Equipment) Grounding System for constant voltage (parallel) circuits: minimum #6 AWG bare stranded copper, annealed or soft drawn.

2.21.1.5 Sequence Flashing Trigger Circuits

REA Bull 1753F-205 compliant cables.

2.21.1.6 Control Cable

Multiconductor type for 120 V ac control, rated 600 volts, #12 AWG, and conforming to the following unless indicated or specified otherwise. Insulate each conductor with a thickness of not less than 30 mils and rate for continuous operation at 194 degrees F. Conductors must be color coded. An overall jacket of heavy-duty neoprene rated for direct burial must be included. Cable must conform to NEMA WC 70for rubber insulation, ANSI/NEMA WC 71/ICEA S-96-659 for cross-linked polyethylene insulation, or NEMA WC 74/ICEA S-93-639 for ethylene-propylene rubber insulation.

2.21.1.7 Cable Tags

Install cable tags for each cable or wire at duct entrances entering or leaving manholes, handholes, and at each terminal within the lighting vault, and in all base cans. Use stainless steel, bronze or copper strip cable tags, approximately 1/16 inch thick or hard plastic 1/8 inch thick suitable for immersion in salt water and impervious to petroleum products. Use sufficient material length for imprinting the legend on one line using raised letters. Permanently mark or stamped with letters not less than 1/4 inch in height as indicated. Two-color laminated plastic is acceptable. When providing plastic tags utilize white colored with markings of black color to provide contrast so that identification can be easily read. Use nylon or stainless steel ties must be of a type that will not deteriorate when exposed to water with a high saline content and to petroleum products.

2.21.1.8 Cable Connectors and Splices

FAA AC 150/5345-26, Item L-823 for connections and splices appropriate for FAA Type L-824 cable.

2.21.2 Conduit, Conduit Fittings, and Boxes

2.21.2.1 Rigid Metal Conduit (RMC) or Electrical Metallic Tubing (EMT) and Fittings

UL 6 and UL 797.

2.21.2.2 Liquid-tight Flexible Metal Conduit (LFMC)

UL 360 liquid-tight flexible metal conduit. See Sections 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.21.2.3 Outlet Boxes for use with RMC, EMT, of LFMC

See 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.21.2.4 Plastic Duct for Concrete Encasement

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.21.2.5 Plastic Conduit for Direct Burial

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.21.2.6 High Density Polyethylene (HDPE) Electrical Conduit for Directional Bore

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.21.2.7 Frangible Couplings and Adapters

FAA FO 6850.19 and FAA E-2519. Provide upper section of frangible coupling with one of the following:

a. Unthreaded for slip-fitter connections.

b. 2-13/32 inch 16N-1A modified thread for nut and compression ring to secure 2 inch EMT.

c. 2 inch 11-1/2-N.P.T. (tapered) with 7/32 inch nominal wall thickness to accept rigid conduit coupling.

d. Frangible Couplings for specialized applications as approved.

e. Electrical Metallic Tubing UL 797, where indicated for use with frangible couplings and adapters.

2.21.3 Electrical Tape

Provide as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.21.4 Ground Rods

As specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.21.5 Bolts and Hardware

2.21.5.1 Locking Type Washers

Use locking washers of the two-piece wedge-lock design to prevent damage to the fixture. Do not use split-ring, serrated or star type lock washers.

2.21.5.2 Anti-Seize Compound

Use anti-seize compounds for elevated light fixtures with stainless steel bolts but not for ceramic-metallic/fluorocarbon polymer coated bolts for in-pavement light fixtures. Use as recommended by the fixture manufacturer to provide the required clamping force except as indicated in Part 3 of this specification.

2.21.5.3 Ceramic-Metallic/Fluorocarbon Polymer Coated Bolts

Ceramic-metallic/fluorocarbon polymer coated bolts must be used for in-pavement light fixtures or may be used where recommended by the fixture manufacturer in lieu of using an anti-seize compound.

2.21.5.4 Stainless Steel Bolts for Elevated Fixtures

Use anti-seize lubricating compound.

2.21.6 Sealants for Fixtures and Wires in Drilled Holes or Saw Kerfs

FAA AC 150/5370-10, Type P-605 and P-606, for use in asphaltic concrete (AC) or Portland cement concrete (PCC) pavement compatible with AC pavement and having a minimum elongation of 50 percent. Do not use formulations of Type P-606 which are compatible with PCC pavement only.

2.21.7 Manufacturer's Nameplates

Provide on each item of equipment a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.21.8 Field Fabricated Nameplates

Provide field fabricated nameplates as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.21.9 Spare Airfield Lighting Equipment Materials

Contractor must provide the following equipment and materials:

a. Lamps - Type and Quantity

b. Isolation Transformers - Type and Quantity

c. Constant Current Regulators - Type and Quantity

d. FAA L-823 Connectors - Type and Quantity

e. Control Cable - Type and Quantity

f. FAA L-824 Cable - Type and Quantity

g. Lamps for Airfield Lighting Fixtures and Signs

h. Refractors and Filters for Airfield Lighting Fixtures - Type and Quantity

i. Light Bases - Type and Quantity

j. Frangible Couplings - Type and Quantity

k. Sequenced Flashing Light System - Provide a spare part trunk with parts.

2.22 ACCESSORIES

2.22.1 Special Tools

List of special tools and test equipment required for installation, maintenance of testing of the products supplied by the Contractor. Items to be listed include, but are not limited to, the following:

4-Jack Positioning Jig, used to install the light base to ensure correct orientation and leveling of in-pavement fixtures.

Crimping Tool

Cable Penciler

Elevated Light Level

PART 3 EXECUTION

3.1 LIGHT FIXTURE INSTALLATION REQUIREMENTS

3.1.1 Existing Airfield Lighting Systems

Existing airfield lighting systems must remain in operating condition and interuptions must be held to a minimum. Where interuptions are necessary, they must be scheduled as approved in writing by the Contracting Officer. Prior to the scheduled time for each interuptions, all necessary materials and a sufficient labor force must be assembled to permit completing the work within the scheduled time interval. Under no circumstances must any of the existing airfield lighting circuits be left inoperative without making provisions for suitable temporary connections in the affected area or areas. All airfield lighting circuits covered under this contract must bereplaced in such a manner that they will be operational at dusk each day. The Contractor must submit to the Contracting Officer a plan for outages and maintaining lighting and lighting control..

3.1.2 General Installation Requirements

Conform to IEEE C2, NFPA 70, NFPA 70B, and requirements specified herein. Circuits installed underground must conform to the requirements of Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, except as required herein. Steel conduits installed underground must be installed and protected from corrosion in conformance with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical metallic tubing (EMT) must not be installed underground or encased in concrete. Except as covered herein, perform excavation, trenching, and backfilling in accordance with the requirements of Section 31 00 00 EARTHWORK and Section 32 11 23.23 BASE COURSE DRAINAGE LAYERS.

3.1.3 Airfield Light Fixture Installation

Use 2-part locking type washers for the installation of all airfield light fixtures. Tighten bolts to washer manufacturers recommended torque based on bolt type used. Use only adjustable torque limiting tools.

Where stainless steel bolts are used for elevated fixture installation use an anti-seize lubricating compound.

Where ceramic-metallic/fluorocarbon polymer coated bolts are used for in-pavement fixture installation do not use anti-seize lubricating compounds.

3.1.4 Light Base Installation

3.1.4.1 Installation in Cored Pavement

Wipe down the sides and bottom of each light base immediately prior to installation. For bored hole installations cover the inside faces of bored hole and bottom and sides of light base with a coating of compatible P-606 sealant that will completely fill the void between concrete and base. Use a jig or holding device when installing each light fixture to ensure positioning to the proper elevation, alignment, level control, and azimuth control. Orient the light fixture with the light beams parallel to the runway or taxiway centerline and facing in the required direction. Outermost edge of fixture must be level with the surrounding pavement. Remove surplus sealant or flexible embedding material. The holding device must remain in place until sealant has reached its initial set. Properly arrange fixture lead wires with respect to their connecting position. Block the wireway entrance into the light recess to retain the sealant material during curing.

3.1.4.2 Installation in Concrete Bed

Where light base can is partially embedded in concrete with jig or holding devices, leave device in place for minimum 24 hours. Let base can set for an additional 48 hours before remaining concrete is placed to the top of the light base.

3.1.5 Frangible Requirements

Install frangible supports, couplings, and adapters as indicated or specified. At the 1000 foot cross bar and beyond, mount approach lights up to 6 feet above concrete foundation on threaded frangible couplings and 2 inch electrical metallic tubing (EMT). For mounting heights greater than 6 feet, mount approach lights on low-impact resistant frangible towers as indicated. The elevation of approach lights must be as indicated on drawings.

3.1.6 Elevated Light Fixtures

Elevated lights must be frangibly mounted, not to exceed 14 inches in height except where higher mounting is permitted in snow accumulation areas. For equipment exceeding 14 inches in height, frangibly mount as indicated. Use a 4-jack positioning jig to install the light base to ensure correct orientation and leveling. The individual setting the jig must fully understand reference marks that are provided by the surveyor. Check azimuth by survey before the concrete anchor is placed and again before paving. A factory representative of the light base manufacture must be on-site when the first light base is being installed and verify that the installation crew understands proper azimuth and elevation required for the light base. Do not place the near light base edge closer than two feet from a planned pavement joint. If conflict occurs, immediately notify the Contracting Officer Representative of the conflict.

3.1.6.1 Elevated Light Level

Level elevated light fixture using manufacturers system required for fixture type.

3.1.7 In-Pavement Airfield and Heliport Lights

Remove water, debris, and other foreign substances prior to installing in-pavement light base and light. Use a 4-jack positioning jig, obtained from the L-868 base manufacturer, to install the light base to ensure correct orientation and leveling. The individual setting the jig must fully understand reference marks that are provided by the surveyor. Check azimuth by survey before the concrete anchor is placed and again before paving. A factory representative of the light base manufacture must be on-site when the first light base is being installed and verify that the installation crew understands proper azimuth & elevation required for the light base. Do not place the near light base edge closer than two feet from a planned pavement joint. If conflict occurs, immediately notify the Contracting Officer Representative of the conflict.

3.1.7.1 In-Pavement Light Installation

For in-pavement installations, pavement around the light base must be level with the surrounding pavement; dished or mounded pavement near the light base is not acceptable.

3.1.7.2 Snow Plow Ring Installation

For in-pavement fixtures that require snow plow rings, coordinate the light base can, light fixture and snow plow ring to meet the installation tolerances shown in the paragraph Light Fixture Installation Tolerances. The Contractor may need to provide spacer rings to meet these tolerances. The top edge of the snow plow ring must be slightly higher than the top of the light fixture. Install the silicone rubber O-ring to seal the light base can. Install the ceramic fluoropolymer coated bolts to attach the light fixture and snow plow ring to the light base can.

3.1.8 Light Fixture Installation Tolerances

	IN-PAVEMENT	ELEVATED
ELEVATION (relative to finished pavement surface)	+0 inch, -1/16 inch (fixture edge on low side in snow areas or on high side in non-snow areas)	+1/4 inch, -0 inch
AZMUTH (*) (w/respect to line parallel to RW/TW centerline)	+/- 1/2 degree	+/- 1/2 degree
LEVEL	+/- 1/2 degree	+/- 1/2 degree
STATIONING (in line parallel to RW/TW centerline)	+/- 2 inch	+/- 2 inch
OFFSET (perpendicular to RW/TW centerline)	+/- 1/4 inch	+/- 1/4 inch

(*)For omni-directional fixtures the Azimuth does not apply.

3.1.9 Enclosures in Saw Kerfs and Drilled Holes

3.1.9.1 Holes for Light Fixtures

Bore holes in existing pavement to the dimensions indicated with a diamond-edged bit to provide a smooth, straight cut. Bottom of hole must be flat or slightly concave, except that an area at least 1 inch wide around the perimeter must be flat. Fill surfaces deeper than the prescribed depth with sealant to the level of the flat area and allow sealant to cure before further placement.

3.1.9.2 Holes for Transformer Enclosures

Drill or excavate holes through concrete pavement and remove loose material. Fill hole with concrete to depth indicated. Provide a minimum of 3 inches of concrete at bottom of hole.

3.1.9.3 Saw Kerfs and Splice Chambers

Cut saw kerfs and splice chambers in pavements where indicated. Saw cuts must be in straight lines with vertical sides. Width and depth of saw cuts must be adequate for the required number of wires. Chamfer the vertical edges of saw kerfs at intersections. Where a saw kerf crosses a construction joint, increase the depth sufficiently to allow for slack wire under the joint. Enclose the wire in flexible tubing which extends not less than 2 feet each side of the joint.

3.1.9.4 Sandblasting

Sandblast saw kerfs, grooves, and holes to remove foreign or loose material. Use approved equipment maintained in good working order.

Utilize the proper size and quality of sand necessary to perform the work. Use nozzles of the proper size in relation to the groove or holes to be cleaned. Replace nozzles enlarged by wear as necessary. Sandblast air pressure must be not less than 90 psi.

3.1.9.5 Cleaning

Immediately prior to installation of wire or light fixtures, flush saw kerfs and holes with a high velocity water jet or steam, and then clean and dry with a high velocity air jet to remove dirt, water, and foreign material.

3.1.10 Isolation Transformers

Conform to FAA AC 150/5345-26 for transformer lead connections. Plug transformer secondary connectors directly into a mating connector on the transformer secondary leads. During installation, cover mating surfaces of connectors until connected and clean when plugged together. At joint where connectors come together, install heat shrinkable tubing with waterproof sealant or with two half-lapped layers of tape over the entire joint. Joint must prevent entrapment of air which might subsequently loosen the joint.

3.2 CABLES

3.2.1 Cable Installation

In addition to the requirements of Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, use kit type connectors to splice 5 kV single-conductor series lighting cables. During installation, keep mating surfaces of connectors covered until connected and clean when plugged together. At joint where connectors come together, install heat shrinkable tubing with waterproof sealant. Joint must prevent entrapment of air which might subsequently loosen the joint.

3.2.2 Low Voltage Cables

For splices in wires #8 AWG single conductor cable, use FAA AC 150/5345-26 Type L-823 connectors Splices below grade or in wet locations must be sealed type conforming to NEMA C119.1 or must be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

Cable must be rated 600 volts, except that secondaries of isolation transformer to in-pavement lights installed in pavement saw kerf and 48 volt DC control cables may be 300 volts. Other parts of cable systems such as splices and terminations must be rated at not less than 600 volts. Splices in wires #10 AWG and smaller must be made with an insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. Splices in wires #8 AWG single conductor cable must be made with FAA AC 150/5345-26 Type L-823 connectors Splices below grade or in wet locations must be sealed type conforming to NEMA C119.1 or must be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

3.2.3 Airfield 5kV Series Lighting Cables

3.2.3.1 Connectors

Use kit type connectors to splice 5 kV single-conductor series lighting cables. During installation and prior to covering with earth, cover mating surfaces of connectors until connected and clean when plugged together. At joint where connectors come together, install heat shrinkable tubing with waterproof sealant with two half-lapped layers of tape over the entire joint. Joint must prevent entrapment of air which might subsequently loosen the joint.

3.2.3.2 Crimping Tool

Use only splice kit manufacturer's crimping tool on splice connectors for all primary and secondary airfield cable splices. Crimping tool must have an embossed die with gauge marks for gauge of cable being used.

3.2.3.3 Cable Penciler

Airfield cable insulation must only be removed using cabling penciler made specifically for airfield cable.

3.2.4 Installation of Circuit Wires in Saw Kerfs

Place wires in saw kerfs and anchor them at bottom by means of rubber or plastic wedges or noncorrosive metal clips placed every 2 or 3 feet or as often as necessary to hold the wire down. Encase wires crossing existing joints in a 24 inch length of flexible tubing of polyethylene material conforming to ASTM D1248, Type II or Type III, to break the bond between the wires and the sealing material. Center flexible tubing on the joint and ensure the tubing is of sufficient size to accommodate the wires to allow for movement of the wires as the joint opens and closes. Wrap ends of tubing with tape to prevent entrance of sealing materials. The adjacent joint area must be packed temporarily with roving material, such as hemp, jute, cotton or flax, to prevent sealing material from flowing into the open joint. Carefully mix and apply sealing materials in accordance with the manufacturer's instructions and at the recommended temperature. Remove surplus or spilled material.

3.2.4.1 Splicing Fixtures to the Wires in Pavement Saw Kerfs

Use preinsulated watertight connector sleeves crimped with a tool that requires a complete crimp before tool can be removed. Tape splice with plastic insulating tape.

3.2.5 Cable Markers

Provide cable markers or tags for each cable at duct entrances entering or leaving manholes or handholes and at each termination within the lighting vault. Provide not less than two tags per cable in in each manhole or handhole, one near each duct entrance hole. Immediately after cable installation, permanently attached tags to cables and wires so that they cannot be accidentally detached.

3.2.6 Maximum Allowable Non-Armored Cable Pulling Tension, Using Dynamometer

Cable	Tension LB
2 - 1/C #8 solid	275

Cable	Tension LB
3 - 1/C #8 solid	367
4 - 1/C #8 solid	550
2 - 1/C #6 stranded	420
3 - 1/C #6 stranded	630
4 - 1/C #6 stranded	840
1 - 2/C #8 stranded	305
1 - 3/C #8 stranded	395
1 - 4/C #8 stranded	585
1 - 2/C #6 stranded	455
1 - 3/C #6 stranded	685
1 - 4/C #6 stranded	880
1 - 6/C #12 stranded	315
1 - 12/C #12 stranded	630
1 - 12 pair #19 solid	230
1 - 25 pair #19 solid	541
1 - 50 pair #19 solid	1061
1 - 100 pair #19 solid	2000

3.3 COUNTERPOISE

Install counterpoise above multiple conduits/duct banks for airfield lighting cables, with the intent being to provide a complete cone of protection over the airfield lighting cables. When multiple conduits and/or duct banks for airfield cable are installed in the same trench, the number and location of counterpoise conductors above the conduits must be adequate to provide a cone of protection measured 22 1/2 degrees each side of vertical. Install one continuous length of conductor, except where distance exceeds the length usually supplied. Install the counterpoise approximately 6 inches above single duct lines that are not adjacent to pavement. Where trenches or duct lines intersect, electrically interconnect the counterpoise wires. Connect the counterpoise conductor to a ground rod at every 2,000feet of cable run, at lighting vault(s) (but not to vault equipment), and at feeder connection to light circuit(s). Install the counterpoise conductor in a separate duct under roads, railroads and paved areas, above the highest duct containing electrical or communications circuits.

For in-pavement light fixtures, connect the counterpoise to the exterior one-hole ground lug on fixture bases installed in pavement subject to routine aircraft traffic (runway touchdown zone lights, runway centerline lights, runway guard lights and taxiway centerline lights). Where fixture bases are installed in pavement not subject to routine aircraft traffic (runway and taxiway edge lights) do not connect the counterpoise to fixture bases. In such cases, install the counterpoise at a location half way between the fixture line and the defined runway or taxiway edge. Use exothermic welding for all counterpoise connections. Provide counterpoise ground rods at maximum 2,000 foot spacing.

The counterpoise must be connected to the exterior one-hole ground lug on fixture bases. Use bolted ground clamps when bases are supplied with ground lug. Bolts and fasteners must be bronze or stainless steel. Torque to manufacturer's recommendation.

3.4 SAFETY (EQUIPMENT) GROUNDING SYSTEM

The purpose of the safety ground is to protect personnel from possible contact with an energized light base that may result from a shorted power cable or isolation transformer. Install and connect a #16 AWG conductor by one of the following methods from base to a ground rod

a. Connect each fixture base to a dedicated ground rod located outside the base on the side opposite the counterpoise.

b. Bond a group of adjacent fixture bases to a common safety ground conductor.

Connect the safety ground conductor to ground rods by exothermic welding and bolted connections. A safety ground is not required for in-pavement fixture bases where a counterpoise is connected to the exterior ground lug. In all cases connect the light fixture, whether in-pavement or elevated, to the base interior ground lug by means of a braided ground strap specified in paragraph "Light Bases".

3.5 DUCT LINES

Duct lines as required in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and as indicated. Ducts must be installed in trench for 24 hours before trench is backfilled to allow ducts to reach final ground temperature.

3.6 MANHOLES AND HANDHOLES

The manholes and handholes as required in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.6.1 Manholes and Handholes Within Paved Areas

Manholes and handholes within paved areas must have their top surface flush with grade, -0 to +1/4 inch.

3.6.2 Manholes and Handholes Within Unpaved Areas

Manholes and handholes within unpaved areas must have their top surface +1 to +2 inches above grade.

3.7 MARKING AND LIGHTING OF AIRWAY OBSTRUCTIONS

Mark and light all towers, poles, smokestacks, buildings of certain shapes and sizes, and other obstructions in accordance with FAA AC 70/7460-1 and as indicated.

3.7.1 Painting of Airway Obstructions

Conform with FAA AC 70/7460-1 and as indicated for patterns and colors to mark obstructions.

3.7.2 Obstruction Marker Lights

Install obstruction marker lights on radio towers, elevated water tanks, smokestacks, buildings, and similar structures with 1 inch zinc-coated rigid steel conduit stems using standard tees and elbows, except that lowering devices, when required, must be installed in accordance with equipment manufacturer's recommendations.

3.8 APPROACH LIGHTING SYSTEMS

Install approach lighting system as indicated. Provide nameplates for equipment, controls, devices, and for each lighting circuit.

3.8.1 Frangible Requirements

At the 1,000 foot crossbar and beyond, mount overrun lights up to 6 feet above concrete foundations on threaded frangible couplings and 2 inch RMC or EMT conduit. For mounting heights greater than 6 feet, install light on low impact-resistant (LIR) frangible supports. When rigid towers, trestles, and similar structures are required, install the light unit at least 20 feet above the rigid structure with this support unit being frangible.

3.8.2 Alignment of Lights

Align lights in azimuth, with beams axes parallel to the approach lighting system centerline. Aim elevated lights vertically at a point on the glide path with the angular elevation of each light as indicated. In-pavement lights have a preset vertical aiming angle and require alignment in azimuth only.

3.9 ROTATING BEACONS

3.9.1 Airfield Rotating Light Beacon

Install beacon in accordance with the manufacturer's instructions and other contract requirements including cleaning, lubrication, adjustment, and other special instructions. Provide foundations and supports as indicated.

3.9.1.1 Beam Adjustment

Adjust beam during hours of darkness. Aim beam to provide a minimum of 5.5 degrees above the horizontal, but not higher than necessary to clear principal obstructions.

3.9.1.2 Power Supply and Wiring

Install panelboard at working height at ground level with lockable panel cover and disconnects at top of structure to provide separately protected circuits for beacon lamps, heaters, motor, and obstruction lights. Install cabinet on side of platform opposite ladder. Conduit riser must be installed on tower in a corner angle and not near ladder.

3.9.2 Heliport Light Beacon

Install beacon in accordance with the manufacturer's instructions and other contract requirements including cleaning, lubrication, and adjustment.

Provide foundations and supports as indicated.

3.9.2.1 Beam Adjustment

Adjust beam during hours of darkness. Aim beam to provide a minimum of 5.5 degrees above the horizontal, but not higher than necessary to clear principal obstructions.

3.9.3 Power Supply and Wiring

Install panelboard at working height at ground level with lockable panel cover and disconnects at top of structure to provide separately protected circuits for beacon lamps, motor, and obstruction lights. Install cabinet on side of platform opposite ladder. Install conduit riser on tower in a corner angle and must not be located near ladder. The terminal cabinet must be in accordance with NEMA ICS 6 Type 3R or as indicated on drawings.

3.10 WIND DIRECTION INDICATORS

Include in the installation a black circle constructed on a concrete pad the ground with center at center of the base. Guy the wind cone direction indicator as indicated on drawings. Energize the wind cone illumination lights and obstruction lights from circuits as indicated.

3.11 CONSTANT CURRENT REGULATORS

Install as indicated in strict accordance with manufacturer's instructions.

3.12 CIRCUIT SELECTOR SWITCHES

Install as indicated and in strict accordance with manufacturer's instructions.

3.13 APPLICATION

3.13.1 Exothermic Welding

Utilize only personnel who are experienced in and regularly engaged in this type of work to make these connections. Prior to any installations in the field, provide documentation that the welding kits, materials and procedures to be used for welded connections are satisfactory. Comply with the manufacturer's recommendations and the following:

a. Remove all slag from welds.

b. The light fixture base cans should be provided with internal and external one-hole ground lugs that are coated with hot dipped galvanizing, the same as the rest of the base cans. The external ground lug should be bolted to a separate ground lug that is exothermically welded to a #4 AWG stranded bare copper grounding cable. That is connected to a ground rod for Air Force or Army projects or the counterpoise for Navy projects.

c. All direct buried welds must be thoroughly coated 6 mil of 3M "Scotchkote", or approved equivalent, or coated with coal tar bitumastic material to prevent surface exposure to corrosive soil or moisture.

3.13.2 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.13.3 Equipment for Silicone Sealant

Equipment for silicone sealant must be air-powered pump, components, and hoses as recommended by the sealant manufacturer. Hoses and seals must be lined to prevent moisture penetration and withstand pumping pressures. Equipment must be free of contamination from previously used other type sealant.

3.13.4 Painting

As specified in Section 09 90 00 PAINTS AND COATINGS.

3.13.5 Concrete

Concrete used in underground structures, such as manholes, handholes, pull boxes and foundations must have minimum 28-day strength of 4000 psi. Similar structures in areas where freeze/thaw conditions are common, must have minimum 28-day strength of 4500 psi. Concrete used for non-structural items, such as equipment pads, must have minimum 28-day strength of 2000 psi.

3.13.6 Grounding

Ground non-current carrying metallic parts associated with electrical equipment as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.14 FIELD QUALITY CONTROL

Notify the Contracting Officer five working days prior to each test. Correct all deficiencies and repeat tests. Field test reports must be written, signed and provided as each circuit or installation item is completed. Include resistance-to-ground and resistance between conductors field tests, and continuity measurements for each circuit. For each series circuit measure the input voltage and output current of the constant current regulator at each intensity. For multiple circuits measure the input and output voltage of the transformer for each intensity setting. Provide report documenting the visual inspection of the lights operation .

3.14.1 Visual Inspection

Inspection reports must be prepared and provided as each stage of installation is completed. Identify the activity by contract number, location, quantity of material placed, and compliance with requirements.

3.14.2 Operating Test

Upon completion of tests, show by demonstration in service that circuits, control equipment, and lights covered by the contract are in good operating condition. Operate each switch in the control tower lighting panels so that each switch position is engaged at least twice. During this process, observe lights and associated equipment to determine that each switch controls properly corresponding circuit. Provide telephone or radio communication between the operator and the observers. Repeat tests from the alternate control station, from the remote control points, and again from the local control switches on the regulators. Test each lighting circuit by operating the lamps at maximum brightness for not less than 30 minutes. Visually examine at the beginning and at the end of this test to ensure that the correct number of lights are burning at full brightness. Conduct one day and one night operating test for the Contracting Officer.

Provide performance test reports, upon completion and testing of the installed system, in booklet form showing all field tests performed to adjust each component and all field tests performed to provide compliance with the specified performance criteria. For each test, indicate the final position of controls.

3.14.3 Distribution Conductors, 600-Volt Class

Using an instrument which applies a voltage of approximately 500 volts providing a direct reading in resistance, performing testing to verify that no short circuits or accidental grounds exist.

3.14.4 Counterpoise System Test and Inspection

At accessible locations, visually inspect counterpoise system to ensure continuity of counterpoise system. Test continuity of counterpoise system to the vault grounding system in manhole closest to the vault.

3.14.5 Progress Testing for Series Lighting Circuits

Conduct a megger test on each section of circuit or progressive combinations of sections as they are installed. Test each section or progressive combination of sections with a megohmmeter providing a voltage of approximately 1000 volts, a direct reading in resistance. Document all results. Eliminate faults found by these tests, and re-test before proceeding with the circuit installation.

3.14.6 Electrical Acceptance Tests

Perform acceptance tests for series and multiple airfield and heliport lighting circuits only on complete lighting circuits. Each series and multiple lighting circuit must receive a high voltage insulation test. Check that cable insulation resistance to ground is not less than 50 megohms per FAA-C-1391, Installation and Splicing of Underground Cable.

3.14.7 Low-Voltage Continuity Tests

Test each series circuit for electrical continuity. Eliminate faults indicated by this test and perform retest before proceeding with the high-voltage insulation resistance test.

3.14.8 High-Voltage Insulation Resistance Tests

Subject each series lighting circuit to a high-voltage insulation resistance test by measurement of the insulation leakage current with a suitable high-voltage test instrument which has a steady, filtered direct current output voltage and limited current. High-voltage tester must include an accurate voltmeter and microammeter for reading voltage applied to the circuit and resultant insulation leakage current. Do not exceed voltage test values specified below.

a. Test Procedure: Disconnect both leads from regulator output terminals and support so that air gaps of at least 3 inches or as defined by FAA AC 150/5345-7 Table 1 exists between bare conductors and ground. Clean and dry cable sheaths for a distance of 1 feet from ends of cables and exposed insulation at ends of cables. Connect ends of both conductors of the circuit together and to high-voltage terminals of test equipment, and test voltage applied as specified in the following tabulation between conductors and ground for a period of 5 minutes.

Test Voltage, DC		
	First Test on New Circuits	Test on Existing Circuits
High Intensity Series Lighting Circuits (5,000 volt leads, 500 and 200 watt transformers)	9000	5000
Medium Intensity Series Lighting Circuits (5,000 volt leads, 30/45 watt transformers)	6000	3000
600-Volt Circuits	900	600

When additions are made to existing circuits, test only new sections in accordance with "First Test on New Circuits" in table above. To ensure reliable operation, test complete circuit at reduced voltages indicated above.

b. Leakage Current: Measure and record insulation leakage current for each circuit after a 1 minute application of the test voltage. If leakage current exceeds values specified below, sectionalize the circuit and retest, and repair or replace defective parts. Leakage current limits include allowances for the normal number of connectors and splices for each circuit as follows:

1. Three microamperes for each 1000 feet of cable.

2. Two microamperes for each isolation transformer.

3. If measured value of insulation leakage current exceeds calculated value, sectionalize the circuit and test as specified for each section. Repair or replace defective components until repeated tests indicate an acceptable value of leakage current for the entire circuit.

c. Resistance Values versus Cable Length

An alternate test procedure for circuit validation is to use a megohmeter. Use 5000V test for new circuits and 3000V test for existing circuits. If the minimum resistance values are not achieved then use the leakage current test indicated above.

Circuit Length in Feet Meters	Minimum Resistance to Ground (Megohms)
10,000	50

Circuit Length in Feet Meters	Minimum Resistance to Ground (Megohms)
10,000-20,000	40
>20,000	30

3.15 PHOTOMETRIC TESTING

3.15.1 Inspection

Provide test reports from an FAA approved, third-party, certification body to insure full compliance with the photometric requirements. Submit for approval for each type of light fixtures to the Contracting Officer prior to final acceptance of the installation. Include certification of compliance with specified requirements, identify deficiencies, and recommend corrective action when appropriate. Type and neatly bind test reports to form a part of the final record. Submit test reports documenting the results of each test not more than 10 days after test is completed.Items to be tested include, but are not limited to, the following:

a. Airfield Guidance Signs

b. Discharge-Type Flashing Light Equipment

c. LED Fixtures or PAPIs

3.15.2 Test Instrument Calibration

a. Use a photometric tester that has a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. The accuracy must be directly traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule must not exceed 12 months.

d. Dated calibration labels must be visible on all test equipment.

e. Calibrating standard must be of higher accuracy than that of the instrument tested.

f. Up-to-date records which indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

    1. Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

    2. Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

3.15.3 Pre-Testing Requirements

a. Verify Constant Current Regulator (CCR) Performance. When the CCR is energized at the highest brightness intensity and at the middle brightness intensity, measure the following electrical characteristics for each CCR powering the light fixtures:

1. Input Current.

2. Input Voltage.

3. Input Power Factor.

4. Input Voltage Harmonic Distortion.

5. Input Current Harmonic Distortion.

6. Output Voltage.

7. Output Current.

8. Output Power Factor.

9. Output Voltage Harmonic Distortion.

10. Output Current Harmonic Distortion.

Analyze the data, and perform any adjustments or calibration required.

b. Clean Light Fixture. Clean all of the light fixtures to be tested one day prior to commencement of photometric testing. Perform the photometric testing at night. At the end of each night the photometric testing firm must provide a list of the deficient fixtures to the Contractor for corrections. A minimum 10% spare lamps and/or fixtures, transformers, and other accessories required to correct possible deficiencies must be available so that any corrections can be made daily and retested the following night.

c. Use photometric testing equipment that has an array of photometric sensors capable of taking simultaneous readings along the main photometric beam of the light output in direct correlation with Tables 1, 2, and 3 of the current edition FAA AC 150/5345-46 and the appropriate UFC requirements. The number and angles of measurement as well as sensor location and placement must be in accordance with Paragraphs 4.3.1 and 4.3.3 and the above-mentioned tables of the current edition FAA AC 150/5345-46 which provide specific requirements for photometric testing. Compare the average photometric intensity to the horizontal and vertical requirements detailed in Tables 1, 2, and 3 of the current edition FAA AC 150/5345-46. Include the measurement of each light fixture in both directions. All of the sensor readings for the light fixture being evaluated must be displayed simultaneously for operator and Airport representative review and evaluation. All sensor readings must be recorded automatically through the computer. Hand written data recording will not be accepted. Measure the chromaticity (x, y) or color of 5 percent of the light fixtures to ensure compliance with MIL-C-25050A, "Aviation Colors". Measure the chromaticity along one point in the center of the main photometric ellipse.

d. The testing firm must submit initial reports daily to the Contractor during the progress of the work so that corrective measures can be taken as required. A list of the deficient fixtures and the photometric output for each fixture must be provided in a field report to the Contractor prior to the testing firm leaving the job-site. Document the final results in a Final Report, with six (6 copies) submitted to the Airport. The final report must present an evaluation of each fixture tested, including proposed or performed corrective measures, such as cleaning or replacement of lenses, re-aiming of fixture, repair or replacement of fixture, for those fixtures that do not meet the performance requirements. Tabulate the photometric test data for each fixture with the following information:

Fixture Number - Provided by Airport.
Light Direction -Direction of light beam (ex. North, South, East, West).
Fixture type - FAA Fixture Type (ex. L-852C).
Lens Color - Color of lens on fixture being tested.
Max CD - Maximum candela output in a point along the main beam.
Avg CD - Average candela output of main beam.
Max/Avg - Ratio of max. candela output over the ave. output.
FAA Min Level - FAA specified output for type of fixture.
Chromaticity - x, y color coordinates of the sample fixture.

3.15.4 Photometric Testing of Airfield Guidance Signs

Evaluate the performance of the guidance signs with respect to RAA criteria (reference test methods in FAA AC 150/5345-44):

a. Uniformity: Make photometric measurements on a 3 inches grid over the entire face of the sign, with no measurement being closer than 3 inches to the sign frame. Adjacent measurements must not exceed a 1.5:1 ratio.

b. Discernability: The sign must be discernable from 800 feet away.

c. Contrast: For L-858R signs the ratio of average luminance between white legend and red background must be no greater than 10:1 and no less than 5:1.

Test all new airfield guidance panels or signs at night. Test the signs at their highest rated input current. Evaluate the photometric performance of the signs using digital color images. Convert these images to gray-scale images that can be analyzed directly for photometric output. To provide calibration and control for the evaluation of the gray-scale image, direct photometric readings of the light output in foot-lamberts (FL) must be taken at several locations on the face of the sign using a calibrated photometer. Only light emitted from the sign is permitted to reach the photometer.

To document compliance with FAA requirements, present the following information and data for each color for each sign tested in the Final Report:

a. Sign Designation & Date Sign was tested.

b. Digital & Gray-Scale Image of Sign.

c. Step - The step intensity of the regulator controlling the sign.

d. Arithmetic average of luminance levels.

e. Maximum luminance level on sign face and/or message.

f. Minimum luminance level sign face and/or message.

g. Ratio of Maximum luminance to Minimum luminance.

h. Uniformity. The maximum ratio of the average luminance levels of adjacent 3 inches areas over the face of the sign.

i. Visual Discernability of the Sign including comments.

j. Statements whether or not sign meets the specified luminance criteria.

Take photometric measurements of the red background on mandatory signs (white message on red background) to evaluate the sign's red to white contrast.

3.15.5 Photometric Testing of Discharge-Type Flashing Light Equipment

To evaluate the equipment performance with respect to the criteria in FAA AC 150/5345-51, paragraph 3.4, perform photometric testing of the discharge-type lights. Conduct tests per FAA-E-1100, Photometric Test Procedures for Condenser Discharge Lights. Include in test results a graph showing the isocandela curve of effective intensity for each brightness setting and oscilloscope photographs or digital image files (e.g., TIF, JPG, BMP) of the discharge pulse shape.

3.15.6 Photometric Testing of PAPIs

Using photometric testing, evaluate the photometric intensity of the PAPI system and verify that the center of the light beams are aimed at the appropriate vertical and horizontal angle. Provide support to adjust the PAPI while it is flight tested by the government.

a. Prior to performing the test measure the electrical characteristics of the CCR, if applicable, powering the PAPI or APAPI circuit. Include the measurement of the Volt-Amperes, Current, Voltage, and Harmonic Distortion for each intensity settings on the both the output and input to the CCR.

b. Sensors. Utilize sensors that are accurate to 5 percent as traceable to the National Institute of Standards and Technology (NIST) secondary standard or approved equal. Sensor must be color corrected to account for the different white and red lens associated with the system.

c. Measurement Points. Test on a one-degree horizontal interval and one-degree vertical interval inside the photometric ellipse indicated in Figure 3-12, UFC 3-535-01.

d. Measurement distance from lighting system. Take measurements at a minimum of 10 feet from the edge of the lenses.

e. Measurement Duration. Each measurement point must last a minimum of 30 seconds. To minimize stray light which may enter the lens, intentensity measurements at each point must be the average measurement over the 30 second time span.

f. Test Results. Compare measured light intensity values to the minimum values established in Figure 3-12, UFC 3-535-01. The angular difference for successive light units in a light bar must comply with paragraph 3-7.3.1, UFC 3-535-01.

3.15.7 Constant Current Regulators

3.15.7.1 Visual Examination

Examine each constant current regulator to ensure that porcelain bushings are not cracked, no shipping damage has occurred, internal and external connections are correct, switches and relays operate freely and are not tied or blocked, fuses, if required, are correct, and oil level of oil-filled regulators is correct. Remove relay panel covers only for this examination; it is not necessary to open the main tank of oil-filled regulators. Accomplish the instructions on the plates attached to the regulators. Replace covers tightly after completing examinations and tests.

3.15.7.2 Electrical Tests

Ensure that supply voltage and input tap correspond. With load disconnected, energize regulator and observe the open circuit protector to ensure that it de-energizes the regulator within 3 seconds. After testing circuits for open connections and grounds and after determining that lamps are good and in place, apply circuit load to the regulator and measure the voltage and current simultaneously on brightness taps. Voltmeter and ammeter must have an accuracy of plus or minus one percent. Record readings and make readings during the day and night in order to obtain the average supply voltage. Output current on each brightness tap must be within plus or minus 2 percent of the nameplate values after making necessary correction in the supply voltage. Late model regulators have automatic supply voltage correction in lieu of input taps, and output current does not change as supply voltage varies. When output current on tap 5 deviates from nameplate value by more than 2 percent, and regulator is not overloaded, check internal adjustment as described on regulator instruction plate. Since adjustment may be rather delicate, allow a deviation of up to plus or minus 5 percent on taps 1 through 4 before attempting to readjust the regulator.

3.16 FINISHING

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory must be as required in Section 09 90 00 PAINTS AND COATINGS.

3.17 CLOSEOUT ACTIVITIES

3.17.1 Demonstration

After completion of installations and the above tests, circuits, control equipment, and lights covered by the contract must be demonstrated to be in acceptable operating condition. Each switch in the control tower lighting panels must be operated so that each switch position is engaged at least twice. During this process, lights and associated equipment must be observed to determine that each switch properly controls the corresponding circuit. Telephone or radio communication must be provided between the operator and the observer. Tests must be repeated from the alternate control station, from the remote control points, and again from the local control switches on the regulators. Each lighting circuit must be tested by operating the lamps at maximum brightness for not less than 30 minutes. At the beginning and at the end of this test the correct number of lights must be observed to be burning at full brightness. One day and one night operating test must be conducted for the Contracting Officer.

3.17.2 Training

Submit requirements of training four weeks before training is scheduled to begin. Submit information describing training to be provided, training aids to be used, samples of training materials, and schedules; instructions necessary to checkout, troubleshoot, repair, and replace components of the systems, including integrated electrical and mechanical schematics and diagrams and diagnostic techniques necessary to enable operation and troubleshooting after acceptance of the system.

a. Provide training on the proper operation and maintenance procedures for the system. Submit a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

b. Submit six copies of operation for the equipment furnished. One complete set must be furnished prior to performance testing and the remainder must be furnished upon acceptance. Operating manuals must detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals must include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features.

c. Submit six copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals must include conduit and equipment layout and simplified wiring and control diagrams of the system as installed.

3.17.3 As-Built Drawings

Submit as-built drawings that provide current factual information including deviations from, and amendments to the drawings and changes in the work, concealed and visible, as instructed. The as-built drawings must show installations with respect to fixed installations not associated with the systems specified herein. Cable and wire must be accurately identified as to direct-burial or in conduit and must locate the connection and routing to and away from bases, housings, and boxes.

3.17.4 Posted Instructions

Submit a typed copy of the proposed posted instructions showing wiring, control diagrams, complete layout and operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system.

3.18 MAINTENANCE

3.18.1 List of Parts

A list of parts and components for the system by manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair necessary to ensure continued operation with minimal delays.

3.18.2 Maintenance and Repair Instructions

Instructions necessary to check out, troubleshoot, repair, and replace components of the systems, as specified.

3.18.3 Posted Operations and Maintenance Instructions

Submit proposed diagrams, instructions, and other sheets prior to posting.

3.19 SCHEDULES

Refer to Section 01 35 13 SPECIAL PROJECT PROCEDURES for construction outage plan requirements.

-- End of Section --

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SECTION 26 60 13.00 40

LOW-VOLTAGE MOTORS
05/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 112	(2017) Standard Test Procedure for Polyphase Induction Motors and Generators
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
NETA MTS	(2015) Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003; R 2008) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Low-Voltage Motors; G

SD-06 Test Reports

Factory Test Results; G

Field Test Report; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions; G

SD-10 Operation and Maintenance Data

Operating and Maintenance Manual; G

SD-11 Closeout Submittals

Warranty; G

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Qualifications

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

1.3.3 Predictive Testing and Inspection Technology Requirements

This section contains systems and/or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

1.3.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Provide products that have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, use items of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.3.4.1 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.

1.4 DELIVERY, STORAGE, AND HANDLING

Ensure all motors and related equipment are packaged and protected to prevent any damage during shipping, after acceptance of delivery, storage, and handling at the project site. Include manufacturer's instructions for proper handling and uncrating with the shipment of the Low-Voltage Motor(s).

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide Low-Voltage Motors of a sufficient size for the duty to be performed while not exceeding the full-load rating when the driven equipment is operating at specified capacity under the most severe loading conditions.

2.1.1 Service Factor

Ensure service factor of general purpose and other open ac motors is in accordance with NEMA MG 1.

Provide totally enclosed ac motors with a service factor of 1.15 .

2.1.2 Motor Types

Provide Low-Voltage Motors of the following types:

a. 1/3 and smaller, single phase - capacitor start

b. 1/2 and larger, three-phase - induction squirrel-cage type, NEMA Design B, having normal starting torque and low starting current

2.1.3 Design Requirements

Provide Low-Voltage Motors (LVM) designed for across-the-line starting with torque characteristics to carry the specified rated starting load. Ensure LVM have factory-sealed ball bearings with an L-10 rated life of not less than 30,000 hours in accordance with ABMA 9 or ABMA 11.

Ensure design, fabrication, testing, allowable balance limits and performance of polyphase induction motors are in accordance with NEMA MG 1 and ISO 1940-1 and meets or exceeds the requirements as specified herein.

Ensure motors are premium efficiency in accordance with NEMA MG 1 Table 12-12.

Ensure efficiency labeling is in accordance with NEMA MG 1.

2.1.4 Electrically Driven Equipment

When electrically driven equipment differs from that indicated, make adjustments to the motor size, wiring and conduit systems, disconnect devices, and circuit protection to accommodate the equipment actually installed, at no additional cost to the Government. Provide control and protective devices in accordance with Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 24 19.00 40 MOTOR CONTROL CENTERS.

2.1.5 Voltage Ratings

Provide motors with the following minimum voltage ratings:

MOTOR SIZE			MOTOR
MOTOR TYPE	HORSEPOWER	SERVICE	VOLTAGE RATING
Fractional horsepower, single-phase	1/3 and smaller	120/208-volt, 3-phase, 4-wire	120-volt, 60-hertz
Fractional and integral horsepower, 3-phase	1/2 and larger	120/208-volt, 3-phase, 4-wire	200-volt, 3-phase 60-hertz

MOTOR SIZE			MOTOR
MOTOR TYPE	HORSEPOWER	SERVICE	VOLTAGE RATING
Fractional and integral horsepower, 3-phase	1.5 and larger	480-volt, 3-phase, 3 or 4-wire	230/460-volt, 3-phase, 60-hertz

2.1.6 Temperature Rating and Insulation

Provide motors designed for continuous operation at the rated full load in an ambient temperature of 104 degrees F , with an insulation level of at least Class F .

2.2 COMPONENTS

2.2.1 Motor Housing

Provide a smooth surface motor housing in the vertical, horizontal, and axial directions at each bearing housing for attaching a magnet mounted accelerometer in order to monitor the motor vibration. Ensure the smooth surface is on the bearing housing, with the axial surface as close to the motor centerline as possible. Provide a motor housing with a surface finish of 63 micro-inch minimum, corrosion resistant, with a minimum diameter finished surface of 2 inch. As an option sound disks with a minimum thickness of 3/8 inch can be used to meet the smooth surface requirement.

Ensure surface is level within 1 degree or 0.001 inch.

Identify the smooth surface using a printed label or embossed plate stating "Vibration data collection point - Do Not Paint".

2.2.2 Motor Enclosures

2.2.2.1 Indoor Type Enclosures

For motors installed in indoor, clean, dry, non-hazardous locations, provide the following:

a. Open-type drip-proof enclosures

b. Hinged access cover, large enough to enable the placement of a magnet/accelerometer data collection instrument, at each vibration collection point

For motors installed in indoor, wet, non-hazardous locations, provide the following:

a. Open splash-proof enclosures

b. Hinged access cover, large enough to enable the placement of a magnet/accelerometer data collection instrument, at each vibration collection point

For motors installed in indoor, non-hazardous locations where it is necessary to protect the motor from dirt, moisture, chemical fumes, or other harmful ingredients in the surrounding atmosphere, provide either of the following type of enclosure:

a. Totally enclosed, not fan-cooled, enclosures not equipped for cooling by means external to the enclosing parts, with a hinged access cover at each vibration collection point, large enough to enable the placement of a magnet/accelerometer data collection instrument.

b. Totally enclosed fan-cooled enclosures for exterior cooling by means of a fan or fans integral with the machine but external to the enclosing parts, with a hinged access cover at each vibration collection point, large enough to enable the placement of a magnet/accelerometer data collection instrument.

2.2.2.2 Outdoor Type Enclosures

For motors installed in outdoor, non-hazardous locations, provide waterproof enclosures.

Provide all motors with weatherproof/waterproof enclosures with permanent accelerometers installed in the horizontal, vertical, and axial directions. Ensure the enclosure has a penetration installed to enable the accelerometer cables to be routed to outside the enclosure. Include a NEMA 4R rated data collection box mounted to the outside of the motor enclosure in a location that is easily accessible.

2.2.2.3 Hazardous Type Enclosures

For motors installed in hazardous locations for Classification I, Division 1 or 2, meet or exceed the minimum requirements of NFPA 70, Article 501.8, using hazard type enclosure for the class and group of hazard in which the motors are located. Ensure motor is approved by the Contracting Officer prior to fabrication.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Factory test all motors in accordance with the requirements of NEMA MG 1. Ensure polyphase induction motors are factory-tested in accordance with IEEE 112, Method B, consisting of measurements of voltage, frequency, speed, and current under no-load conditions; voltage, frequency, and current under locked-rotor conditions; and efficiency, noise, power factor, and thermal protection. Verify routine tests on wound-rotor induction motors include the measurement of wound-rotor open-circuit voltage across the slip rings under locked-rotor conditions. Provide written documentation of electrical tests including winding resistance, insulation resistance, and high-potential tests. Submit certified copies of factory test results for approval prior to shipment from the factory. Previous test reports on identical motors are not acceptable for these tests.

PART 3 EXECUTION

3.1 INSTALLATION

Install, align, and connect motors in accordance with the equipment manufacturer's instructions.

Mount motors with bolts. Ensure motor feet are coplanar within 0.001 inch, and base mounting points are accessible and adjustable to enable machine alignment. Install alignment jack bolts for motors over 7.5 hp to enable alignment.

3.1.1 Alignment

Before attempting alignment, demonstrate that the load does not have any load/force imposed by the piping system. Minimum alignment values (below) are for motor and load at normal running temperatures. Ensure values are compensated for thermal growth. Correct limited movement of the motor or load (commonly known as bolt-bound) to ensure alignment capability. Do not undercut hold down bolts in order to perform adjustment.

Provide commercially die-cut shims, without seams or folds, made of corrosion resistant stainless steel. Use no more than four shims at any single point.

Align motor and load to the following minimum specifications:

Speed(RPM)	Close-Coupled Offset (mils)	Close-Coupled Angle(mils/in.)	Spool Piece Angle (mils/in. @ coupling pt.)
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5
7200	1.0	0.3	0.4

Perform motor and load alignment under the direction of the manufacturer's representative.

Recheck alignment of motors and adjust as required after the motor has been in operation for not less than 48 hours.

Provide written final alignment settings as part of the final test data.

3.2 FIELD QUALITY CONTROL

Submit Field Test Report containing results of all tests and checks contained in paragraphs entitled "Electrical Tests" and "Vibration Tests". Catalog and bind results. Submit to the Contracting Officer before Final Acceptance.

3.2.1 Electrical Tests

Perform continuity test on all phases.

Perform insulation resistance and polarization index test on each phase of motor. Conduct insulation tests on 480-volt and 600-volt motors using a 1000-volt insulation test set. For insulation tests on motors rated less than 480-volts, use a 500-volt insulation test set.

Include in test data the location and identification of motors and megohm readings versus time. Record test data at 15, 30, 45 seconds, and in 1 minute increments not to exceed 10 minutes. Ensure Megohm readings are not less than 25 megohms for each phase; and each phase reading is within 10 percent of the other two.

Perform inspections and test procedures on all motors in accordance with NETA ATS and NETA MTS 7.15.1 for rotating machinery, AC motors.

Calculate the polarization index of each phase by dividing the 10 minute reading by the 1 minute reading. Verify that the polarization index is less than 1.25. Reject any lower values and return the motor to the factory.

3.2.2 Vibration Tests

3.2.2.1 Vibration Analyzer

To measure vibration levels, use a Fast Fourier Transformer (FFT) analyzer having the following characteristics:

a. A dynamic range greater than 70 dB; a minimum of 400 line resolution

b. A frequency response range of 5 Hz-10 KHz(300-600000 cpm)

c. The capacity to perform ensemble averaging

d. The capability to use a Hanning window

e. Auto-ranging frequency amplitude

f. A minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB

Use an accelerometer, either stud-mounted or mounted using a rare earth, low mass magnet and sound disk (or finished surface) with the FFT analyzer to collect data. Ensure the mass of the accelerometer and its mounting have minimal influence on the frequency response of the system over the selected measurement range.

3.2.2.2 Vibration Data

Collect vibration data in the axial, vertical, and horizontal direction for each motor bearing.

Obtain two narrowband spectra for each data collection point in the following manner:

a. For all machines regardless of operating speed, obtain a 5 to 500 Hz spectrum with a minimum of 400 lines of resolution.

b. Acquire an additional spectrum of 5 to 2500 or 5 to 5000 Hz for machines operating at or below 1800 RPM or greater than 1800 RPM, respectively.

Ensure vibration limits conform to the following:

Frequency Range(CPM)	Vibration limit(inch/sec)
0.3 x RPM to 0.8 x RPM	0.04
0.8 x RPM to 1.2 x RPM	0.75
1.2 x RPM to 3.5 x RPM	0.04

Frequency Range(CPM)	Vibration limit(inch/sec)
3.5 x RPM to 120,000cpm	0.03

3.3 CLOSEOUT ACTIVITIES

3.3.1 Operation and Maintenance

Submit manufacturer's operating and maintenance manual to the Contracting Officer no later than 10 days prior to final acceptance.

Submit manufacturer's instructions for Low-Voltage Motors including special provisions required to install equipment components and system packages. Include all special notices regarding detail impedances, hazards and safety precautions.

3.3.2 Warranty

Submit manufacturer's warranty to the Contracting Officer no later than 10 days prior to final acceptance.

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SECTION 27 05 28.36 40

CABLE TRAYS FOR COMMUNICATIONS SYSTEMS
05/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A1008/A1008M	(2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA VE 2	(2018; ERTA 1-2 2018) Cable Tray Installation Guidelines

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Pre-Installation Meetings

The Contracting Officer will schedule a pre-installation meeting within 30 days of contract award. Submit fabrication drawings for review and approval.

Submit manufacturer's product data for the following items:

a. Cable Trays

b. Supports

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings; G

Installation Drawings; G

SD-03 Product Data

Cable Trays; G

Supports; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.4 QUALITY CONTROL

Comply with NEMA VE 1.

Comply with NEC, requirements that apply to the construction and installation of cable tray and cable channel systems (Article 392 NEC).

Provide products that are UL-classified and labeled with the UL classification mark.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide ladder cable trays consisting of two longitudinal side members connected by individual transverse members.

2.2 FABRICATION

Submit fabrication drawings for cable trays. Ensure the drawings contain details showing the fabrication and assembly details performed in the factory.

Before assembly, use an antioxidant compound to coat the contact surfaces of trays. Ensure that the finishes of edges, fittings, and hardware are free from burrs and sharp edges. Include splice and end plates, dropouts, and miscellaneous hardware.

2.3 COMPONENTS

2.3.1 Supports

Permit both vertical and horizontal adjustment, where possible on supports and hangers. Provide an adequate bearing surface for the tray on the horizontal and vertical tray supports, and ensure that the surface can accommodate holddown clamps or fasteners. Provide a means, other than friction, for securely fastening cable trays to supports.

Provide support for cable trays at intervals of no more than 6 -foot. Place supports for horizontal-elbow tray fittings within 2 -feet of each fitting extremity and as recommended by the cable tray manufacturer.

Ensure that the cable trays can carry at least 150 pounds per linear foot when supported at 6 -foot intervals. Ensure that the tray fittings have a load-carrying capacity that is equal to or greater than that of straight tray sections. Ensure that the radius of tray fittings is based on the minimum bending radius of the cables, as specified by the cable manufacturer.

2.4 MATERIALS

Provide cable trays constructed of high-strength corrosion-resistant aluminum Alloy No. 5052-H32 or steel in accordance with ASTM A1008/A1008M and that has a zinc coating which was applied after fabrication.

Provide hot-dipped galvanized steel trays with a finish in accordance with ASTM A123/A123M.

PART 3 EXECUTION

Comply with NEMA VE 2 for cable tray installation.

3.1 INSTALLATION

3.1.1 Manufacturer's Instructions

Submit the manufacturer's instructions for cable trays, including special provisions required to install equipment components and system packages. Ensure that the instructions specify impedances, hazards and safety precautions.

3.1.2 Installation Drawings

No later than 30 calendar days before shipment, submit installation drawings to the Contracting Officer for approval. Coordinate drawings with those being used for all other work in the immediate area to ensure that this other work does not conflict with the installation. Include the layout of the cable tray work and details on both horizontal and vertical supports as specified in the paragraph SUPPORTS.

3.1.3 Grounding

Provide properly grounded cable trays by means that has a low-resistance conductor of sufficient capacity, and that is no smaller than No. 1/0 AWG copper. Bond the grounding conductor to cable tray sections and fittings by compatible bolted connections. Consider cable tray sections in tandem assembly as having electrical continuity when these sections are bonded with appropriate high-strength bolts. Provide permanent and continuous effective grounding with an impedance that is low enough to limit the potential above ground and to facilitate operation of overcurrent devices in the circuit. Provide grounding and bonding for cable trays in accordance with NFPA 70.

-- End of Section --

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SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM
08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596	(2021) Indoor Optical Cable
ICEA S-90-661	(2021) Category 3 and 5E Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in General Purpose and LAN Communications Wiring Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568	(2006) Standard for Installing Building Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66	(2019) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-21	(1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices
TIA-526-7	(2015a; R 2022) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC 61280-4-2 edition 2: Fibre-Optic Communications Subsystem Test Procedures - Part 4-2: Installed Cable Plant - Single-Mode Attenuation and Optical Return Loss Measurement
TIA-526-14	(2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-568.0	(2020e) Generic Telecommunications Cabling for Customer Premises
TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-568.2	(2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568.3	(2016d; Add 1 2019) Optical Fiber Cabling Components Standard
TIA-569	(2019e) Telecommunications Pathways and Spaces
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-1152	(2016; R 2021) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding
TIA/EIA-604-3	(2004b; R 2014) Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 444	(2017; Reprint Jun 2021) UL Standard for Safety Communications Cables
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1286	(2008; Reprint Apr 2021) UL Standard for Safety Office Furnishings
UL 1666	(2007; Reprint Sep 2021) UL Standard for Safety Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1863	(2004; Reprint Oct 2019) UL Standard for Safety Communication Circuit Accessories

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 82 00 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP), apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, TIA-606 and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.6 Equipment Room (ER) (Telecommunications)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star. Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for

Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Drawings; G

Telecommunications Space Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Telecommunications Cabling (backbone and horizontal); G

Patch Panels; G

Telecommunications Outlet/Connector Assemblies; G

Equipment Support Frame; G,

Connector Blocks; G

Spare Parts; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications Cabling Testing; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test Plan; G

SD-09 Manufacturer's Field Reports

Factory Reel Tests; G

SD-10 Operation and Maintenance Data

Telecommunications Cabling and Pathway System Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

In exception to Section 01 33 00 SUBMITTAL PROCEDURES, submitted plan drawings shall be a minimum of 11 by 17 inches in size using a minimum scale of 1/8 inch per foot, except as specified otherwise. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide registered communications distribution designer (RCDD) approved, drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, BD's, and FD's to the telecommunications work area outlets. The following drawings shall be provided as a minimum:

a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.

b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable Identification (ID’S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, access points and detail call outs for common equipment rooms and other congested areas.

c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT). Detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.1.2 Telecommunications Space Drawings

Provide T3 drawings in accordance with TIA-606 that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, rack, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with TIA-568.1, TIA-568.2 and TIA-568.3.

1.6.3 Test Plan

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the components and accessories for each cable type specified, 60 days prior to the proposed test date. Include procedures for certification, validation, and testing.

1.6.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system, Data Package 5. Submit operations and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data Package 5, include the requirements of paragraphs TELECOMMUNICATIONS DRAWINGS, TELECOMMUNICATIONS SPACE DRAWINGS, and RECORD DOCUMENTATION. Ensure that these drawings and documents depict the as-built configuration.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided in hard copy format Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

1.10.3 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking.

PART 2 PRODUCTS

2.1 COMPONENTS

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286.

2.3 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568.0, TIA-568.1, TIA-568.2, TIA-568.3 and NFPA 70. Provide a labeling system for cabling as required by TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for for unshielded twisted pair (UTP) in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.1 Backbone Cabling

2.3.1.1 Backbone Copper

Copper backbone cable shall be solid conductor, 24 AWG, 100 ohm, 100 -pair, Category 3, UTP, in accordance with ICEA S-90-661, TIA-568.1, TIA-568.2 and UL 444, formed into 25 pair binder groups covered with a gray thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular length marking intervals in accordance with ICEA S-90-661 . Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG)communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70.

2.3.1.2 Backbone Optical Fiber

Provide in accordance with ICEA S-83-596, TIA-568.3, UL 1666 and NFPA 70. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches.

Provide the number of strands indicated, (but not less than 12 strands between the main telecommunication room and each of the other telecommunication rooms), of single-mode(OS1), tight buffered fiber optic cable.

Provide tight buffered fiber optic multimode, cable as indicated.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

Provide plenum (OFNP) riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

2.3.2 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568.1.

2.3.2.1 Horizontal Copper

Provide horizontal copper cable, UTP, 100 ohm in accordance with TIA-568.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661 . Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6, with a blue thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG) communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70.

2.3.2.2 Horizontal Optical Fiber

Provide optical fiber horizontal cable in accordance with ICEA S-83-596and TIA-568.3. Cable shall be tight buffered, single-mode, 8/125-um diameter, OS1. Cable shall be imprinted with manufacturer, flammability rating and fiber count at regular intervals not to exceed 40 inches.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70.Cables installed in conduit within and under slabs be UL listed and labeled for wet locations in accordance with NFPA 70. The cable jacket shall be of single jacket construction with color coding of cordage jacket, fiber, unit, and group in accordance with TIA/EIA-598.

2.3.3 Work Area Cabling

2.3.3.1 Work Area Copper

Provide work area copper cable in accordance with TIA-568.2, with a blue, thermoplastic jacket.

2.3.3.2 Work Area Optical Fiber

Provide optical work area cable in accordance with TIA-568.3.

2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment rooms to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

2.4.1 Backboards

Provide void-free, interior grade A-C plywood 3/4 inch thick 4 by 8 feet . Backboards shall be fire rated by manufacturing process. Fire stamp shall be clearly visible. Backboards shall be provided on a minimum of two adjacent walls in the telecommunication spaces.

2.4.2 Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E and UL 50.

a. Bracket, wall mounted, 8 gauge aluminum. Provide hinged bracket compatible with 19 inches panel mounting.

b. Racks, floor mounted modular type, 11 gauge aluminum construction, minimum, treated to resist corrosion. Provide rack with vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a surge protected power strip with 6 duplex 20 amp receptacles. Rack shall be compatible with 19 inches panel mounting.

c. Cabinets, freestanding modular type, 16 gauge steel construction, minimum, treated to resist corrosion. Cabinet shall have removable and lockable side panels, front and rear doors, and have adjustable feet for leveling. Cabinet shall be vented in the roof and rear door. Cabinet shall have cable access in the roof and base and be compatible with 19 inches panel mounting. Provide cabinet with grounding bar, roof mounted 550 CFM fan with filter and a surge protected power strip with 6 duplex 20 amp receptacles. All cabinets shall be keyed alike.

d. Cabinets, wall-mounted modular type, 16 gauge steel construction, minimum, treated to resist corrosion. Cabinet shall have have lockable front and rear doors, louvered side panels, 250 CFM roof mounted fan, ground lug, and top and bottom cable access. Cabinet shall be compatible with 19 inches panel mounting. All cabinets shall be keyed alike. A surge protected power strip with 6 duplex 20 amp receptacles shall be provided within the cabinet.

2.4.3 Connector Blocks

Provide insulation displacement connector (IDC) Type 110 for Category 6 systems. Provide blocks for the number of horizontal and backbone cables terminated on the block plus 25 percent spare.

2.4.4 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19 inches equipment racks cabinets and telecommunications backboards. Cable guides of ring or bracket type devices for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, or nuts and lockwashers.

2.4.5 Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized optical fiber and copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568.3. Patch cords shall meet minimum performance requirements specified in TIA-568.1, TIA-568.2 and TIA-568.3 for cables, cable length and hardware specified.

2.4.5.1 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568.1 and TIA-568.2. Panels shall be third party verified and shall comply with EIA/TIA Category 6 requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be cabinet, rack or wall mounted and compatible with an ECIA EIA/ECA 310-E 19 inches equipment rack. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568A or T568B. Patch panels shall terminate the building cabling on Type 110 IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2.4.5.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 16 gauge steel minimum and shall be cabinet, rack or wall mounted and compatible with a ECIA EIA/ECA 310-E 19 inches equipment rack. Each panel shall provide multimode and single-mode adapters as duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic alignment sleeves. Provide dust cover for unused adapters. The rear of each panel shall have a cable management tray a minimum of 8 inches deep with removable cover, incoming cable strain-relief and routing guides. Panels shall have each adapter factory numbered and be equipped with laminated plastic nameplates above each adapter.

2.4.6 Optical Fiber Distribution Panel

Cabinet, Rack or Wall mounted optical fiber distribution panel (OFDP) shall be constructed in accordance with ECIA EIA/ECA 310-E utilizing 16 gauge steel or 11 gauge aluminum minimum. Panel shall be divided into two sections, distribution and user. Distribution section shall have strain relief, routing guides, splice tray and shall be lockable, user section shall have a cover for patch cord protection. Each panel shall provide multimode and single-mode pigtails and adapters. Provide adapters as duplex SC with zirconia ceramic alignment sleeves. Provide dust covers for adapters. Provide patch cords as specified in the paragraph PATCH PANELS.

2.5 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.5.1 Outlet/Connector Copper

Outlet/connectors shall comply with FCC Part 68, TIA-568.1, and TIA-568.2. UTP outlet/connectors shall be UL 1863 listed, non-keyed, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with TIA-568.2 Category 6 requirements. Outlet/connectors provided for UTP cabling shall meet or exceed the requirements for the cable provided. Outlet/connectors shall be terminated using a Type 110 IDC PC board connector, color-coded for both T568A and T568B wiring. Each outlet/connector shall be wired T568A or T568Bas indicated. UTP outlet/connectors shall comply with TIA-568.2 for 200 mating cycles. UTP outlet/connectors installed in outdoor or marine environments shall be jell-filled type containing an anti-corrosive, memory retaining compound.

2.5.2 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex SC in Accordance with TIA/EIA-604-3 with zirconia ceramic alignment sleeves, as indicated. Provide dust cover for adapters. Optical fiber adapters shall comply with TIA-455-21 for 500 mating cycles.

2.5.3 Optical Fiber Connectors

Provide in accordance with TIA-455-21. Optical fiber connectors shall be duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic ferrule, epoxyless crimp style compatible with 62.5/12550/125 multimode 8/125 single-mode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 1300 1310 1550 nm with less than a 0.2 dB change after 500 mating cycles.

2.5.4 Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568.1, , TIA-568.3; flush design constructed of to match color of receptacle/switch cover plates specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

Provide labeling in accordance with the paragraph LABELING in this section.

2.6 MULTI-USER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

Provide MUTOA(s) in accordance with TIA-568.1.

2.7 TERMINAL CABINETS

Construct of zinc-coated sheet steel,as indicated. Trim shall be fitted with hinged door and locking latch. Doors shall be maximum size openings to box interiors. Boxes shall be provided with 5/8 inch backboard with two-coat varnish finish. Match trim, hardware, doors, and finishes with panelboards. Provide label and identification systems for telecommunications wiring and components consistent with TIA-606.

2.8 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, TIA-607, and NFPA 70. Components shall be identified as required by TIA-606. Provide ground rods, bonding conductors, and grounding busbars as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.9 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING.

2.10 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.11 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inches thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inches high normal block style.

2.12 TESTS, INSPECTIONS, AND VERIFICATIONS

2.12.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA-568.1, TIA-568.2, TIA-568.3, TIA-526-7 for single mode optical fiber cables.

PART 3 EXECUTION

3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with

NECA/BICSI 568, TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, NFPA 70, and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling. Cabling shall be run with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

3.1.1 Cabling

Install UTP, and optical fiber telecommunications cabling system as detailed in TIA-568.1, TIA-568.2, TIA-568.3. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 25 pounds pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Open Cable

Use only where specifically indicated on plans for use in cable trays, or below raised floors. Install in accordance with TIA-568.1, TIA-568.2 and TIA-568.3. Do not exceed cable pull tensions recommended by the manufacturer. Copper cable not in a wireway or pathway shall be suspended a minimum of 8 inches above ceilings by cable supports no greater than 60 inches apart. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 12 inches shall be maintained when such placement cannot be avoided.

Plenum cable shall be used where open cables are routed through plenum areas. Cable routed exposed under raised floors shall be plenum rated. Plenum cables shall comply with flammability plenum requirements of NFPA 70. Install cabling after the flooring system has been installed in raised floor areas. Cable 6 feet long shall be neatly coiled not less than 12 inches in diameter below each feed point in raised floor areas.

3.1.1.2 Backbone Cable

a. Copper Backbone Cable. Install intrabuilding backbone copper cable, in indicated pathways, between the campus distributor, located in the telecommunications entrance facility or room, the building distributors and the floor distributors located in telecommunications rooms and telecommunications equipment rooms as indicated on drawings.

b. Optical fiber Backbone Cable. Install intrabuilding backbone optical fiber in indicated pathways. Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket 10 inches leaving strength members exposed for approximately 10 inches. Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be in accordance with manufacturer's recommendations.

3.1.1.3 Horizontal Cabling

Install horizontal cabling as indicated on drawings Do not untwist Category 6 UTP cables more than one half inch from the point of termination to maintain cable geometry. Provide slack cable in the form of a figure eight (not a service loop) on each end of the cable, 10 feet in the telecommunications room, and 12 inches in the work area outlet.

3.1.2 Pathway Installations

Provide in accordance with TIA-569 and NFPA 70. Provide building pathway as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.3 Service Entrance Conduit, Overhead

Provide service entrance overhead as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEMS.

3.1.4 Service Entrance Conduit, Underground

Provide service entrance underground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.5 Cable Tray Installation

Install cable tray as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Only CMP and OFNP type cable shall be installed in a plenum.

3.1.6 Work Area Outlets

3.1.6.1 Terminations

Terminate UTP cable in accordance with TIA-568.1, TIA-568.2 and wiring configuration as specified. Terminate fiber optic cables in accordance with TIA-568.3.

3.1.6.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

3.1.6.3 Cables

Unshielded twisted pair and fiber optic cables shall have a minimum of 12 inches of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.6.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.6.5 Multi-User Telecommunications Outlet Assembly (MUTOA)

Run horizontal cable in the ceiling or underneath the floor and terminate each cable on a MUTOA in each individual zone. MUTOAs shall not be located in ceiling spaces, or any obstructed area. MUTOAs shall not be installed in furniture unless that unit of furniture is permanently secured to the building structure. MUTOAs shall be located in an open work area so that each furniture cluster is served by at least one MUTOA. The MUTOA shall be limited to serving a maximum of twelve work areas. Maximum work area cable length requirements shall also be taken into account. MUTOAs must be labeled to include the maximum length of work area cables. MUTOA labeling is in addition to the labeling described in TIA-606, or other applicable cabling administration standards. Work area cables extending from the MUTOA to the work area device must also be uniquely identified and labeled.

3.1.7 Telecommunications Space Termination

Install termination hardware required for Category 6 and optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.7.1 Connector Blocks

Connector blocks shall be cabinet, rack or wall mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

3.1.7.2 Patch Panels

Patch panels shall be mounted in equipment cabinets, racks or on the plywood backboard with sufficient ports to accommodate the installed cable plant plus 25 percent spares.

a. Copper Patch Panel. Copper cable entering a patch panel shall be secured to the panel with cable ties to prevent movement of the cable.

b. Fiber Optic Patch Panel. Fiber optic cable loop shall be 3 feet in length. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.1.7.3 Equipment Support Frames

Install in accordance with TIA-569:

a. Bracket, wall mounted. Mount bracket to plywood backboard in accordance with manufacturer's recommendations. Mount rack so height of highest panel does not exceed 78 inches above floor.

b. Racks, floor mounted modular type. Permanently anchor rack to the floor in accordance with manufacturer's recommendations.

c. Cabinets, freestanding modular type. When cabinets are connected together, remove adjoining side panels for cable routing between cabinets. Mount rack mounted fan in roof of cabinet.

d. Cabinets, wall-mounted modular type. Mount cabinet to plywood backboard in accordance with manufacturer's recommendations. Mount cabinet so height of highest panel does not exceed 78 inches above floor.

3.1.8 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.9 Grounding and Bonding

Provide in accordance with TIA-607, NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.2 LABELING

3.2.1 Labels

Provide labeling in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process or laser printer .

3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA-606.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3.1 Painting Backboards

If backboards are required to be painted, then the manufactured fire retardant backboard must be painted with fire retardant paint, so as not to increase flame spread and smoke density and must be appropriately labeled. Label and fire rating stamp must be unpainted.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 TESTING

3.5.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568.1, TIA-568.2, TIA-568.3. Test equipment shall conform to TIA-1152. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

3.5.1.1 Inspection

Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A or T568B pin assignments, and inspect cabling connections to confirm compliance with TIA-568.1, TIA-568.2, TIA-568.3, . Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.

3.5.1.2 Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but prior to being cross-connected.

For multimode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568.3 and TIA-526-14 using Method A, Optical Power Meter and Light Source for multimode optical fiber. Perform verification acceptance tests.

3.5.1.3 Performance Tests

Perform testing for each outlet and MUTOA as follows:

a. Perform Category 6 link tests in accordance with TIA-568.1 and TIA-568.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.

b. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568.3.

3.5.1.4 Final Verification Tests

Perform verification tests for UTP and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed.

a. Voice Tests. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.

b. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

SECTION 27 21 10.00 40

FIBER OPTIC DATA TRANSMISSION SYSTEM
11/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

ANSI/TIA-455-80C	(2003) FOTP-80 - IEC 60793-1-144 Optical fibres Part 1-44: Measurement Methods and Test Procedures - Cut-off Wavelength

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232	(1997f; R 2012) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

TIA-455-13	(1996a; R 2012) FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
TIA-455-58	(2001b) FOTP-58 Core Diameter Measurement of Graded-Index Optical Fibers
TIA-455-78-B	(2020c) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-455-82	(2020c) FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
TIA-455-91	(1986; R 1996) FOTP-91 Fiber Optic Cable Twist-Bend Test
TIA-455-104	(2016b) Standard for FOTP-104 Fiber Optic Cable Cyclic Flexing Test
TIA-455-177	(2020c) FOTP-177 IEC-60793-1-43: Measurement Methods and Test Procedures - Numerical Aperture
TIA-485	(1998a; R 2012) Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA/EIA-455-25	(2016d) FOTP-25 Impact Testing of Optical Fiber Cables
TIA/EIA-455-41	(1993a; R 2013) FOTP-41 Compressive Loading Resistance of Fiber Optic Cables
TIA/EIA-455-81	(2000b) FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable
TIA/EIA-455-88	(2001) FOTP-88 Fiber Optic Cable Bend Test
TIA/EIA-455-171	(2001a) FOTP-171 - Attenuation by Substitution Measurement for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1666	(2007; Reprint Sep 2021) UL Standard for Safety Test for Flame Propagation Height

of Electrical and Optical-Fiber Cables
Installed Vertically in Shafts

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fiber Optic System; G

Installation; G

SD-03 Product Data

Fiber Optic System; G

Spare Parts; G

Enclosures; G

Data Transmission Converters; G

SD-06 Test Reports

Test Procedures and Reports

Power Attenuation Test

Analog Video Signal Test

Digital Video Signal Test

Optical Time Domain Reflectometer Tests

SD-07 Certificates

Fiber Optic System

Optic Cable Assemblies

Labeling Format

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

Manufacturer's Recommendations

SD-10 Operation and Maintenance Data

Operating Instructions

1.3 MAINTENANCE MATERIAL SUBMITTALS

1.3.1 Spare Parts

Submit spare parts data for each different item of material and equipment specified and furnished, after approval of detail drawings not later than 2 months prior to the date of beneficial occupancy. Include a list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 year of service.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a fiber optics (FO) data transmission system (DTS). The data transmission system consists of FO transmission media, transmitter and receiver modules, modems, transceiver modules, repeaters, cable and power line surge protection, terminal devices (such as connectors, patch panels and breakout boxes) and power supplies for operating active components. Interconnect the data transmission system system components as shown. Certify that computing devices comply with the requirements for Class A computing devices and are labeled as set forth in 47 CFR 15.

2.1.1 Environmental Requirements

Rate equipment and cable used indoors for continuous operation under ambient environmental conditions of 32 to 122 degrees F dry bulb and 10 to 95 percent relative humidity, non-condensing. Rate equipment and cables for continuous outdoor operation under ambient environmental conditions of minus 40 to plus 166 and humidity of up to 100 percent condensing or as normally encountered for the installed location. Rate all equipment and cable for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location. Install cables in ducts, plenums, and other air-handling spaces per NFPA 70. Ensure cables installed in plenums are plenum-rated cables listed for the use. Ensure cables installed in risers are riser-rated cables listed for the use, unless the installed cable is identified as a permitted substitution for the required riser-rated cable type.

2.1.2 Hazardous Environment

Rate the system components and wiring located in areas where fire or explosion hazards may exist with the proper Classes, Divisions, and Groups. Also rate the components and wiring for the operating temperatures. Install according to Chapter 5 of NFPA 70 and as shown.

2.1.3 Electrical Requirements

Operate the equipment from a voltage source as shown, plus or minus 10 percent, and 60 Hz, plus or minus 2 percent.

2.1.4 Input Line Surge Protection

Protect inputs and outputs against surges induced on wiring and cables including wiring and cables installed outdoors. For components requiring protection, select surge protection devices based on voltages and current ratings of components to be protected. Protect communications equipment against surges induced on any communications circuit. Install surge protection circuits at each end of cables and conductors (except non-conductive FO cables which serve as communications circuits from consoles to field equipment and between field equipment). Furnish protection at equipment. Install additional triple electrode gas surge protectors rated for the application on each conductive wire line and coaxial circuit within 3-feet of the building cable entrance. Do not use fuses for surge protection. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

2.1.5 Power Line Surge Protection

Protect equipment connected to AC circuits from power line surges. Select surge protection devices based on voltages and current ratings of components to be protected. Provide equipment that meets the requirements of IEEE C62.41.1 and IEEE C62.41.2. Do not use fuses for surge protection.

2.2 COMPONENTS

2.2.1 FO Modems

Select FO modems to meet FO system requirements. Ensure the modems allow full duplex, asynchronous, point-to-point digital communication for the system being installed.

2.2.1.1 FO Modem Operating Wavelength

Center the operating wavelength on 850 1300 1550 nanometers (nm).

2.2.1.2 FO Modem Inputs and Outputs

Provide FO modems that accept inputs and provide outputs compatible with TIA-232 TIA-485 20 mA current loop T1 10 Base-F. Digital data rates through each link are 1.54 MBPS .

2.2.2 FO Transmitter And Receiver Modules

Ensure FO transmitter/receiver pairs have signal-to-noise power ratio of 40 dB or better after photo detection at the receiver. Transmitter power output and receiver sensitivity cannot drift more than plus or minus 2 dB over their operational life.

2.2.2.1 Analog FO Transmitter and Receiver Modules

Ensure FO transmitter/receiver pairs used to pass analog video signals accept inputs and provide outputs that have a bandwidth of 6 MHz or greater.

2.2.2.2 Digital FO Transmitter and Receiver Modules

Ensure FO transmitter/receiver pairs used to pass digital signals accept inputs and provide outputs compatible with TIA-232 TIA-485 20 mA current loop T1 10 Base-F. Digital data rates through each link are 1.54 MBPS . House FO transmitter and receiver modules in field equipment enclosures where possible . Provide FO transmitter and receiver modules compatible with each other, the FO cable, and connectors.

2.2.2.3 FO Transmitter Module

Provide a FO transmitter module that accepts electronic signals and modulates a light source. Couple the light source into an FO cable. Center the operating wavelength on 850 1300 and 1550 nanometers.

2.2.2.4 FO Receiver Module

Ensure the FO receiver module receives light from the FO cable and converts this light into an electronic signal identical to the electronic signal applied to the FO transmitter module. Ensure the operating wavelength is the same as the transmitter.

2.2.3 FO Digital Repeaters

Use FO digital repeaters to extend the range of the FO data transmission system when necessary to meet the requirements of paragraph SYSTEM REQUIREMENTS. For simplex circuits, the repeater consists of an FO receiver connected to an FO transmitter. For Duplex circuits, the repeater consists of a pair of FO receivers that are connected to a pair of FO transmitters. The FO receivers receive the optical signal and drive the transmitters. The transmitters regenerate the optical signal at the transmission rate specified. Ensure the FO repeater is mechanically and optically compatible with the remainder of the FO system.

2.2.4 FO Analog Repeaters

Use FO analog repeaters to extend the range of the FO data transmission system when necessary to meet the requirements of paragraph SYSTEM REQUIREMENTS. For simplex circuits, the repeater consists of an FO receiver connected to an FO transmitter. For duplex circuits, the repeater consists of a pair of FO receivers that are connected to a pair of FO transmitters. The FO receivers receives the optical signal and drive the transmitters. Ensure the FO repeater is mechanically and optically compatible with the remainder of the FO system.

2.2.5 Transceivers for Video Applications

Provide FO Transceivers that allow bi-directional signal transmission on a single fiber. The operating wavelength in one direction is 1300/850 nanometers, while in the opposite direction, 850/1300 nanometers. Crosstalk attenuation between channels is 40 dB or greater. Select FO transceivers to match or exceed the highest data rate of attached input devices. Ensure the FO transceiver is mechanically and optically compatible with the remainder of the FO system.

2.2.6 Transceivers for Lan Applications

Provide transceivers for FO LAN applications that are active units, and compatible with the LAN cards, modems and repeaters used in the system. Provide indicators for power, collision detection, receive, transmit, and status. Derive power for transceivers from the Attachment Unit Interface (AUI) port of LAN equipment or from a dedicated power supply. Ensure transceiver loss characteristics are less than 1.0 db. Provide low loss connectors that are compatible with LAN equipment. Include circuitry so when a device is disconnected, other devices on the LAN continue to operate without any disruption.

2.2.7 FO Switches

Provide single pole, double throw FO switches with switching speed less than 15 milliseconds, and insertion loss less than 1.5 dB. Provide crosstalk attenuation between FO outputs at 40 dB or greater. FO switches are latching or nonlatching, as shown.

2.2.8 FO Splitter/Combiner

For FO splitter/combiner units, provide full-duplex communications in a multi-point configuration. Ensure each unit has one input port module and up to four output port modules. Ensure FO splitter/combiner units are mechanically and optically compatible with the remainder of the FO system. The splitter/combiner allows a mixed configuration of port module operating wavelengths and single-mode or multimode FO cables. Ensure each port module has a separate FO cable input and output. Connect port modules using an electronic data bus. Port module FO transmitters regenerate the optical signal at the transmission rate specified. Rack mount port modules in a 19-inch rack complying with ECIA EIA/ECA 310-E. Ensure the total propagation delay through the splitter/combiner is less than 100 nanoseconds.

2.2.9 Fiber Optic Digital Repeaters (FODR)

FODRs combine the features specified for Fiber Optic Digital Repeaters and Local Area Network (LAN) transceivers. FODRs regenerate the optical signal at the transmission rate specified. Ensure the FODRs are mechanically and optically compatible with the remainder of the Fiber Optic System. Ensure FODRs restore the optical signals amplitude, timing and waveform and provide an electrical interface to the transmission media. Ensure the electrical interface is identical to all other network interfaces as specified.

Submit a manufacturer's certificate of the Fiber Optic System indicating compliance with transmission and reliability requirements. Where equipment or materials are specified to conform to the standards or publications and requirements of CFR, ANSI,IEEE, NEMA, NFPA, EIA, or UL, furnish certificates attesting that the items identified conform to the specified requirements.

2.2.10 Data Transmission Converter

Use data transmission converters to connect equipment using TIA-485 data transmission when necessary and as shown. Install converters that operate full duplex and support two wire circuits at speeds up to 2 megabytes per second and have a built in 120 Ohm terminating resistor. Ensure converters are mechanically, electrically, and optically compatible with the system.

2.2.11 Enclosures

Ensure enclosures conform to the requirements of NEMA 250 for the types specified. Use the manufacturer's standard finish color, unless otherwise indicated. Repair and refinish damaged surfaces using original type finish.

2.2.11.1 Interior

Ensure the enclosures installed indoors meet the requirements of NEMA 250 Type 12 or as shown.

2.2.11.2 Exterior

Ensure enclosures installed outdoors meet the requirements of NEMA 250 Type 4 unless otherwise specified or shown.

2.2.11.3 Corrosive Environment

For enclosures in a corrosive environment, meet the requirements of NEMA 250, Type 4X.

2.2.11.4 Hazardous Environment

For enclosures installed in a hazardous environment, meet the requirements as specified in paragraph ENVIRONMENTAL REQUIREMENTS.

2.2.12 Tamper and Physical Protection Provisions

Provide enclosures and fittings of every description having hinged doors or removable covers that contain the FO circuits, connections, splices, or power supplies, with cover-operated, corrosion-resistant tamper switches, arranged to initiate an alarm signal when the door or cover is moved. Mechanically mount tamper switches to maximize the defeat time when enclosure covers are opened or removed. Ensure the enclosure and the tamper switch function together to not allow direct line of sight to any internal components and tampering with the switch or the circuits before the switch activates.

Ensure tamper switches are inaccessible until the switch is activated; have mounting hardware concealed so that the location of the switch cannot be observed from the exterior of the enclosure; are connected to circuits which are under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating; are spring-loaded and held in the closed position by the door cover; and are wired so that they break the circuit when the door or cover is disturbed.

Ensure tamper switches located in enclosures which open to make routine maintenance adjustments to the system and to service the power supplies are push/pull-set, automatic reset type.

2.2.12.1 Enclosure Covers

Covers of pull and junction boxes provided to facilitate installation of the system need not be provided with tamper switches if they contain no splices, connections or power supplies, but are protected by security screws to hold the covers in place. Affix zinc labels to such boxes indicating they contain no connections. Do not indicate with these labels that the box is part of a security system. Clean and repair damage to the enclosure or its cover's surface protection using the same type of surface protection as the original enclosure. Secure the conduit enclosures constructed of fiberglass with tamper proof security servers.

2.2.12.2 Conduit-Enclosure Connections

Protect conduit enclosure connections by tack welding or brazing the conduit to the enclosure. Apply tack welding or brazing in addition to standard conduit-enclosure connection methods as described in NFPA 70. Clean and repair any damage to the enclosure or its cover's surface protection using the same type of surface protection as the original enclosure. Secure conduit enclosures constructed of fiberglass with tamper proof security screws.

2.2.12.3 Locks and Key-Lock-Operated Switches

a. Locks

When locks are required, install UL listed locks on system enclosures for maintenance purposes, shall be UL listed, keyed and match to the base/post standard. Stamp keys U.S. GOVT. DO NOT DUP. Arrange the locks so that the key can only be withdrawn when in the locked position. Key all maintenance locks alike and furnish only two keys for all of these locks.

b. Key-Lock-Operated Switches

Install UL listed key-lock-operated switches when locks are required to be installed on system components, shall be UL listed, keyed and match to the base/post standard. Stamp keys U.S. GOVT. DO NOT DUP. Provide two position key-lock-operated switches, with the key removable in either position. Key all key-lock-operated switches differently and furnish only two keys for each key-lock-operated switch.

2.2.13 Optical Fibers

2.2.13.1 General

Coat optical fibers with a suitable material to preserve the intrinsic strength of the glass. The outside diameter of the glass-cladded fiber is nominally 125 microns, and concentric with the fiber core. Ensure optical fibers meet TIA-455-78-B, and TIA-455-177.

2.2.13.2 50 Micron Multimode Fibers

Use conductors that are multimode, graded index, solid glass waveguides with a nominal core diameter of 50 microns. Ensure the fiber has transmission windows centered at 850 and 1300 nanometer wavelengths, with a numerical aperture minimum of 0.20. The attenuation at 850 nanometers is 3.5 dB/Km or less. The attenuation at 1300 nanometers is 1.5 dB/Km or less. For both transmission windows, the minimum bandwidth is 500 MHz-Km. Certify the fibers to meet TIA/EIA-455-204 and TIA-455-58.

2.2.13.3 62.5 Micron Multimode Fibers

Use conductors that are multimode, graded index, solid glass waveguides with a nominal core diameter of 62.5 microns. Ensure the fiber has transmission windows centered at 850 and 1300 nanometer wavelengths, with a numerical aperture minimum of 0.275. The attenuation at 850 nanometers is 3.5 dB/Km or less. The attenuation at 1300 nanometers is 1.5 dB/Km or less. The minimum bandwidth is 160 MHz-Km at 850 nanometers and 500 MHz-Km at 1300 nanometers. Certify FO cable to meet TIA/EIA-455-204 and TIA-455-58.

2.2.13.4 8.3 Micron Single-Mode Fibers

Use conductors that are single-mode, solid glass waveguides with a nominal core diameter of 8.3 microns. Ensure the fiber has a transmission windows centered at 1310 and 1550 nanometer wavelengths with a numerical aperture minimum of 0.10. The attenuation for inside cable at 1310 and 1550 nanometers is 1.0 dB/Km or less. The attenuation for outside cable at 1310 and 1550 nanometers is 0.5 dB/Km or less. Certify the fibers to meet ANSI/TIA-455-80C.

2.2.14 Cross-Connects

2.2.14.1 Patch Panels

Install patch panels as a complete system of components by a single manufacturer; provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Ensure patch panel connectors and couplers are the same type and configuration as used elsewhere in the system. Patch panels are a 19-inch rack mount type or wall mounted .

2.2.14.2 Patch Cords

Provide patch cord cable assemblies consisting of factory connector-terminated flexible optical fiber cable with connectors of the same type as used elsewhere in the system. Optical fiber is the same type as used elsewhere in the system. Install patch cords as complete assemblies from manufacturer's standard products.

2.3 SYSTEM REQUIREMENTS

2.3.1 Signal Transmission Code Format

Ensure FO equipment uses the same transmission code format from the beginning of a circuit to the end of that circuit. Different transmission code formats may be used for different circuits as required to interconnect supported equipment.

2.3.2 Flux Budget/Gain Margin

Provide FO links with a minimum gain margin of 6 dB. The flux budget is the difference between the transmitter output power and the receiver input power required for signal discrimination when both are expressed in dBm. Ensure the flux budget is equal to the sum of losses (such as insertion losses, connector and splice losses, and transmission losses) plus the gain margin. When a repeater or other signal regenerating device is inserted to extend the length of an FO circuit, both the circuit between the transmitter and the repeater-receiver, and the circuit between the repeater-transmitter and the receiver are considered independent FO links for gain margin calculations.

2.3.3 Receiver Dynamic Range

Ensure the dynamic range of receivers is large enough to accommodate both the worst-case, minimum receiver flux density, and the maximum possible receiver flux density, with a range of at least 15 dB. Where required, use optical attenuators to force the FO link power to fall within the receiver dynamic range.

2.4 ACCESSORIES

2.4.1 FO Connectors

Use field installable, self-aligning and centering FO connectors. Match FO connectors with the fiber core and cladding diameters. Provide FO cable connectors at field equipment of the type to match the field equipment connectors . Provide FO connectors at terminal head end equipment of the type to match terminal head equipment connectors . Connector insertion loss is nominally 0.3 dB and maximum loss less than 0.7 dB.

2.4.2 Mechanical Splices

Mechanical splices are suitable for installation in the field. External power sources are not required to complete a mechanical splice. Use self-aligning mechanical splices for optimum signal coupling. Do not use mechanical splices for exterior applications where they may be buried underground or laced to aerial messenger cables. Mechanical splices may be used for interior locations and within enclosures. Protect the spliced fibers from moisture and prevent physical damage with splice closures. Use the splice closure to provide strain relief for the cable and the fibers at the splice points.

2.4.3 Fusion Splices

Use a portable, fully automatic, and compact fusion splicer, suitable for fusion splicing all types of telecommunication grade optical fibers and individual fibers as well as cables containing multiple optical fibers. Ensure the fusion splicer is capable of operation under various environmental conditions (e.g., temperature, humidity, altitude, etc.) for all types of optical cable deployments. Start the automatic splicing process by pressing one button and can be interrupted at any time. Alternatively, make available semi-automatic (step-by-step) or manual splicing by menu selection. Conduct communication with the fusion splicer through a language unspecific keyboard with universal symbols and display the dialogue with the splicer on the device screen.

2.4.4 Conduit, Fittings And Enclosures

Ensure conduit, fittings, and enclosures are as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and as shown.

2.4.5 Fan-Out Kits

For all loose-tube optical fibers, furnish and install fan-out kits using furcating tubes for connectorization. Incorporate strain relief for loose-tube optical fiber furcating tubes if the connectorization is not contained within a protective enclosure such as a patch panel. For tight-buffered optical fibers, furnish and install fan-out kits using furcating tubes and which incorporate strain relief, if the connectorization is not contained within a protective enclosure such as a patch panel. Furcating tubes required to incorporate strain relief also provide increased pullout protection. Tubes are comprised of an inner tube, surrounded by a layer of nonconductive strength members, then surrounded by an enclosing outer jacket layer. Color code fan-out kits to match the industry fiber color scheme. Length of furcating tube is 36-inches minimum when installation is complete. Rate fan-out kits for the ambient conditions of the location as specified in paragraph ENVIRONMENTAL REQUIREMENTS. Provide terminations for each fiber, regardless whether fiber is active or spare.

2.5 CABLE CONSTRUCTION

2.5.1 General

Ensure the cable contains a minimum of two FO fibers for each link circuit. The number of fibers in each cable is as shown. Protect each fiber by a protective tube. Ensure cables have a jacketed strength member, and an exterior jacket. Ensure cable and fiber protective covering are free from holes, splits, blisters, and other imperfections. Insulation and jacketing material for interior cables cannot contain any polyvinyl chloride (PVC) compounds. Use a covering that is flame retardant, moisture resistant, non-nutrient to fungus, ultraviolet light resistant as specified, and nontoxic. Do not transmit mechanical stress present in cable to the optical fibers. Ensure strength members are non-metallic and an integral part of the cable construction. Ensure the combined strength of all the strength members is sufficient to support the stress of installation and to protect the cable in service. For exterior cables, select a minimum storage temperature range of minus 104 to plus 167 degrees F. A minimum storage temperature of plus 14 to plus 167 degrees F is required for interior cables. Ensure all optical fiber cables and all optical fiber raceways furnished meet the requirement of NFPA 70. Apply a flooding compound into the interior of the fiber tubes, into the interstitial spaces between the tubes, to the core covering, and between the core covering and jacket of all cable to be installed aerially, underground, and in locations susceptible to moisture. Ensure flooded cables comply with TIA/EIA-455-81 and TIA-455-82. Provide cables from the same manufacturer, of the same cable type, of the same size, and of the same optical characteristics. Ensure each fiber and protective coverings is continuous with no factory splices. Certify by the manufacturer, optic cable assemblies, including jacketing and fibers, to have a minimum life of 30 years. Ensure cables meet UL 1666. Certify FO cable to meet the following: TIA-455-13, TIA/EIA-455-25, TIA/EIA-455-41, TIA-455-177, TIA-455-78-B, TIA/EIA-455-88, TIA-455-91, TIA-455-104, and TIA/EIA-455-171.

2.5.2 Exterior Cable

2.5.2.1 Aerial Cable

Surround the optical fibers by a tube buffer, contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Select cable with the following characteristics:

a. Cable outer jacket: Medium density polyethylene material containing at least 2.6 percent carbon black with only black pigment added for additional coloring.

b. Tensile strength: Withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

c. Impact and Crush resistance: Withstand an impact of 1.7 lbs/in as a minimum, and have a crush resistance of 317 psi as a minimum.

2.5.2.2 Duct Cable

Surround the optical fibers by a tube buffer, contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Select cable with the following characteristics:

a. Cable outer jacket: Medium density polyethylene material with orange pigment added for ease of identification.

b. Tensile strength: Withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

c. Impact and Crush resistance: Withstand an impact of 1.7 lbs/in as a minimum, and have a crush resistance of 317 psi as a minimum.

2.5.2.3 Direct Burial Cable

Surround the optical fibers by a tube buffer, contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Select cable with the following characteristics:

a. Cable outer jacket: Medium density polyethylene material containing at least 2.6 percent carbon black with only black pigment added for additional coloring.

b. Tensile strength: Withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

c. Impact and Crush resistance: Withstand an impact of 1.7 lbs/in as a minimum, and have a crush resistance of 317 psi as a minimum.

Protect direct burial cable with plastic coated steel armor. Apply the plastic coated steel armor longitudinally directly over an inner jacket and have an overlap of 0.20-inch minimum. Select armoring materials that provide corrosion protection from local environmental/soil conditions over the projected life of the cable.

2.5.3 Interior Cable

Loose buffer tube cable construction is such that the optical fibers are surrounded by a tube buffer, and contained in a channel or otherwise loosely packaged to provide clearance between the fibers and the inside of the container allowing for thermal expansions without constraining the fiber. Extrude the protective container from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Use fluorocopolymer (FCP) for the cable outer jacket, which complies with NFPA 70 for optical fiber nonconductive plenum (OFNP) applications. Do not exceed the manufacturers' recommended values for tensile strength, impact resistance, and crush resistance. Insulation and jacketing cable material cannot contain any polyvinyl chloride (PVC) compounds.

For tight buffer tube cable construction, use extrusion of plastic over each cladded fiber, with an outer jacket of FCP, which complies with NFPA 70 for optical fiber nonconductive riser (OFNR) requirements for riser cables and vertical shaft installations. Cover optical fibers in near contact with an extrusion tube and an intermediate soft buffer to allow for the thermal expansions and minor pressures. Do not exceed manufacturers' recommended values for tensile strength, impact resistance, and crush resistance. Insulation and jacketing cable material cannot contain any polyvinyl chloride (PVC) compounds.

2.5.4 Pigtail Cables

Use flexible fiber pigtail cables for connections to equipment having the same physical and operational characteristics as the parent cable. Ensure the cable jacket is FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cable is 3.5 dB/km at 850 nanometers, and 1.0 dB/km at 1300 nanometers, and dB/Km at 1550 nanometers.

PART 3 EXECUTION

3.1 INSTALLATION

Install system components and appurtenances in accordance with the manufacturer's instructions and as shown. Provide interconnections, services, and adjustments required for a complete and operable data transmission system.

Where installation procedures, or any part thereof, are required to be in accordance with the manufacturer's recommendations of the material being installed, submit printed copies of these recommendations prior to installation. Installation of the item is not allowed to proceed until the recommendations are received and approved.

3.1.1 Interior Work

Install conduits, tubing and cable trays for interior FO cable as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as shown. Ensure cable installation and applications meet the requirements of NFPA 70, Article 770. Properly support and secure cables not installed in conduits or wireways. If installed in plenums or other spaces used for environmental air, comply with NFPA 70 requirements for this type of installation.

3.1.2 Exterior Work, Aerial

Except as otherwise specified, install poles and associated aerial hardware for an overhead FO cable system as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION, as specified herein, and as shown.

a. Furnish and install a messenger system meeting the requirements of IEEE C2 to support aerial cables. The messenger system includes all messenger support and attachment hardware and appurtenances needed to install the messenger. Ensure messenger tension due to combined ice and wind loading on the messenger with supported cables does not exceed 60 percent of the messenger rated breaking strength. Messenger tension due to extreme wind loading on the messenger with supported cables cannot exceed 80 percent of the messenger rated breaking strength. Provide messenger support and attachment hardware with a rated strength not less than the messenger rated breaking strength. Size all messenger support and attachment hardware and appurtenances to exceed the rated breaking strength of the messenger cable. Use galvanized zinc coated steel or aluminum clad steel messenger cables.

b. Ground the messenger cables at all corners, dead ends, at the entrance to each facility, and at intervals not exceeding 1000-feet. Provide new grounding conductors and electrodes at each ground connection.

c. For aerial FO cables, meet the horizontal, vertical and climbing space clearances prescribed in IEEE C2 and those of the installation.

d. Provide transitions from aerial cable to underground cable as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION and as shown.

e. Make aerial cable splices within 3-feet of a pole and placed inside a watertight enclosure. Form drip loops at the cable entrance to the enclosure. Place lashing clamps within 12-inches of the enclosure.

f. Form loops in the aerial cables at points of connection and at poles to prevent damage from thermal stress and wind loading. Protect the communications cable from chafing and physical damage with the use of spiral cut tubing and PVC tape, or plastic sleeves. The ground clearance of installed cabling is as shown.

g. Vertically run cable and when possible use gravity to assist in cable pulling. Pull cable from top of run to bottom of run. Hand pull cable, if possible. If machine assistance is required, monitor tension using dynamometers or load-cell instruments and do not exceed specified cable tension limits. After installation, relieve the vertical tension on the cable at maximum intervals of 100- feet using a split support grip.

h. Wind lashing wire tightly around both the communication cable and the messenger cable by machine methods. Ensure the lashing wire has a minimum of 1 turn per 15 linear inches and not less than the number of turns per unit length that is recommended by the cable manufacturer for the distance between cable support points and the combined ice and wind loading and extreme wind loading specified or normally encountered loading for the installed location. Place lashing clamps at all poles and splices.

i. Provide soft drawn copper ground conductors not smaller than No. 6 AWG, having a current capacity of at least 20 percent of that of the messenger to which it is connected. Connect the ground conductor to a copper or copper clad steel ground rod not less than 3/4-inch in diameter with a length as needed to achieve the specified ground resistance. After installation is completed, the top of the ground rod is approximately 1-foot) below finished grade. Protect the ground conductor with half-round wood, plastic, or fiber molding from the ground to a point at least 8-feet above the ground. Measure ground resistance in normally dry conditions, not less than 48 hours after a rainfall, and the total ground resistance is not to exceed 25 ohms.

3.1.3 Exterior Work Underground

Except as otherwise specified, install conduits, ducts, and manholes for underground FO cable systems as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and as shown.

a. Minimum burial depth for cable is 30-inches, but not less than the depth of the frost line. Burial depth specified takes precedence over any requirements specified elsewhere.

b. Where direct burial cable passes under sidewalks, roads, or other paved areas, place the cable in a 1-inch zinc-coated rigid conduit or larger as required to limit conduit fill to 80 percent or less.

c. Place buried cables below a plastic warning tape buried in the same trench or slot. Place the warning tape 12-inches above the cable. Continuously imprint the warning tape with the words "WARNING - COMMUNICATIONS CABLE BELOW" at not more than 48-inch intervals. Use warning tape that is acid and alkali resistant polyethylene film, 3-inches wide with a minimum thickness of 0.004-inch, with a minimum strength of 1750 psi lengthwise and 1500 psi crosswise.

d. Transitions from underground cable to aerial cable are as shown.

e. For cables installed in ducts and conduit, use a cable lubricant compatible with the cable sheathing material on all cables pulled. Attach pulling fixtures to the cable strength members. If indirect attachments are used, match the grip diameter and length to the cable diameter and characteristics. If an indirect attachment is used on cables having only central strength members, reduce the pulling forces to ensure that the fibers are not damaged from forces being transmitted to the strength member. During pulling, continuously monitor the cable pull line tension using dynamometers or load-cell instruments. Do not exceed the maximum tension specified by the cable manufacturer. Ensure the mechanical stress placed upon the cable during installation is such that the cable is not twisted or stretched. Use a cable feeder guide between the cable reel and the face of the duct or conduit to protect the cable and guide it into the duct or conduit as it is un-spooled from the reel. As the cable is un-spooled from the reel, inspect it for jacket defects or damage. Do not kink or crush the cable. Do not exceed the minimum bend radius of the cable during installation. Hand feed and guide cable through each manhole and apply additional lubricant at all intermediate manholes. When practicable, use the center pulling technique to lower pulling tension. That is, pull the cable from the center point of the cable run towards the end termination points. The method may require the cable to be pulled in successive pulls. If the cable is pulled out of a junction box or manhole, protect the cable from dirt and moisture by laying the cable on a ground covering.

3.1.4 Service Loops

Ensure each FO cable has service loops of not less than 9.8-feet in length at each end. House the service loops in a service loop enclosure.

3.1.5 Metallic Sheath Grounding

Ground the FO cable with metallic sheath that enter buildings at a point as close as practivable to the building point of entrance. Ensure FO cable with metallic sheath routed in the trench with a power cable has the metallic sheath grounded at the cable termination points.

3.1.6 Splices

3.1.6.1 General

No splices are permitted unless the length of cable being installed exceeds the maximum standard cable length available from a manufacturer or unless FO pigtails are used to connect transmitters, receivers, or other system components for terminations to the fiber. Make splices using the method recommended by the cable manufacturer. Place splices in a splice enclosure and encapsulate with an epoxy, ultraviolet light cured splice encapsulant or otherwise protected against infiltration of moisture or contaminants. Field test FO splices at the time of splicing. Ensure fusion splices have a nominal splice loss of 0.15 dB for multimode and for single mode cable fusion splices and a maximum fusion splice loss not more than 0.3 dB loss.

3.1.6.2 Mechanical Splices

Install mechanical splices with a nominal splice loss of 0.15 dB for multimode fiber mechanical splices and 0.2 dB for single mode fiber mechanical splices with a maximum mechanical splice loss not more than 0.3 dB loss for multimode and single mode fiber mechanical splices. Install no more than 1 splice per 0.62 mile in any of the FO cables excluding terminations. Locate field splices in cable boxes. Provide sufficient cable in each splicing location to properly rack and splice the cables, and to provide extra cable for additional splices. Protect cable ends with end caps except during actual splicing. During the splicing operations, provide means to protect the unspliced portions of the cable and its fibers from the intrusion of moisture and other foreign matter.

3.1.7 Connectors

Prior to and during installation of connectors, perform appropriate cleaning to ensure that any contaminant particulates larger than 0.06 micron in size are removed. Connectors are as specified in paragraph FO CONNECTORS. Connectors or splices which leave residue on the connector ferrule or optical connector "lens", are not permitted. Ensure fibers at each end of the cable have jumpers or pigtails installed of not less than 3 feet in length. For fibers at both ends of the cable, have connectors installed on the jumpers. Ensure the mated connector pair loss does not exceed 0.7 dB. The pull strength between the connector and the attached fiber cannot be less than 50 pounds.

3.1.8 Identification and Labeling

Provide identification tags or labels for each cable. For markers, tags and labels, use indelible ink or etching which does not fade in sunlight, or in buried or underground applications. Use markers, tags, and labels that do not become brittle or deteriorate for a period of 20 years due to moisture, sunlight, soil minerals, chemicals or other environmental elements. Label all termination blocks and panels with cable number or pair identifier for cables in accordance with TIA-606 and as specified on drawings. Identify the labeling format and provide a complete record to the Government with the final documentation. Identify each cable with type of signal being carried and termination points.

3.1.9 Enclosure Sizing and Cable

Size termination enclosures to accommodate the FO equipment to be installed. Sizing includes sufficient space for service loops to be provided and to accommodate a neat layout of equipment and the bend radii of fibers and cables terminated inside the enclosure.

3.1.10 Enclosure Penetrations

Install enclosure penetrations from the bottom. Seal penetrations with rubber silicone sealant to preclude the entry of water. Internally seal conduits rising from underground.

3.2 FIELD QUALITY CONTROL

3.2.1 General

Provide personnel, equipment, instrumentation, and supplies necessary to perform testing.

3.2.2 Field Test

Verify the complete operation of the data transmission system in conjunction with field testing associated with systems supported by the fiber optic data transmission system as specified in other Sections prior to formal acceptance testing. Include a flux density test in field tests. Perform these tests on each link and repeated from the opposite end of each link.

3.2.2.1 Optical Time Domain Reflectometer Tests

Perform optical time domain reflectometer tests using the FO test procedures of TIA-455-78-B. Perform an optical time domain reflectometer test on all fibers of the FO cable on the reel prior to installation. Calibrate the optical time domain reflectometer to show anomalies of 0.2 dB as a minimum. Furnish photographs of the traces to the Government. Perform an optical time domain reflectometer test on all fibers of the FO cable after it is installed. Calibrate the optical time domain reflectometer to show anomalies of 0.2 dB as a minimum. If the optical time domain reflectometer test results show anomalies greater than 1 dB, the FO cable segment is unacceptable to the Government. Replace the unsatisfactory segments of cable with a new segment of cable. Then test the new segment of cable to demonstrate acceptability. Furnish photographs of the traces to the Government for each link.

3.2.2.2 Power Attenuation Test

Perform power attenuation test at each light wavelength of the transmitter to be used on the circuit being tested. Measure the flux at the FO receiver end and compare to the flux injected at the transmitter end. Add a jumper at each end of the circuit under test so that end connector loss is validated. Rotational optimization of the connectors is not permitted. If the circuit loss exceeds the calculated circuit loss by more than 2 dB, the circuit is unsatisfactory. Examine the circuit to determine the problem. Notify the Government of the problem and propose procedures to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.3 Gain Margin Test

Test and verify that each circuit has a gain margin which exceeds the circuit loss by at least the minimum gain margin specified in paragraph FLUX BUDGET/GAIN MARGIN.

3.2.2.4 Analog Video Signal Test

Test analog video circuits. Ensure the monitor or automated test set is stable. If the result is unsatisfactory, examine the circuit to determine the problem. Notify the Government of the problem and of the procedures proposed to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.5 Digital Video Signal Test

Test digital video circuits. Ensure the monitor or automated test set is stable. If the result is unsatisfactory, examine the circuit to determine the problem. Notify the Government of the problem and of the procedures proposed to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.6 Performance Verification Test and Endurance Test

Test the FO data transmission system as a part of other systems during the Performance Verification Test and Endurance Test.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Delivery of Technical Data

Delivery computer software and technical data (including technical data which relates to computer software), which are specifically identified in this specification strictly in accordance with the CONTRACT CLAUSES, SPECIAL CONTRACT REQUIREMENTS, and in accordance with the Contract Data Requirements List (CDRL), DD Form 1423, which is attached to and thereby made a part of this contract. Identify by reference all data delivered to the particular specification paragraph against which it is furnished. If the data transmission system (DTS) is being installed in conjunction with another system such as an intrusion detection system, electronic SECURITY system, closed circuit television system, or utility monitoring and control system, submit the Technical Data Packages as part of the Technical Data Package; submit 4 hard copies and 1 electronic copies (DC-ROM or DVD-R) of the Technical Data Package(s).

3.3.1.1 Group I Technical Data Package

3.3.1.1.1 System Drawings

Include the following information:

a. Communications system block diagram.

b. FO receivers, transmitters, transceivers, multiplexers, and FO modem installation, block diagrams, and wiring and cabling diagrams.

c. FO receivers, transmitters, transceivers, multiplexers, and FO modem physical layout and schematics.

d. Details of interfaces with other systems.

e. Details of connections to power sources, including grounding.

f. Details of surge protection device installations.

g. Details of cable splicing and connector installations.

h. Details of aerial cable and messenger installation on poles, cable entrance to buildings, and termination inside enclosures.

i. Details of underground cable and duct installation, cable entrance into buildings, and terminations inside enclosures.

Show on the drawings the proposed layout and anchorage of equipment, appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operations. Show the proposed configuration on the drawings, including location, type and termination of both interior and exterior FO and showing the location, duct and inner duct arrangement, and fiber assignment. Show the ac power consumption and heat dissipation under both normal and maximum operating conditions.

3.3.1.1.2 Equipment Data

Deliver a complete data package for all material, including field and system equipment.

3.3.1.1.3 Data Transmission System Description and Analyses

Include in the data package a complete system description, and analyses and calculations used in sizing equipment required by these specifications. Descriptions and calculations show how the equipment operates as a system to meet the specified performance. The data package includes the following:

a. FO receivers, transmitters, transceivers, multiplexers, FO modem transmit and receive levels, and losses in decibels (dB) on each communication link.

b. Digital transmitter and receiver communication speed and protocol description.

c. Analog signal transmission method and bandwidth of the transmitter and receiver.

d. Data transmission system expansion capability and method of implementation.

e. FO system signal-to-noise ratio calculation for each communication link.

f. Flux-budget and gain margin calculation for each communication link.

3.3.1.1.4 System Overall Reliability Calculations

The data package includes manufacturers' reliability data and calculations required to show compliance with the specified reliability. Base the calculations on the configuration specified, and as shown on drawings.

3.3.1.1.5 Certifications

Include the specified manufacturers' certifications with the data package.

3.3.1.1.6 Key Control Plan

3.3.1.2 Group II Technical Data Package

Verify that site conditions are in agreement with the design package. Submit a report to the Government documenting changes to the site, or differing conditions that affect performance of the system to be installed. For those changes or conditions which affect system installation or performance, provide specification (with the report), or written functional requirements to support the findings, and a cost estimate to correct the deficiency provided with the report. Do not correct any deficiency without written permission from the Government.

3.3.1.3 Group III Technical Data Package

Prepare test procedures and reports for the factory test in accordance with this specification. The test procedures describe the applicable tests to be performed, and other pertinent information such as specialized test equipment required, length of test, and location of the test. The procedures explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system. The test report describes the results of testing to include the date, time, location and system component designations of material and equipment tested. Record testing action whether successful or not. Describe reasons for termination of testing. Include testing work sheets, printouts, strip charts, oscilloscope or optical time domain reflectometer (OTDR) printouts/photographs, raw and analyzed data, and testing conclusions in the report. Deliver the factory test procedures to the Government for approval. After receiving written approval of the test procedures, schedule the factory test. Provide written notice of the test to the Government at least 2 weeks prior to the scheduled start. Deliver the final test reports in booklet form within 15 days after completion of the test.

3.3.1.4 Group IV Technical Data Package

3.3.1.4.1 Performance Verification and Endurance Testing Data

Prepare procedures and reports for the performance verification test and endurance test. Prepare test procedures in accordance with this specification. Perform testing on an installed system as approved by the Government. Where required and approved by the Government, simulate conditions of operation to demonstrate the performance of the system. The test plan describes the applicable tests to be performed, other pertinent information such as specialized test equipment required, length of performance verification test and endurance test, and location of the performance verification test and endurance test. The procedures explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system. The test report describes the results of testing to include the date, time, location and system component designations of material and equipment tested. Record testing action whether successful or not. Record reasons for termination of testing for any reason in the report. Include testing work sheets, printouts, strip charts, oscilloscope or OTDR printouts/photographs, raw data, analyzed data and testing conclusions in the report. Deliver the performance verification test and endurance test procedures to the Government for review and approval. After receipt of written approval of test procedures, schedule the performance verification and endurance tests. Provide written notice of the performance verification test and the endurance test to the Government at least 2 weeks prior to the scheduled start of the test. Deliver the final performance test and endurance test report 30 days after completion of testing.

3.3.1.4.2 Operation and Maintenance Data

Deliver a draft copy of the operation and maintenance data, in manual format, as specified for the Group V technical data package, to the Government prior to beginning the performance verification test for use during site testing.

3.3.1.4.3 Training Data

Deliver lesson plans and training manuals, including the type of training provided, with a list of reference material for approval by the Government prior to starting any training.

3.3.1.5 Group V Technical Data Package

The Group V package consists of the operation and maintenance data, in manual format. Deliver final copies of the manuals bound in hardback, loose-leaf binders,and electroic format to the Government within 30 days after completing the endurance test. Update the draft copy used during site testing with any changes required prior to final delivery of the manuals. Identify each manual's contents on the cover. Include with the manuals, the names, addresses, and telephone numbers of each subcontractor installing the equipment and systems, and of the nearest service representative for each item of equipment and each system. Ensure the manuals have a table of contents and tab sheets. Place tab sheets at the beginning of each chapter or section and at the beginning of each appendix. The final copies delivered after completion of the endurance test include all modifications made during installation, checkout, and acceptance. Ensure the delivered manuals include:

a. Functional Design Manual: two copies 1 hard copies 1 CD-ROM(s).

b. Hardware Manual: two copies 1 hard copies 1 CD-ROM(s).

c. Maintenance Manuals: two copies. 1 hard copies 1 CD-ROM(s).

d. Operator's Manual: six copies 5 hard copies 1 CD-ROM(s).

3.3.1.5.1 Functional Design Manual

The functional design manual identifies the operational requirements for the data transmission system and explain the theory of operation, design philosophy, and specific functions. Include a description of hardware functions, interfaces, and requirements for all system operating modes.

3.3.1.5.2 Hardware Manual

Furnish a manual describing all equipment and devices specified and under PART 2 PRODUCTS. Include the following information:

a. General description and specifications.

b. Installation and checkout procedures.

c. Equipment electrical schematics and layout drawings.

d. Data transmission systems schematics.

e. Alignment and calibration procedures.

f. Manufacturer's repair parts list indicating sources of supply.

g. Interface definition.

3.3.1.5.3 Maintenance Manual

Include the maintenance descriptions for all equipment including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

3.3.1.5.4 Operator's Manual

Ensure the operator's manual fully explains procedures and instructions for operation of the system. This includes an operator's manual for any FO systems in which system operators control any function of the system.

3.3.1.6 Group VI Technical Data Package

The Group VI Technical Data Package consists of the as-built drawings revised to include system revisions and modifications. Deliver copies of the updated as-built drawings to the Government following approval of the PVT and endurance test.

3.3.2 Training

Conduct a training course for designated personnel in the maintenance of the FO system. Orient the training to the specific system being installed under this specification. Furnish all training materials and supplies.

3.3.2.1 System Maintenance Training Course

Provide six copies of operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions includes the manufacturer's name, service manual, parts list, and a brief description of equipment, components, and their basic operating features. Provide six copies of the maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed. A video describing operating and maintenance instructions may be included.

Provide a system maintenance course taught at the project site after completion of the endurance test for a period of 1 training day. A maximum of five personnel designated by the Government will attend the course. A training day consists of 8 hours of classroom or lab instruction, including two 15 minute breaks and excluding lunchtime during the daytime shift in effect at the facility. Training includes:

a. Physical layout of the system and each piece of hardware.

b. Troubleshooting and diagnostics procedures.

c. Repair instructions.

d. Preventative maintenance procedures and schedules.

e. Calibration procedures.

-- End of Section --

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SECTION 27 51 16

PUBLIC ADDRESS SYSTEMS
05/20, CHG 1: 05/22

PART 1 GENERAL

1.1 RELATED SECTIONS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.
Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

1.2 SUMMARY

1.2.1 Scope

a. This work includes design and providing a new, complete, public address system as required. Provide a turnkey system capable of receiving, processing, and transmitting indicated input signals including the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, amplifiers, microphones, speakers, mounting hardware and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide systems complete and ready for operation. See paragraph titled SYSTEM DESCRIPTION for additional requirements.

b. Submit plan view drawing showing all component locations, cable routing, junction boxes, other related equipment, conduit routing, and wire counts for all floors.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2 (2020) American National Standard Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E (2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1 (2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 800-82	(2015; Rev 2) Guide to Industrial Control Systems (ICS) Security

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8510.01	(2020; Change 1-2020) Risk Management Framework (RMF) for DoD Information Technology (IT)
UFC 4-010-06	(2016; with Change 1, 2017) Cybersecurity of Facility-Related Control Systems

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1449	(2021) UL Standard for Safety Surge Protective Devices

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications; G

SD-02 Shop Drawings

Detail Drawings; G

System Layout; G,

System Design; G

SD-03 Product Data

Spare Parts

SD-05 Design Data

Design Analysis and Calculations; G

SD-06 Test Reports

Approved Test Procedures; G

Acceptance Tests

Accreditation; G

SD-07 Certificates

Components

SD-10 Operation and Maintenance Data

Public Address System; G

Submit Data Package 5 for each component in accordance with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5 SYSTEM DESCRIPTION

1.5.1 Design Requirements

Provide a Public Address System, capable of distributing the indicated audio signals from equipment including LAN controllers, communication links, cabling, battery backup, power line surge protection and all other necessary components to make a complete and operational system. Complete coverage will be provided for all interior public spaces and other spaces as indicated on the drawings.

Provide a zoned system capable of evenly distributing live and pre-recorded paging and music program sources. Provide balanced and highly intelligible distributed sound free of noise and distortion. Provide capability of both individual and simultaneous paging all separate paging zones. Intelligibility must meet the requirements of Modified Rhyme Test (MRT) of ASA S3.2

Provide all headend interface, amplification components, conditioners and any other equipment necessary. Provide system capable of interfacing with the GFGI telephone system for zone paging.

Provide all materials and labor needed for a complete and operational system for the services in this specification plus the additional system capabilities as indicated. This includes but not limited to all necessary equipment, interfaces, jumpers, terminations, cabling, amplifiers, conditioners, power supplies, battery backup, software and all components required for system operation.

1.5.2 System Application Design

Provide the system application design required to provide a public address system that complies with and satisfies all of the requirements specified in this Section and indicated on the Telecommunications Drawings for this application and project.

1.5.3 Standard Products

Provide an application design that utilizes standard system components that are the product of a Manufacturer regularly engaged in the manufacture of networked public address system, and that have been in satisfactory use for at least six months. Provide all major components from the same manufacturer. The System must be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the facility. Do not deliver material to the project site more than six months prior to the scheduled date of installation.

Provide hardware, software, and installation of a complete and engineered system. Provide a submitted design that is properly engineered for the operational requirements. Include all components required to meet this specification section in the design, other than a change in, or in addition to the operational frequencies identified herein.

1.5.4 Local Products

Incorporate local materials to the greatest extent possible. All proposed local products must meet all applicable hardware and software requirements set forth in these specifications.

1.5.5 Minimum Requirements

Specifications are minimum requirements. If the provided system requires enhanced specifications that exceed those specified herein in order to satisfy the specified design, configuration, capability, and performance requirements, then a provide a system with the enhanced specifications.

1.5.6 Current State-of-the-Art Technology

Provide application design and products that utilize current state-of-the-art products that provide the enhanced capability and performance specified herein. Provide design and products representing the latest manufacturer make and model.

1.5.7 Design Analysis and Calculations

Include in the design analysis and calculations, at a minimum, the following:

a. Power supply requirements for each component and each separate speaker zone of the system in accordance with the manufacturer's instructions. Provide power consumption and dissipation data under normal and maximum operating conditions.

b. Cable types and sizes.

c. Interfaces with all other systems such as the fire alarm and mass notification system for muting of public address system upon fire alarm or mass notification announcement.

1.5.8 Environmental Requirements

Provide equipment to be used indoors rated for continuous duty operation under ambient environmental conditions of 35 to 120 degrees F dry bulb and

10 to 95 percent reflective humidity, noncondensing. Provide all other equipment rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

1.5.9 Electrical Requirements

105 VAC to 130 VAC at 60 Hz operating voltage range, plus or minus 2 percent.

1.5.10 Power supplies

Provide power supplies that provide sufficient power for worst-case conditions of system operation that could occur without signal loss or perceptible degradation.

1.5.11 Power Line Surge Protection

Provide power line surge protection for all equipment connected to AC power. Provide surge protection integral to the equipment or installed as an accessory item in accordance to manufacturer's recommendations. Do not use fuses for surge protection.

1.5.12 Shielding and Grounding

Provide shielding and grounded as required by the system design, Manufacturer's instructions, FCC Part 15 listing, and regulatory requirements.

1.5.13 System Capability and Configuration

1.5.13.1 System Capability

Provide a public address system with capabilities to support VoIP interface, zone paging,background music,all-call,priority paging,messaging processors, software,input modules,controllers,interface modules, .

1.5.14 Performance Requirements

1.5.14.1 System Initiation and Operation

No user controlled features are permitted on this system. System is to be active on power up and perform as specified without any form of manual control.

1.5.14.2 Priority
Provide paging priorities as indicated.

1.6 CYBERSECURITY

a. The Risk Management Framework (RMF) is the process by which information systems are accredited for operation by a designated official from the Using Military Department. It is the standard process under which all DoD information systems must achieve and maintain their Authority To Operate. The Cyber Security process is documented in DOD 8510.01 and NIST SP 800-82. Refer to UFC 4-010-06 for additional requirements.

b. All systems that are IP addressable or interface with the Assured Network must be certified to operate. Coordinate with the Government to initiate and complete the accreditation process.

c. Cybersecurity requires input from the system vendor or provider and support from the local IMD. The local IMD-IA office is the point of contact for all Cybersecurity requirements. The local CMIO is the point of contact for all clinical and functional system requirements.

1.7 QUALIFICATIONS

1.7.1 General Qualification Requirements

a. The System Contractor, Installer and Manufacturer must each have the minimum qualifications specified, related to the type of system specified for this project.

b. The Government reserves the right to accept or reject the System Contractor, Installer or Manufacturer based upon qualifications and ability to conform to specified technical or licensing requirements of this Section. System Contractors, Installers and Manufacturers that do not have the specified qualifications will not be acceptable and will not be allowed to perform the work of this section.

c. The Government will determine the acceptability of any proposed System Contractor, Installer and Manufacturer based on submitted and verified documentation that substantiates that the proposed System Contractor, Installer and Manufacturer have the qualifications specified in this Section.

d. Submit documented verification of the specified qualifications as part of the Data Qualifications submittal. The Government maintains the right to request, inspect and verify references and resumes of all technical and managerial personnel assigned to the project.

e. Include qualification documentation, but not limited to the information outlined below:

(1) A list of projects performed by the System Contractor and Installer during the last five years explicitly involving the type of system specified in this section, including:

(a) Name of facility where work was completed.

(b) Name, title, address and telephone number of a point of contact for the listed facility.

(c) The make and model of the system provided and total scope of work for the facility.

(d) Restrict list to the facilities where the same type of system was installed for the same purpose provided.

1.7.2 System Contractor Qualifications

a. Contractor qualifications must include the following:

(1) The Contractor is regularly engaged in the system application design, documentation, installation, testing, training, and maintenance of the type of system specified in this section.

(2) The Contractor has a minimum of five years experience providing these services for systems having the same level of features and functions as the system being provided.

(3) The Contractor has a minimum of five years as the manufacturer or an authorized distributor and service organization for the manufacturer of the system provided.

b. Contactor personnel qualifications must:

(1) Be factory trained or certified for the make and model of the system provided.

(2) Have a minimum of five years experience performing the services specified in this specification section.

(3) Maintain a full compliment of spare parts for the provided system with the ability to furnish on-call maintenance 24 hours per day, 365 days per year.

1.7.3 Installer Qualifications

a. The installer personnel must be regularly engaged in the installation of the type of system in this specification section.

b. The installation supervisor must be factory trained or certified for the make and model of the system provided.

c. The installation supervisor must have a minimum of five years experience providing services having the same level of features and functions for the system included in this specification section.

d. The installation personnel must have a minimum of three years experience providing services having the same level of features and functions for the system included in this specification section.

1.7.4 Manufacturer Qualifications

The system manufacturer must:

a. Have a minimum of five years experience in producing the products and type of system included in this specification section.

b. Produce a system that satisfies all specified features, functions and product requirements.

c. Guarantee the availability of the replacement parts for the designed system for a minimum of seven years from the date of final acceptance of the system by the Contracting Officer.

1.8 DELIVERY, STORAGE, AND HANDLING

Equipment placed in storage until installation must be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.9 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 2 months prior to the date of beneficial occupancy. The data must include a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The public address system must consist of an audio distribution network to include amplifiers, mixers, microphones, speakers, cabling, and ancillary components required to meet the required system configuration and operation. Submit Data Package 3 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

2.1.1 Multi-Channel System with Paging

The system must include microphones, microphone outlet receptacles, microphone inputs with preamplifiers, inputs for digital music, telephone, program sources, single and all channel paging, control for each input, power amplifying equipment, and accessories required to output the public address and paging audio signals through selected portions of the audio distribution network as indicated. The paging signal must be replaced by zones channel of the system output, when the paging function is activated.

2.1.2 Single-Channel System

The system must control and amplify an audio program for distribution within the areas indicated. Components of the system must include a mixer-preamplifier, mixer-amplifier, mike input expander, power amplifier, microphone, speaker system, cabling and other associated hardware.

2.1.3 System Performance

The system must provide even sound distribution throughout the designated area, plus or minus 3 dB for the 1/1 octave band centered at 4000 Hz. The system must provide uniform frequency response throughout the designated area, plus or minus 3 dB as measured with 1/3-octave bands of pink noise at locations across the designated area selected by the Contracting Officer. The system must be capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level (SPL) in the area at an acoustic distortion level below 5 percent total harmonic distortion (THD). Unless otherwise specified the sound pressure reference level is 20 micro Pascal (0.00002 Newtons per square meter).

2.1.4 Detail Drawings

Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical speakers. Check the layout based on the actual speakers to be installed and make necessary revisions in the detail drawings. Detail drawings must also contain complete point to point wiring, schematic diagrams and other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings must show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

2.1.5 Network IP System Design

Submit system design consisting of a design analysis, calculations, and drawings as described in paragraph titled Detail Drawings. In the design analysis, describe all components, equipment, and appurtenances required for a fully functional system. Also include a detailed description of system operation to include paging priorities, interfaces with other systems, telephone interface for paging, all system inputs, and paging zones.

2.2 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products, and that essentially duplicate material and equipment that have been in satisfactory use at least 2 years. All components used in the system must be commercial designs that comply with the requirements specified. Submit copies of current approvals or listings issued by UL, or other nationally recognized testing laboratory for all components. Equipment must be supported by a service organization that is within 200 miles of the site.

2.2.1 Identical Items

Items of the same classification must be identical. This requirement includes equipment, modules, assemblies, parts, and components.

2.2.2 Nameplates

Each major component of equipment must have the manufacturer's name, address, model and catalog number, and serial number on a plate secured to the equipment.

2.3 LOUDSPEAKERS

2.3.1 Cone Speaker

The cone speaker must as a minimum conform to the following specifications:

Application	Wall baffle or Ceiling
Frequency range	60 to 12,000 Hz
Power Rating	Normal - 8 watts
	Peak - 10 watts
Voice Coil Impedance	8 ohms
Line Matching Transformer Type	25/ 70.7 volt line
Capacity	4 watts
Magnet	10 ounces or greater
Primary Taps	0.5, 1, 2 and 4 watts

Primary Impedance	25 volts - 1250, 625, and 312 ohms
	70.7 volts - 10k, 5k, and 2.5k ohms
Frequency Response	30 - 20,000 Hz
Insertion Loss	Less than 1 dB

2.3.2 Horn Speaker

The horn speaker must as a minimum conform to the following specifications:

Application	Indoor Outdoor Weatherproof
Frequency Response	400 - 14,000 Hz
Power Taps	70 volt line - .9, 1.8, 3.8, 7.5, and 15 watts
Impedance	5000, 2500, 1300, 670, 330, 90, and 45 ohms
Power Rating	Normal - 16 watts
	Peak - 18 watts
Dispersion	110 degrees

2.3.3 Dual Horn Speaker

The dual horn speaker must meet the minimum requirements of horn speaker except the dispersion must be 100 degrees.

2.3.4 High Output Speaker Enclosures

High Output speaker enclosures must be of the tuned-port design for precise balancing and tuning of the speaker. The enclosures must be constructed throughout of 3/4 inch high density board, with screwed and glued joints, durably braced, and padded with fiberglass where acoustically required. Speaker enclosures must have a 90 degree vertical dispersion and 90 degrees horizontal dispersion. The effective length of throw must be a minimum of50 feet.

2.3.5 Wall Baffle Speaker Enclosures

The wall baffle speaker must be of full steel construction painted off-white and complete with black cloth grille. Baffle must feature 9.5 degree slope to provide directional sound dispersion offset in the direction of radiation. Wall baffle enclosure must come equipped with a wall mounting bracket designed to assure a rigid mounting to any flat surfaces.

2.3.6 Ceiling Speaker Enclosures

Ceiling speaker enclosure must be constructed of heavy gauge cold steel with interior undercoating and 1-1/2 inch thick high density fiberglass

1-1/2 lbs/cu. ft. The unit must be round or square and designed for recessed or surface installations which will be accomplished via standard screw or flange mount mounting. Recessed models must have a rust-preventive, textured black coating and the surface mount unit finished in textured white . Enclosure must include four triple compound conduit knockouts.

2.4 SPEAKER SWITCHING PANEL

2.4.1 Selector Switches

Zone control must be provided for the paging function. The speaker switching panel must contain at least as required selector switches and must be rack-mounted or desk mounted to activate priority relays. Selector switches labeling must be provided to identify the zones.

2.4.2 System Power supply

Power supply must be provided for priority relays and controls, rack-mounted and sized for a capacity equal to 200 percent of the as-built control system, and must operate at 24 Vdc. Input and output must be protected to permit Class 2 wiring in accordance with NFPA 70.

2.5 PRIORITY RELAYS AND CONTROLS

Provide priority relays and controls required to accomplish operations specified. Relays must be completely enclosed with a plastic dust cover for maximum protection against foreign matter, and must be plug-in type. Relays must be provided with a diode wired across the relay coil for transient suppression and must be installed utilizing factory-prewired, rack-mounted receptacle strips. Coil must be maximum 24 volts dc.

2.6 SWITCHES AND CONTROLS

2.6.1 Remote Loudspeaker ON/OFF Switches

Remote switches must be toggle switch 2-pole, wall-mounted, single gang type with engraved switch plates finished to match the approved finish of electrical wall switches. Low-voltage priority override relays must be provided as part of the switches with all wiring to the racks to allow override of the ON/OFF switches for priority announcements.

2.6.2 Remote Loudspeaker Volume Controls

Remote volume controls must be an auto transformer type with detented 3 dB steps and an OFF position. The controls must be wall-mounted in single-gang outlet boxes and furnished with engraved switching plates finished to match approved finish of electrical wall switches. Insertion loss of the controls must not exceed 0.6 dB and the power-handling capacities of the control must be 10 watts. Low-voltage priority override relays must be furnished as part of these controls with all wiring to the racks to allow override of the volume controls for priority announcements.

2.7 EQUIPMENT RACKS AND CABINETS

Equipment must be mounted on 19 inch racks as indicated on the drawings UL listed andin accordance with ECIA EIA/ECA 310-E and located as shown on drawings. Ventilated rear panels, solid side panels, and solid top panels must be provided for cabinets. Equipment cabinets must be provided with lockable front panels that limit access to equipment. The lockable front must not cover items that require operator access. Cabinet cooling must be through perforations or louvers in front panels to ensure adequate ventilation of equipment . The racks and cabinets must be factory finished with a uniform baked enamel over rust inhibiting primer.

2.8 CABLES

2.8.1 Speaker Cable

Cables must be of the gauge required depending upon the cable run length. In no case are cables to be used which is smaller than 18 AWG. Insulation on the conductors must be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.009 inch. Cables must be jacketed with a PVC or Fluoropolymer compound. The jacket thickness must be 0.02 inch minimum.

2.8.2 Microphone Cable

Cable conductor must be stranded copper 20 AWG. Insulation on the conductors must be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.009 inch. Cable must be shielded 100 percent of aluminum polyester foil with a bare 22 gauge stranded soft copper drain conductor. Cables must be jacketed with a PVC or Fluoropolymer compound. The jacket thickness must be 0.02 inch minimum.

2.9 TERMINALS

Terminals must be solderless, tool-crimped pressure type.

2.10 SURGE PROTECTION

2.10.1 Power Line Surge Protection

Major components of the system such as power amplifiers, mixer-preamplifiers, and tuners, must have a device, whether internal or external, which provides protection against voltage spikes and current surges originating from commercial power sources in accordance with IEEE C62.41.1/IEEE C62.41.2 B3 combination waveform and NFPA 70. Fuses must not be used for surge protection. The surge protector must be rated for a maximum let thru voltage of 350 Volts ac (line-to-neutral) and 350 Volt ac (neutral-to-ground). Surge protection device must be UL listed and labeled as having been tested in accordance with UL 1449.

2.10.2 SIGNAL SURGE PROTECTION

Major components of the system must have internal protection circuits which protects the component from mismatched loads, direct current, and shorted output lines. Communication cables/conductors must have surge protection installed at each point where it exits or enters a building.

2.11 TELEPHONE INTERFACE MODULE

2.11.1 Analog Interface Module

Telephone Interface module must provide one way all call paging access from telephone to PA system. Paging must be accomplished by the building telephone system instruments interconnected to the PA system via an interface module to allow telephone dial up access to the paging amplifier. Telephone interface module must as a minimum conform to the following specifications:

Impedance	600 ohms
Frequency response	100Hz to 10Khz
70V Input Impedance	200K ohms
Output level	400mV rms
Input Power Requirement	12-24Vdc (from power supply)
Access requirement	Electronic (analog) or IA2 line key (line card required) PABX loop or ground-start trunk port, or dedicated single-line phone

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with the details of the work and working conditions, verify dimensions in the field, and advise the Contracting Officer of any discrepancies before performing the work.

3.2 INSTALLATION

Install equipment as indicated and specified, and in accordance with the manufacturer's recommendations except where otherwise indicated. Equipment mounted out-of-doors or subject to inclement conditions must be weatherproofed.

3.2.1 Equipment Racks

Mount racks side-by-side and bolt together. Group items of the same function together, either vertically or side-by-side. Arrange controls symmetrically at a height as indicated. Make audio input and interconnections with approved shielded cable and plug connectors; output connections may be screw terminal type. All connections to power supplies must utilize standard male plug and female receptacle connectors with the female receptacle being the source side of the connection. Inputs, outputs, interconnections, test points, and relays must be accessible at the rear of the equipment rack for maintenance and testing. Each item must be removable from the rack without disturbing other items or connections. Empty space in equipment racks must be covered by blank panels so that the entire front of the rack is occupied by panels.

3.2.2 Wiring

Install wiring in rigid steel conduit, intermediate metal conduit, cable trays, or electric metallic tubing as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring for microphone, grounding, line level, speaker and power cables must be isolated from each other by physical isolation and metallic shielding. Shielding must be terminated at only one end.

3.3 GROUNDING

All grounding practices must comply with NFPA 70. Equipment must be grounded to the serving panelboard ground bus through a green grounding conductor. Metallic conduits serving the equipment must be isolated on the equipment end with an insulating bushing to prevent noise from being transferred to the circuit. Equipment racks must be grounded to the panelboard ground bus utilizing a 8 AWG conductor. Grounding conductor must be terminated to the rack using connector suitable for that purpose.

3.4 TRAINING

Conduct a training course for 4 members of the operating and maintenance staff as designated by the Contracting Officer. The training course will be given at the installation during normal working hours for a total of 8 hours and must start after the system is functionally complete but prior to final acceptance tests. The field instructions must cover all of the items contained in the approved operating and maintenance manuals, as well as demonstrations of routine maintenance operations. Notify the Contracting Officer at least 14 days prior to the start of the training course.

3.5 ACCEPTANCE TESTS

Submit test reports in booklet form showing all field tests performed to adjust each component and to prove compliance with the specified performance criteria, upon completion and testing of the installed system. The reports must include the manufacturer, model number, and serial number of test equipment used in each test. Each report must indicate the final position of controls and operating mode of the system. After installation has been completed, conduct acceptance tests, utilizing the approved test procedures, to demonstrate that equipment operates in accordance with specification requirements. Submit test plan and test procedures for the acceptance tests. The test plan and test procedures must explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements specified. The procedure must also explain methods for simulating the necessary conditions of operation to demonstrate system performance. Notify the Contracting Officer 14 days prior to the performance of tests. In no case will notice be given until after the Contractor has received written Contracting Officer approval of the test plans as specified.

3.5.1 Testing Requirements

Include the following minimum testing:

a. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.

b. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

   (1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.

(2) Repeat test for each separately controlled zone of loudspeakers.

(3) Minimum acceptance ratio is 50 dB

c. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.

d. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.

e. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.

f. Power Outage Test: Turn off AC power at the circuit breaker for AC powered components connected to a UPS unit to ensure components continue to operate for a minimum of 15 minutes.

g. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

Public address system will be considered defective if it does not pass any of the required individual tests and inspections listed above.

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SECTION 28 08 10

ELECTRONIC SECURITY SYSTEM ACCEPTANCE TESTING
05/16

PART 1 GENERAL

1.1 SUMMARY

This specification defines the process and procedures for initial acceptance testing of electronic security systems (ESS) to include intrusion detection, access control and video as well as associated power and communications. Requirements to plan, conduct, and document all testing activities are covered along with the Government responsibility to witness testing and review and approve submittals. During the course of the acceptance test, demonstrate that, without exception, the completed and integrated ESS complies with the contract requirements.

1.2 DEFINITIONS

The Government Representative is a qualified individual given specific authority to witness system acceptance testing and evaluate the results.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-05 Design Data

Test Plan; G

SD-06 Test Reports

Draft Test Report

Final Test Report; G

SD-07 Certificates

Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

1.4.1.1 General

The Test Director, Operator, and Technician must have prior experience with the specific equipment, hardware and software installed under the contract.

1.4.1.2 Test Director

The Test Director must have at least five years of hands-on ESS experience to include any combination of design, installation, testing and maintenance.

1.4.1.3 Operator

The Operator must have at least two years of hands-on experience installing and maintaining ESS workstations to include both hardware and software. The Operator must be capable of demonstrating all workstation features and capabilities.

1.4.1.4 Technician

The technician must have at least two years of hands-on experience installing and maintaining ESS field equipment to include sensors, card readers, cameras, local processors, and communications equipment. The Technician must be capable of demonstrating all features and capabilities of ESS field equipment. Qualifications may be met by the individual experience of one technician or by the combined experience of a team of technicians.

1.4.1.5 Test Intruder

The purpose of the test intruder is to activate intrusion sensors in a realistic and repeatable manner. The test intruder must be between 70 and 72 inches tall and weigh between 175 and 190 pounds. The test intruder must possess sufficient physical strength, agility, and endurance to perform movements required for intrusion testing. These movements may include, but are not limited to, walking, running, crawling, jumping, and climbing.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 TEST PLAN

Clearly establish the scope for ESS testing prior to beginning testing. Submit a Test Plan that addresses the following topics:

3.1.1 Personnel

Identify the Test Director, Operator, Technician, Test Intruder, and any other personnel that will be performing test activities.

3.1.2 Equipment

List all equipment that is required to support testing. State the purpose of each piece of equipment. Describe equipment that will be used to enable voice communications between the monitoring location and the field.

3.1.3 Procedures

Provide a step-by-step procedure for conducting each functional test. Describe actions and expected results. Ensure that functional test procedures address performance standards described in contract specifications.

Download example procedures from
http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-

and review for applicability and completeness. Adapt example procedures to meet specific project requirements and develop additional ones as needed. Follow TEST-MASTERTP0023-005 for Air Force projects.

3.1.4 Special Provisions

Discuss any special test provisions such as facility access, safety, integration with existing systems, and coordination with other work.

3.1.5 Test Logs

Provide logs for recording all data from functional testing and burn-in testing.

Download example logs from http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-t and review for applicability and completeness. Adapt example logs to meet specific project requirements and develop additional ones as needed.

3.1.6 Schedule

Provide an overall schedule that includes all testing milestones.

3.2 PRE-ACCEPTANCE TESTING

Conduct a complete test of all field equipment, workstations, and central system hardware and software in accordance with the approved Test Plan. The Test Director must be on site to conduct a pre-test inspection and oversee all testing activities. Prior to testing, visually inspect all ESS components and correct workmanship and neatness deficiencies as needed. During the pre-test inspection, verify the accuracy of redline drawings and update drawings as needed. Conduct testing in two phases - functional testing followed by burn-in testing.

3.2.1 Phased Testing

3.2.1.1 Functional Testing Phase

During the functional testing phase, verify system performance in accordance with approved Test Plan. Record results in approved Test Logs, and provide a written explanation of each failure to include cause, corrective action, and retest result. Continue functional testing until all tests have been successfully completed with no unresolved failures.

3.2.1.2 Burn-In Testing Phase

Begin burn-in testing after successful completion of all functional testing.During the burn-in testing phase, place the ESS in normal operating mode and evaluate system performance for a continuous 24-hour period. During this time, the ESS must be fully functional and programmed such that all features can be exercised and evaluated through normal use. Record all system anomalies in approved Test Logs. Include a description of each anomaly along with any actions taken in response. Immediately correct minor deficiencies observed during the course of testing and continue with burn-in testing. Determine the root cause of any failures and make necessary repairs or modifications to restore full functionality. After a failure is corrected repeat functional tests for components and features associated with the failure, and repeat the entire burn-in testing phase .

3.2.2 Draft Test Report

Prepare and submit a Draft Test Report detailing the results of the testing. Refer to paragraph FINAL TEST REPORT for required content. Include a cover letter signed by the Test Director stating that pre-acceptance testing has been completed and that the system is ready for acceptance testing.

3.3 SYSTEM ACCEPTANCE

Test the ESS in accordance with the approved Test Plan in the presence of the Government Representative to certify acceptable performance. Verify that the total system meets all requirements of the specification and complies with the specified standards.

Begin acceptance testing upon arrival of the Government Representative at the project site. Place the ESS in normal operating mode and evaluate system performance during the testing period. Immediately report any deficiencies observed during testing to the Government Representative and discuss possible causes and corrective measures. Obtain Government approval prior to making any adjustments, repairs or modifications. The Government retains the right to terminate testing at any time the ESS is found to be incomplete or fails to perform as specified. Such termination of acceptance testing constitutes a FAILED system acceptance test.

3.3.1 Preparation

Nofity the Contracting Officer of system readiness 15 days prior to the expected start date of acceptance testing. Prior to acceptance testing, complete all clean-up and patch work requirements. Ensure that security equipment closets and similar areas are free of accumulation of waste materials or rubbish caused by prior installation work.

3.3.2 Personnel

Ensure that the following personnel are on site to perform test activities: Test Director, Operator, Technician, and Test Intruder. Ensure that the Quality Control Manager is on site during acceptance testing.

3.3.3 Visual Inspection

Assist the Government Representative in conducting a visual inspection of ESS equipment and wiring. This inspection will focus on the general neatness and quality of workmanship and compliance with applicable codes and manufacturers' recommended installation methods. Provide a comprehensive listing of installed equipment and software along with a complete set of ESS red line drawings to be used during the inspection. Document deficiencies identified during the inspection.

3.3.4 Functional Testing

Comply with requests from the Government Representative to repeat functional tests performed previously during pre-acceptance testing. The Government reserves the right to request the Contractor to repeat all functional tests or a representative sampling thereof as a means of performance verification. Add all test results to approved Test Logs.

3.3.5 System Activity Reports

Retrieve archived data from the system and provide activity reports as requested by the Government Representative. Reports may address any type of activity to include alarms, portal transactions, and video archives. Assist with analyzing reports to identify trends and anomalies.

3.3.6 Corrective Actions

Correct any deficiencies in coordination with the Government Representative. Maintain a punch list and review status at the end of each day. Work diligently to complete corrective actions the same day that deficiencies are observed. Add deficiencies not corrected on the same day to the rework items list maintained by the Quality Control Manager. Failure to resolve punch list items to the satisfaction of the Government constitutes a FAILED system acceptance test.

3.4 FINAL TEST REPORT

Submit a Final Test Report following the successful completion of acceptance testing to include resolution of all punch list items. Address the following topics in the Final Test Report:

3.4.1 Summary

Provide a chronological summary of all testing. Describe test activities and results in narrative form.

3.4.2 Personnel

Provide a list of all Contractor and Government personnel who participated in the testing.

3.4.3 Test Logs

Provide all completed test logs along with a test log verification signed by the Test Director.

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SECTION 28 10 05

ELECTRONIC SECURITY SYSTEMS (ESS)
05/16

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ASC/X9 X9.52	(1998) Triple Data Encryption Algorithm Modes of Operation

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.23	(2010) Electromagnetic Locks

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3	(2018) Ethernet
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTELLIGENCE COMMUNITY STANDARD (ICS)

ICS 705-1	(2010) Physical and Technical Security Standard for Sensitive Compartmented Information Facilities

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ANSI ISO/IEC 7816	(R 2009) Identification Cards - Integrated Circuit Cards

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2	(2001) Security Requirements for Cryptographic Modules
NIST FIPS 197	(2001) Advance Encryption Standard
NIST FIPS 201-2	(2013) Personal Identity Verification (PIV) of Federal Employees and Contractors

OPEN NETWORK VIDEO INTERFACE FORUM (ONVIF)

ONVIF	(2017) Core Specification Version 17.06

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-222	(2018H; Add 1 2019) Structural Standard for Antenna Supporting Structures and Antennas and Small Wind Turbine Support Structures
TIA-568.2	(2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8500.01	(2014) Cybersecurity

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

21 CFR 1020	Performance Standards for Ionizing Radiation Emitting Products
47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 294	(2018; Reprint Oct 2018) UL Standard for Safety Access Control System Units
UL 437	(2013; Reprint Oct 2017) UL Standard for Safety Key Locks
UL 634	(2007; Reprint Mar 2015) Connectors and Switches for Use with Burglar-Alarm Systems
UL 636	(2018) UL Standard for Safety Holdup Alarm Units and Systems
UL 639	(2007; Reprint Nov 2019) Standard for Intrusion Detection Units
UL 681	(2014; Reprint Jan 2021) UL Standard for Safety Installation and Classification of Burglar and Holdup Alarm Systems
UL 796	(2020; Reprint Mar 2022) UL Standard for Safety Printed Wiring Boards
UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 972	(2006; Reprint Nov 2020) UL Standard for Safety Burglary Resisting Glazing Material Type
UL 1037	(2016; Reprint Sep 2017) UL Standard for Safety Antitheft Alarms and Devices
UL 1076	(2018; Reprint Feb 2021) UL Standard for Safety Proprietary Burglar Alarm Units and Systems
UL 1610	(2016; Reprint Apr 2021) UL Standard for Safety Central-Station Burglar-Alarm Units

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

] SD-02 Shop Drawings

ESS Components; G

Overall System Schematic; G

SD-03 Product Data

Premise Control Unit; G

Detection Sensors; G

Access Control Unit; G

Access Control Devices; G

Cameras; G

Camera Lenses; G

Camera Housing and Mounts; G

Thermal Imaging System; G

Video Recording; G

Printers; G

Communications Interface Devices; G

Radio Frequency Link; G

Network Switch; G

Video and ESS Transmission; G

Infant Protection Alarm System (IPAS); G

Uninterruptible Power Supply (UPS); G

Batteries; G

Component Enclosure; G

Equipment Rack; G

SD-05 Design Data

Backup Battery Capacity Calculations; G

Access Control Throughput Rates; G

CCTV Storage Calculations

SD-07 Certificates

Contractor Qualifications; G

Instructor Qualifications; G

Data Encryption; G

SD-10 Operation and Maintenance Data

Training Plan; G

Training Content; G

ESS Components and ESS Software: Data Package 4; G

ESS Software and ESS Components: Data Package 4; G

Submit data package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA

SD-11 Closeout Submittals

As-Built Drawings; G

1.3 QUALITY ASSURANCE

1.3.1 Regulatory Requirements

The advisory provisions in each of the publications referred to in this specification are mandatory. Interpret these publications as though the word "must" has been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer.

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening, and have been utilized in applications of equipment and materials under similar circumstances and of similar size.

b. Have been available on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer.

d. Provide commercial off-the-shelf (COTS) products in which the manufacturer allows a network of qualified distributors to sell, install, integrate, maintain, and repair the hardware and software products that make up the system.

1.3.2.1 Alternative Qualifications

Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.3.2.2 Material and Equipment Manufacturing Date

Products manufactured more than one year prior to date of delivery to the site are not acceptable.

1.3.2.3 Product Safety

System components are to conform to applicable rules and requirements of NFPA 70. Equip system components with instruction stickers including warnings and cautions describing physical safety, and special or important procedures to be followed in operating and servicing system equipment.

1.3.3 Shop Drawings

1.3.3.1 ESS Components

Submit the ESS Components, Data Package 4 with the ESS Software submittal package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.Submit drawings that clearly and completely indicate each ESS component function that includes:

a. Termination device points

b. Interconnections required for system operation

c. Interconnections between modules and devices

d. Proposed wireway or conduit systems to be used including:

 (1) Locations

 (2) Sizes

 (3) Types

e. Drawings showing:

 (1) Device locations and spacing

 (2) Mounting and positioning details

 (3) Riser Diagrams with cable sizes and types

 (4) Bill of Materials (Device make, model and quantities)

 (5) Alarm and access control zones

 (6) CCTV and sensor coverage areas

 (7) Spare capacity

1.3.3.2 Overall System Schematic

Indicate the relationship of integrated components on one-line diagram and show:

a. Power source

b. System controls

c. Impedance matches

d. Interconnecting wire data including:

(1) Number

(2) Size

(3) Identification

(4) Maximum lengths

1.3.4 Evidence of Experience and Qualifications

1.3.4.1 Contractor Qualifications

Submit experience and certified qualifications data prior to installation. Show that specific installers who will perform the work have a minimum of 2 years of experience successfully installing ESS of the same type and similar design as specified. Include the names, locations, and points of contact of at least two installations of similar type and design as specified in this document where the installer has installed such systems. Indicate the type of each system installed. Certify that each system has performed satisfactorily in the manner intended for a period of at least 12 months.

1.3.4.2 Instructor Qualifications

Submit the instructor's experience and certified qualifications data prior to installation. Show that the instructor has received a minimum of 24 hours of ESS training from a technical organization such as the National Burglar and Fire Alarm Association, and 2 years experience in installing the specified ESS type.

1.4 Environmental Conditions

1.4.1 Interior Conditions

Equipment installed in environmentally protected interior areas must meet performance requirements specified for the following ambient conditions:

1.4.1.1 Temperature

32 to 120 degrees F. Components installed in unheated security protected areas must meet performance requirements for temperatures as low as 0 degrees F

1.4.1.2 Pressure

Sea level to 15,000 feet above sea level

1.4.1.3 Relative Humidity

5 to 95 percent

1.4.1.4 Fungus

Components must be constructed of non fungus nutrient materials or be treated to inhibit fungus growth

1.4.1.5 Acoustical Noise

Components must be suitable for use in high noise areas above 100 dB, without adversely affecting their performance

1.4.2 Exterior Conditions

Components in enclosures must meet performance requirements when exposed to the following ambient conditions:

1.4.2.1 Temperature

Minus 25 to 140 degrees F

1.4.2.2 Pressure

Sea level to 15,000 feet above sea level

1.4.2.3 Solar Radiation

Six hours of solar radiation per day at dry bulb temperature of 120 degrees F including 4 hours of solar radiation at 104 watts per square foot

1.4.2.4 Sand and Dust

Wind driven for up to 6 miles per hour (mph)

1.4.2.5 Rain

2 inches per hour and 5 inches per hour cyclic with wind plus one period of 12 inches per hour

1.4.2.6 Humidity

5 to 95 percent

1.4.2.7 Fungus

Warm, humid atmosphere conducive to the growth of heterotrophic plants

1.4.2.8 Wind

Continual velocity up to 50 mph with gusts to 66 mph, except that fence sensors must detect intrusions up to 35 mph

1.4.2.9 Acoustical Noise

Components must be suitable for use in high noise areas above 110 dB without adversely affecting their performance. Examples areas include flight lines, run-up pads, and generator sites.

1.5 SYSTEM CALCULATIONS AND ANALYSIS

1.5.1 Backup Battery Capacity Calculations

Submit calculations showing that backup battery capacity exceeds sensor operation, communications supervision, and alarm annunciation power requirements for proposed equipment plus 25 percent spare capacity.

1.5.2 CCTV Storage Calculations

Submit calculations showing the required storage capacity for each video storage device.

1.6 ESS SOFTWARE, DATA PACKAGE 4

Submit the ESS software, Data Package 4 with the ESS Components submittal package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Describe the functions of all software in the software manual and include:

a. All information necessary to enable proper loading, testing, and operation

b. Terms and functions definitions

c. Use of system and application software

d. Procedures for system initialization, start-up and shutdown

e. Alarm reports

f. Reports generation

g. Database format and data entry requirements

h. Directory of all files

i. All communication protocol descriptions, including data formats, command characters, and a sample of each type of data transfer

j. Interface definition

k. List of software keys

1.7 AS-BUILT DRAWINGS

Maintain a separate set of drawings, elementary diagrams, and wiring diagrams of the system to be used for as-built drawings. Keep this set accurately and neatly up-to-date with all changes and additions. This set is not to be used for installation purposes.

Finish the final drawings submitted with the endurance test report in accordance with Section 01 78 00 CLOSEOUT SUBMITTALS for as-built requirements.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a complete and integrated electronic security system (ESS) that the meet requirements as specified. ESS must be compatible with the Installation's central monitoring system and monitored within the secure/protected area and at the Installation central monitoring station. ESS consisting of the following subsystems and features:

a. Intrusion Detection System (IDS)

b. Access Control System (ACS)

c. Closed-circuit Television System (CCTV)

d. Security Command Center (SCC)

e. Communications System

f. Security Lighting Systems

g. Medical Facility Systems

Include materials not normally furnished by the manufacturer with the ESS equipment as specified in:

a. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION

b. Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION

c. Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

2.2 PERFORMANCE REQUIREMENTS

Integrate the installed and operating subsystems into the overall ESS system to detect intrusion, control access, provide CCTV surveillance, provide visual verification, and perform as an entity, as specified below. Provide electronic equipment that complies with 47 CFR 15 and are suitable for the environment where they will be installed.

2.2.1 Growth Capability

Provide capability for modular ESS expansion of inputs, outputs, card readers, and remote control stations with minimal equipment modification. Software must be able to handle design requirements plus 25 percent spare capacity. Growth capability is not to be limited by the provided products.

2.2.2 Hazardous Locations

When located in areas where fire or explosion hazards exist, provide system components rated and installed according to Chapter 5 of NFPA 70.

2.2.3 Network Certification

Certify all Platform Information Technology (PIT) in accordance with DODI 8500.01 and the individual service implementation policy.

2.2.4 Maintainability

Provide components that can be maintained using commercially available tools and equipment. Arrange and assemble components to be readily accessible to maintenance personnel without compromising system defeat resistance and with no degradation in tamper protection, structural integrity, EMI or RFI attenuation, or line supervision after maintenance when it is performed in accordance with manufacturer's instructions.

2.2.5 Availability

Provide components rated for continuous operation. Provide solid-state electronic components mounted on printed circuit boards, conforming to UL 796. Provide boards that are plug-in, quick-disconnect type. Do not impede maintenance with densely packed circuitry. Provide power-dissipating components with safety margins of not less than 25 percent with respect to dissipation ratings, maximum voltages, and current-carrying capacity. Provide solid-state type or hermetically sealed electromechanical type light duty relays and similar switching devices.

2.2.6 Fail-Safe Capability

Provide fail-safe capability in critical elements of the ESS including, but not be limited to, the capability to monitor communication link integrity and to provide self-test. Provide fault annunciation when diminished functional capabilities are detected. Annunciate fail-safe alarms to clearly distinguish from other types of alarms.

2.2.7 Line Supervision

Provide the same geographic resolution for fault isolation at the systems level as provided for intrusion detection. Provide either a static or dynamic system with active mode for line supervision of communication links of the ESS.

a. The static system must represent "no-alarm" always by the same signal, which is different than the originally transmitted signal.

b. The dynamic system must represent "no-alarm" with a signal which continually changes with time.

2.2.8 Power Loss Detection

Detect AC and DC power loss and generate an alarm when a critical component of the system experiences temporary or permanent loss of power. Annunciate the alarm in the Secured Area and the Security Command Center to clearly identify the component experiencing power loss.

2.2.9 Controls and Designations

Provide controls and designations as specified in NEMA ICS 1.

2.2.10 Special Test Equipment

Provide all special test equipment, special hardware, software, tools, and programming or initialization equipment needed to start or maintain any part of the system and its components. Special test equipment is defined as any test equipment not normally used in an electronics maintenance facility.

2.2.11 Electromagnetic Interference (EMI)

Configure and provide ESS components employing electromagnetic radiation constructed to provide minimal vulnerability to electronic countermeasures.

2.2.12 Electromagnetic Radiation (EMR)

Provide only ESS communication components which are Federal Communications Commission (FCC) licensed and approved. Provide system components which are electromagnetically compatible.

2.2.13 Interchangeability

Use off-the-shelf components which are physically, electrically, and functionally interchangeable with equivalent components as complete items. Equivalent, replacement components must not require new or other component modification. Do not use custom designed or one-of-a-kind items. Interchangeable components or modules must not require trial and error matching in order to meet integrated system requirements, system accuracy, or restore complete system functionality.

2.3 INTRUSION DETECTION SYSTEM (IDS)

The IDS primary function is to detect intrusion into secured areas. Utilize a single database for all IDS programming data that seamlessly integrates with the ESS under a single operating environment. The IDS events must be viewable as separate or as a combined list of all ESS events. Control the IDS alarm monitoring through software control from the ESS.

a. Provide both supervised and non-supervised alarm point monitoring.

b. Secure or access alarm points both manually and automatically by time of day, day of week or by operator command.

2.3.1 IDS Components

Provide components:

a. Premise Control Units (PCU)

b. Detection Sensors

c. Tamper Switches

2.3.2 Detection Sensitivity

The sensitivity of the IDS must allow for the following:

a. Locating intrusions within 300 feet zones along a line or perimeter or to one side of the facility

b. Locating intrusions at individually protected assets or at an individual portal

c. Locating intrusions within the coverage on a single volumetric sensor

d. Locating failures or tampering at individual sensors

2.3.3 Detection Alarm and Reporting Capacity

Identify individual sensors in alarm if the sensor zone is a multiple alarm source combination. Annunciate a single alarm within 1 seconds maximum, after sensor transducer or other detection device activation except that alarms transmitted by radio frequency signaling must communicate in less than 3 seconds.

2.3.4 False Alarm Rate

The false alarm rate for each interior IDS zone must not exceed one false alarm per 30-day period. The false alarm rate for each exterior IDS zone must not exceed one false alarm per 24-hour period.

2.3.5 Nuisance Alarm Rate

The nuisance alarm rate for each interior IDS zone must not exceed three nuisance alarms per 30-day period. The nuisance alarm rate for each exterior IDS zone must not exceed three nuisance alarms per 24-hour period.

2.3.6 Premise Control Unit (PCU)

Install the PCU command processor in a tamper resistant enclosure that is specified in paragraph "Component Enclosure". Package the following with the PCU:

a. Power transformer

b. Battery(s)

c. Network connection cable

d. Keypad(s)

e. Keypad connection cable(s)

f. Additional components as required for full functionality

2.3.6.1 PCU Capabilities

Provide the PCU at a minimum but not limited to, the following capabilities;

a. Expansion to a total of at least 10,000 user codes with 99 user profile definitions.

b. Support keypads with alphanumeric display. Each keypad must be capable of securing and accessing any system area based on a pass code or access control card and or key FOB authorization. Provide keypad alphanumeric display with complete prompt messages during all stages of operation and system programming and display all relevant operating and test data.

c. Four 4 shift schedules per area.

d. A total of at least 100 programmable output relay schedules.

e. 64 individual reporting areas.

f. Data line supervision or two separate lines of communication.

g. Two-man access code or credentials.

h. Support programming to require the same or different access code entered within a programmed delay time of 1 to 15 minutes after disarming before activating a silent ambush alarm.

i. Support area programming that disables schedule and time-of-day changes while system is armed so that area can only be disarmed during scheduled times.

j. Provide a minimum of a 4,000 event log buffer per PCU. Record and hold alarm activity information in the log buffer until the ESS is connected and receives the information. Provide a software-configurable warning log buffer filling notification for PCU(s) configured with network switch capabilities.

k. Support a Network Interface Card (NIC) plug-in module with built in network router capable of 128 Bit AES Rijndael Encryption process certified by NIST (National Institute of Standards and Technology).

2.3.6.2 Overcurrent Protection and Indication

When overcurrent more than it is rated for is detected by the PCU, communication bus(es) and keypad(s) are to be shut down and an overcurrent notification LED lit to indicate the situation.

2.3.6.3 Manual and Self-Test

All testing from any alphanumeric keypad include testing for: standby battery, alarm bell or siren, and communication to the Security Command Center (SCC). Include provisions for an automatic, daily, weekly, 30 day, or up to 60 day communication link test from the PCU installation site to the SCC. Include a provision for displaying the internal system power and wiring conditions.

Include the following for internal monitoring points:

a. The bell circuit

b. AC power

c. Battery voltage level

d. Charging voltage

e. Panel box tamper

f. Phone trouble line 1

g. Phone trouble line 2

h. Transmit trouble

i. Network trouble

A battery test must be automatically performed to test the integrity of the standby battery by disconnecting the standby battery from the charging circuit and placing a load on the battery. Perform this test at an interval no greater than 180 days.

2.3.7 Detection Sensors

a. Sensors are to detect facility perimeter or protected zone penetrations by unauthorized personnel or intruders and transmit an alarm signal to the alarm annunciation system upon change detection. Accomplish this with a probability of detection (PD) of 0.9 with a 95 percent confidence level and conforming to UL 639 where applicable.

b. Required sensor power is 12 VDC unless otherwise specified.

c. An interior IDS zone is a room or space within a building that can be secured and accessed independently from all other zones.

d. Provide line supervision for all sensors with an end-of-line resistor at the sensor or within a tampered junction box with conduit from the junction box to the sensor.

d. Provide sensors and components rated for operation in the installed environment. The sensors must transmit an alarm signal to the alarm annunciation system upon change detection. Provide all sensors with a tamper switch and elements housed in a tamper-alarmed enclosure in accordance of paragraph "Component Enclosure".

2.3.7.1 Interior Sensors

2.3.7.1.1 High Security Balanced Magnetic Switch (BMS)

Mount the BMS inside the secure location and on the opening side of the door. BMS sensors do not have the capability to incorporate an end-of-line (EOL) resistor.

2.3.7.1.1.1 Level 1 Switch

UL 634. Level 1 High Security

2.3.7.1.1.2 Level 2 Switch

UL 634. Level 2 High Security

2.3.7.1.2 Glass Break Detection

UL 639.

2.3.7.1.2.1 Window-Mounted Glass Break Shock Sensor

Provide sensors with an LED for adjusting sensitivity.

Provide sensor with an exterior label to protect tape from direct sunlight. Seismic vibrations or other ambient stimuli are not to initiate an alarm. Test glass breakage sensors by using test units supplied by the manufacturer which simulate glass breakage.

2.3.7.1.2.2 Ceiling Or Wall-Mounted Dual Technology Glass Break Sensor

Provide a sensor that eliminates occupant-generated false alarms by combining a passive infrared motion detector (PIR) with glass break sensing. The combination will extend coverage to occupied areas, allowing the sensors to be armed while people are present.

2.3.7.1.2.3 Ceiling or Wall-Mounted Recessed Glass Break Sensor

Provide a sensor employing pattern recognition technology that listens for the actual pattern of breaking glass. The sensor is to be able to detect the difference from breaking glass and normal room sounds by listening across the glass break frequency spectrum. Provide a range of 25 feet to cover the area to be protected.

2.3.7.1.3 Vibration Vault Sensor

Provide a sensor that senses short duration, large amplitude signals like those produced in attacks from explosions, hammering or chiseling and also detect long duration, small amplitude signals like those produced in attacks from torches, thermic lances, drills, grinders, or cutting discs.

Provide sensor equipped with a manual and an automatic test alarm output with test indicator not visible or audible during normal operations. The test indicator is to annunciate when the sensor detects an intruder when active. The alarm indication may be located within the sensor or as a separate device.

2.3.7.1.4 Fiber Optic Mesh Sensors

Fiber optic mesh sensors are to be comprised of a web of optical fiber cables which are deployed within:

a. Building walls

b. Partitions

c. Flexible structures

d. Water-side installations

e. Mobile facilities

f. Mobile container shells

2.3.7.1.5 Utility Inlet Opening Protection

Provide protection by a sensor of the breakwire or wire trap type consisting of up to 26 AWG hard-drawn copper wire with a tensile strength of 4 pounds maximum interlaced throughout the opening such that no opening between wires is larger than 4 inches on center.

Conceal terminated sensors so that any attempts to cut the wire or enlarge openings between wires cause an alarm.

2.3.7.1.6 Passive Infrared Sensors

UL 639.

2.3.7.1.7 Microwave Sensors

UL 639.

2.3.7.1.8 Dual Technology Sensors

UL 639. Provide sensor combining passive infrared (PIR) and microwave sensors configured and manufactured specifically to be mounted in a single tamper alarmed enclosure. The sensor must provide selectable "AND" logic or "OR" logic for alarm indication configured in the "OR" logic state.

Provide sensors that have a local means of indicating detection for use during installation and calibration with a means of disabling the indication.

The sensor is to have an LED walk test indicator which is not visible during normal operations. When visible, the walk test indicator will light when the sensor detects an intruder. Provide a sensor equipped with a manual control, located within the sensor's housing, to enable and disable the test indicator or with the test indicator located within the sensor housing so that it can only be seen when the housing is open or removed.

2.3.7.1.9 Photoelectric Sensors

UL 639. The sensor is to detect opaque bodies and not allow an intruder to disable detection by shining another light source into the receiver.

Provide sensor with a local means of indicating detection for use during installation and calibration with a means of disabling the indication.

2.3.7.2 Exterior Sensors

2.3.7.2.1 Fence Mounted Sensors

Sensors are fiber optic or strain-sensitive cable sensors as indicated which initiate an alarm when an intruder attempts to scale, cut through, lift the fabric of, or lean climbing devices on to the entire length of a standard chain link fence or physical barrier. Provide sensors that are either tamper alarmed or self-protecting. House exterior components in rugged, corrosion-resistant enclosures, as specified in paragraph COMPONENT ENCLOSURES.

Provide fence cable support hardware that is weather-resistant.

2.3.7.2.1.1 Fiber Optic Sensor

The sensor consists of an ultraviolet resistant fiber optic transducer cable with a microprocessor based dual zone signal processor that is capable of monitoring different styles of metal fabric fencing including chain-link, expanded-metal or welded-mesh fence. The sensor detects intruders by utilizing signals generated by the minute flexing of the fiber optic transducer cable, caused by attempting to cut, climb, or raise the fence fabric.

The signal processor analyzes the signals from the fiber optic transducer cable and detects minute vibrations in the fabric of the fence. The signal processor supports single or dual zones with each zone supporting a maximum 1640 feet of sensing cable. The processor utilizes adaptive algorithms, ambient signal compensation and selectable common-mode rejection, to discriminate between actual, false and nuisance alarms, without lowering the probability of detection. The processor identifies, by type, a cut intrusion and a climb intrusion. Provide sensors with independent adjustments and thresholds for each type of intrusion and have the capability to completely mask climb or cut alarms. Alarms caused by power failure, low input voltage, cable fault (cable cut or high loss due to physical stress), or internal electronic fault are to be identified as supervisory alarms. Equip the sensor with a test indicator if it is an integral sensor signal processor function.

2.3.7.2.1.2 Strain-Sensitive

a. Provide a complete fenceline protection with no dead zones where an intruder can penetrate the fence. Through sensor electronics the fenceline protection must be divided into zones. Sensing unit of sensor must achieve specified performance with transducer cable either by attachment directly to the fence fabric by plastic cable every 12 to 18 inches or by installation inside RGS conduit mounted on the fence. Provide sensing units with equal adjustable sensitivity throughout the entire length.

b. Use only conventional waterproof coaxial cable connectors for connections of the sensing unit to permit installation in extreme EMI environments with no loss of detection capability. Entire sensor system must be capable of detecting tampering within each system portion by sensor zone.

c. Provide capability for alarm threshold sensitivity adjustment to permit compensation by zone for winds up to 35 mph while maintaining the same level of detection performance as under ambient conditions.

d. Sensor zone control unit must provide an analog audio output for interface to an external audio amplifier to permit remote audio assessment regardless of sensor alarm status. Sensor zone control unit alarm output interface is to be a separately supervised relay contact normally open or normally closed, with an adjustable intrusion alarm pulse width of 0.5 second adjustable and a continuous (until corrected) tamper alarm.

2.3.7.2.1.3 Gas Units

Provide gate units in accordance with specific fence sensor manufacturer's recommendations to ensure continuous fence sensor zone protection for the entire protected perimeter. Provide a gate unit for each fence portal.

Provide separately zoned BMS gate sensors when gate units are not provided by the fence sensor manufacturer. BMS sensors perform as specified in paragraph HIGH SECURITY BALANCED MAGNETIC SWITCH (BMS).

2.3.7.2.2 Electrostatic Field Sensors

a. Initiate an alarm when an intruder attempts to approach or scale a fence or physical barrier. Electrostatic field sensors generate an electric field around one or more horizontal wires and sense the induced signal in parallel sensing wires to detect human presence. Provide sensors that monitor the induced signal for changes that result from the presence of a conductive body or a body with a high dielectric constant.

b. Use mounting and support hardware as provided by the equipment manufacturer.

c. Provide spring tension-mounted wire on end-of-line terminators to detect cutting, shorting, or breaking of the wires. Select sensor configuration such that an intruder cannot crawl under the bottom wire, through the wires, or over the top wire without being detected and be divided into sensor zones.

d. Sensors must be capable of following irregular contours and barrier bends without degrading sensitivity below the specified detection level. Adjacent zones must provide continuous coverage to avoid a dead zone and be configured to prevent crosstalk interference.

e. Provide filtering on signal processing circuitry to distinguish nuisance alarms. Sensor configuration is to incorporate balanced, opposed field construction to eliminate far field noise.

f. House exterior components in rugged corrosion-resistant enclosures, protected from environmental degradation and provided with tamper switches. Use underground cables to interface between exterior units. Use stainless steel or galvanized exterior support hardware. Use stainless steel sensor and field wires.

g. Follow manufacturer's specifications for wire spacing of various configurations.

h. Provide adjustable sensor sensitivity which is inaccessible to operating personnel.

2.3.7.2.3 Taut-Wire Sensors

a. Incorporate perimeter intrusion detection sensors into a barbed wire security fence. Detect intrusion of cutting of any single wire or the deflecting, as by climbing, of any wire by more than 3.1 inches. A sensor zone includes one or more 200 feet maximum sections of 7 foot high parallel fence with each sector consisting of 13 horizontal tensioned wires attached to the taut-wire fence posts, and three strands as outriggers, plus an "antiladder" trip wire supported by rods extending from the outriggers for a total vertical height of approximately 8 feet.

b. Mount displacement switches for each horizontal wire within a prewired channel fastened to the fence post at the midpoint of each section. Outrigger barbed wire and tripwire may share the same switch. Mount each taut-wire fence post to the normal security fence (chain link) fabric posts or other barrier via standoffs to position the taut-wire approximately 6 inches from the fence fabric or other barrier.

c. Mount freestanding taut-wire fence posts in concrete to support the taut-wire fence system. Pretension and clamp each barbed wire strand to the lever arm of the displacement switch, such that the lever is in the neutral (off) position; therefore, the forces applied by the barbed wires are balanced equal in opposite directions. Pretension tripwires in a like manner. Line tripwires to the top switch in the sensor switch channel by a special subassembly that includes a rod which transfers tripwire movement as a lever to the end of the actuating sensor switch's lever arm.

d. Initiate an alarm upon abnormal switch lever displacement. This would result from cutting or deflecting its attached wire, as by climbing on or through fence strands. Provide sensor with a damping mechanism which reduces alarm threshold due to slowly changing phenomena including ground shifting, daily and seasonal temperature variations, and winds up to 35 mph.

e. Sensor switch must provide electrical contact closure as the means for initiating an alarm, whenever the wire clamped to the vertical center bolt is pulled laterally in any direction by an amount not over 0.75 inch.

f. Housing for switch assembly must be covered by a neoprene cap to retain the center bolt (lever arm). This bolt translates attached horizontal wire movement into the contact closure. The bolt functions as the fulcrum for the lever when the neoprene cap is firmly seated on the cup-shaped polycarbonate housing.

g. Provide threaded upper exposed end of the lever to accommodate clamping to the horizontal wire. The lower end of the lever, which is fashioned to serve as the movable electrical contact, must be held suspended in a small cup-shaped contact that floats in a plastic putty material. The plastic putty is to retain a degree of elasticity under varying temperature conditions and provide the sensor switch with a self-adjusting property. This provides the switch with a built-in compensating mechanism that ignores small, very slow changes in lever alignment (which may result from environmental changes including extreme temperature variations and ground creepage due to weather conditions) and to react to fast changes only, as caused by manual deflection or cutting of the wires.

h. Provide metal slider strips having slots through which the barbed wires pass with rivets that prevent the wires from leaving the slots. The slider strip must translate horizontal displacement forces normal to the barbed wire to the sensor. Install one slider strip pair, upper and lower, on every fence post except where sensor posts or anchor strips are installed. Provide maximum separation between slider elements along the fence of 10 feet.

i. Attach barbed wires to installed fence anchor posts, located equidistant on both sides of sensor posts and at ends of sensor zone run. Install fastening plates on an anchor strip. Weld strip or otherwise attach the strip to anchor post and ends of tensed barbed wires wrapped around the fastening plates. Fastening plates are to break off when climbed upon or on the attached barbed wires creating an alarm and making it impossible to defeat the system by climbing at the anchor post.

j. Use barbed wire suitable for installation under a preload of approximately 88 pounds tension and be flexible enough for convenient manipulation during tensioning. The minimum acceptable double-strand barbed wire gage is 15-1/2.

k. Sensor zone control unit must monitor up to 10 zones.

l. Provide sensor with relay outputs to interface alarm outputs with the overall ESS. Input power is 120 VAC.

2.3.7.2.4 Dual Technology Sensors

a. Provide dual technology sensor that combines Microwave and Dual PIR into one single all-weather detector. Use the sensor in extreme outdoor conditions to provide the maximum amount of coverage in a horizontal plane.

b. The sensor must come mounted in an industrial-grade housing as specified in paragraph COMPONENT ENCLOSURE. Provide pan-tilt swivel bracket with swivel within 100 degrees of range and tilt within 10 degrees. The swivel bracket is to allow for calibration into 1 degree segments for adjustment to any environment.

c. The sensor must provide either wide angle or long range detection by change of optical mirrors. Wide angle coverage must detect intrusion out to 49 feet and long range coverage out to 130 feet. Provide sensors that allow adjustment masks for wildlife immunity for animals up to 99 pounds.

2.3.7.2.5 Bistatic Microwave Sensor

a. Provide sensor equipped with circuitry that produces an alarm signal when the sensor's receiver is captured by another microwave transmitter. Multiple sensors must be able to operate in adjacent zones without interfering with each other. Provide sensors with adjustable sensitivity controls within the sensor that are not accessible when the sensor housing is in place. Provide sensors that can be adjusted in order to obtain the designed coverage pattern.

b. The bistatic microwave sensor is to consist of a separate transmitter and receiver. The sensor detects changes from a standard intruder's movement in the received microwave signal sensor's detection pattern. The sensor transmits an alarm signal to the alarm annunciation system upon detecting such changes. The sensor must detect a standard intruder moving perpendicular through the sensor's detection pattern at a speed of 0.2 to 25 fps.

c. Equip the sensor with an LED walk test indicator which is not visible during normal operations. When visible, the walk test indicator is to light when the sensor detects an intruder. Provide sensors equipped with a manual control, located within the sensor's housing, to enable and disable the test indicator or with the test indicator located within the sensor housing so that it can only be seen when the housing is open or removed.

2.3.7.2.6 Monostatic Microwave Sensor

a. Multiple sensors must be able to operate in adjacent zones without interfering with each other. Provide sensors with adjustable sensitivity controls within the sensor that are not accessible when the sensor housing is in place. The sensor must be adjustable to obtain the coverage pattern shown and have range cut off capabilities of field selected distance 100 to 400 feet.

b. The monostatic microwave sensor must consist of an integrated transceiver. The sensor detects changes from a standard intruder in the received microwave signal sensor's detection pattern. The sensor must transmit an alarm signal to the alarm annunciation system upon detecting such changes. The sensor must detect a standard intruder moving perpendicular through the sensor's detection pattern at a speed of 0.2 to 25 fps.

c. The sensor is to be equipped with an LED walk test indicator which is not visible during normal operations. When visible, the walk test indicator is to light when the sensor detects an intruder. Provide sensors equipped with a manual control, located within the sensor's housing, to enable and disable the test indicator or with the test indicator located within the sensor housing so that it can only be seen when the housing is open or removed.

2.3.7.2.7 Passive Infrared Sensor (Exterior)

a. UL 639. The passive infrared sensor must detect movement from a standard intruder in the ambient level of infrared emissions within the sensors's field of view.

b. The sensor is to detect a change in temperature of at least 2 degrees F and detect an intruder traveling within the sensor's detection pattern at a speed of 0.6 to 50 fps across 2 adjacent segments of the field of view. The sensor must have a detection range of at least 300 feet. Emissions monitored by the sensor must be in the 8 to 14 micron range.

c. Provide sensors that can be adjusted in order to obtain the designed coverage pattern. The sensor is to be equipped with a temperature compensation circuit.

d. The sensor is to be equipped with an LED walk test indicator which is not visible during normal operations. When visible, the walk test indicator is to light when the sensor detects an intruder. Provide sensors equipped with a manual control, located within the sensor's housing, to enable and disable the test indicator or with the test indicator located within the sensor housing so that it can only be seen when the housing is open or removed.

2.3.7.2.8 Buried Ported Cable

The buried ported cable to monitor for changes in the electromagnetic field between the leaky coax transmit and receive cables within the sensor's detection pattern to detect standard intruder movement. The sensor must transmit an alarm signal to the alarm annunciation system upon detecting such changes. Provide sensors that detect a standard intruder moving through the sensor's detection pattern at a speed of 0.2 to 25 fps.

Provide ported coaxial transmission and receive cables rated for direct burial. Provide sensors to obtain the designed coverage pattern with adjustable sensitivity to 3 feet length by controls within the sensor signal processor. Controls must not be accessible when the sensor signal processor's housing is in place. Equip the sensor with a test indicator if it is an integral sensor signal processor function.

2.3.7.2.9 Active Infrared Sensor (Exterior)

a. The active infrared sensor detects a light beam interruption that links the transmitter and receiver caused by an intruder moving at a speed of less than 7.5 fps through the beam. The sensor must transmit an alarm signal to the alarm annunciation system upon detecting such an interruption.

b. The sensor must use a pulsed infrared light source. Multiple sensors must be able to operate within the same zone without interfering with each other. Provide sensors to obtain the designed coverage pattern with adjustable sensitivity with controls located within the sensor signal processor and not accessible when the sensor signal processor's housing is in place.

c. The sensor is to be equipped with an LED walk test indicator which is not visible during normal operations. When visible, the walk test indicator is to light when the sensor detects an intruder. Provide sensors equipped with a manual control, located within the sensor's housing, to enable and disable the test indicator or with the test indicator located within the sensor housing so that it can only be seen when the housing is open or removed.

d. The sensor may incorporate remote test if it is an integral sensor function.

2.3.7.2.10 Video Motion Sensor (Exterior)

Provide a video motion sensor to detect changes in the video signal within a user defined detection zone as described in paragraph VIDEO ANALYTICS. The system must detect changes in the video signal corresponding to a standard intruder moving within the defined detection zone and wearing clothing with a reflectivity that differs from that of the background scene by a factor of 2. Provide signal processing techniques to eliminate non-alarm background motion including light changes, trees blowing, and birds. Provide sensor with controls and method needed by the operator to define and adjust the sensor detection zone within the video picture.

Video motion sensor system must operate using or digital and thermal cameras. The number of detection zones, the size of the detection zones, and the sensitivity of the detection zones are to be user definable. Provide sensors that accommodate multiple video inputs and have the capability of modular growth. The video inputs must accept composite video. The sensor must not require external sync for operation. Provide one alarm output for each video input. Provide number of video inputs and alarm outputs as required for an operable system. Rack-mount sensor equipment in a standard rack as described in paragraph EQUIPMENT RACK with hardware includes as required to mount the sensor components.

2.3.7.2.11 Radar

The radar system must provide intruder detection to 2300 feet. Provide monostatic type unit in which the transmitter and receiver are encased within a single housing unit (transceiver). The radar is to be equipped with a signal processor that is programmed to recognize reflected energy from the normal environmental surroundings, and eliminate those objects relative to alarm. Provide unit with the capability of preprogramming specific parameters, size and speed, above which an alarm signal is generated.

The system is to provide alarm information to the ESS in order to identify specific zones of concern to include range and azimuth information, as a minimum. The information must have the capability of integrating with CCTV video motion sensor systems, to "call" the cameras to a particular view for alarm verification. The system is to be able to retrofit with existing CCTV or other detection systems. After radar system installation, post warning signs indicating radiation hazard as recommended by the manufacturer.

2.3.7.3 Duress Alarms (Hold Up Switch)

UL 636. Duress alarm switches must provide the means for an individual to covertly notify the alarm annunciation system that a duress situation exists with no visible or audible signal in the secure area.

2.3.7.3.1 Hardwire Duress Alarms

Alarms must be capable of being secretly activated by the foot or hand of an average adult in both standing and seated positions. Upon activation the alarm signal is to lock-in until manually reset with a key or similar device and be readily identifiable by the ESS.

Provide sensors that are easy to operate and configured to minimize the possibility of accidental activation. Hardwire duress alarms must be rated for a minimum lifetime of 50,000 operations. Securely mount sensors in rugged, corrosion-resistant housing.

2.3.7.3.2 Wireless Duress Alarms

Wireless duress alarm switches to consist of portable alarm transmitters easily worn on the body or clothing. Alarm activation is to be by hand-operated switch protected from accidental activation, yet easily activated by hand when worn at the waist on body or clothing which transmits a unique identification code to one or more receivers located within a protected zone. The receivers, in-turn, are to transmit an alarm signal to the ESS system. Sensor activation is to be automatic when mounted on a body or clothing and the wearer is in a horizontal position for longer than one minutes, adjustable. Operations personnel must not be able to adjust time interval activation.

Provide switches rated for a minimum lifetime of 50,000 operations and have a range of at least 2500 feet. Wireless switches must be fully supervised, where the transmitter automatically transmits (checks in) to the receiver on a regular basis to test the system for low battery, tamper, and inactive status.

2.3.7.4 Tamper Switches

a. Corrosion-resistant tamper switches are required for the following IDS and CCTV equipment with hinged doors or removable covers that contain open circuits:

   (1) Enclosures

   (2) Cabinets

   (3) Housings

   (4) Boxes

   (5) Raceways

   (6) Fittings

   (7) Sensors

b. Tamper switches are to initiate an alarm signal when the door or cover is moved as little as 1/4 inch from the normally closed position. Mechanically mount tamper switches to maximize defeat time when enclosure covers are opened or removed. One second is the minimum amount of time required to depress or defeat the tamper switch after opening or removing the cover. Enclosure and tamper switch must prevent direct line of sight to internal components and prevent switch or circuit tampering. Conceal mounting hardware so switch cannot be observed from enclosure exterior.

c. Tamper switches on doors which are opened to make normal maintenance adjustments to the system and to service power supplies must not have a maintenance position.

2.3.7.4.1 Tamper Switch Performance Requirements

Tamper switches are to be:

a. Inaccessible until switch is activated.

b. Under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating.

c. Annunciated to be clearly distinguishable from intrusion detection alarms and exempt from being disarmed, shunted, or silenced.

d. Spring-loaded and held in the closed position by the door, or cover protected.

e. Wired to break the circuit when the door or cover is disturbed.

f. Wired so that each sensor and device is annunciated by zone at the central reporting processor.

2.4 ACCESS CONTROL SYSTEM (ACS)

Provide an access control system based upon a modular distributed microprocessor architecture complete with access control cards and ready for operation.

a. The ACS card credentials are required to be Common Access Cards (CAC), and CAC cards are being provided by the Government. Provide system monitoring and control for the ESS. Provide ACS that meets the communications requirements of UL 1076 and UL 294 and has the capability of controlling up to card readers and keypads per card reader controller, as required alarm inputs, or as required relay outputs or any components combination.

b. System is to grant or deny access or exit based upon:

(1) Keypad identification data

(2) CAC card identification data

(3) Video

(4) Biometric reader identification data

(5) Smart card identification data

(6) Identification technologies combination

(7) Input through the access control devices compared to data stored within the system

(8) Time of day, day of week, and special day and holiday scheduling with card validation override.

c. Decision to grant or deny access or exit is to be based upon authorization for such data to be input at a specific location for the current time period.

d. Provide ACS that supports the configuration and simultaneous monitoring of multiple access control devices when TCP/IP communication interfaces are used between the ESS and the primary Access Control Unit (ACU). The events of the ACS are to be viewable as separate or as a combined list of all ESS events. Provide overall control of the ACS, alarm monitoring, and photo identification through software control of the ESS.

e. Access control, photo imaging, and programming data must reside on a single database and instantly accessible to every networked PC workstation connected to the ESS.

f. Provide both supervised and non-supervised alarm point monitoring.

g. Provide the capability to arm or disarm alarm points both manually and automatically by time of day, day of week or by operator command and the capability to disarm alarm points based on a valid access event.

h. When used for elevator control, the ACS is to grant access to elevator floors based on a valid credential, or by schedule.

i. Provide programmable 'delay' setting for all alarm points. The alarm points are not to report an ENTRY type alarm until the delay setting has expired and not report a dwell type alarm condition until the alarm has been active for the full delay period.

j. Provide the capability to place ACU(s) in an off-line mode. In the off-line mode, the ACU(s) must retain a historical summary of all ACU activity transactions, up to the maximum capacity of the ACU memory buffer. Provide the ability for manual operator control of system output relays with the manual functions to energize, de-energize, enable or disable.

k. Provide the ability to display a stored 'video image' of the cardholder based on card activity, and switch real-time CCTV camera to the card reader location for specific card usage. The card reader must not activate the door lock until positive operator acknowledgment from the SCC.

2.4.1 ACS Programming

Provide software capable of, but not limited to, the following programming:

2.4.1.1 Time Schedules

Provide up to 256 user-definable time schedules. These time schedules are to determine the day(s) and times that access will be granted or a scheduled event is to occur. Any and all of the time schedules are to be available for defining access privileges and scheduled events. Provide ALWAYS and NEVER schedules that cannot be altered or removed from the system. Each user-defined time schedule must have the option of reacting or not reacting to user-defined special days, with the ability to react uniquely to each type of special day.

2.4.1.2 Special Days

Provide an unlimited number of user definable special days to be used for configuring exceptions to the normal operating rules, typically for specifying holiday operating rules. Allow for each special day to be assigned to a user-defined type.

2.4.1.3 ACU Daylight Savings Time Adjustment

Provide a software-configurable, user defined adjustment for Daylight Savings Time. The ACU must not need to be connected to a PC workstation in order for the adjustment to occur.

2.4.1.4 Scheduled Events

Any access controlled reader is to be capable of scheduled unlock periods to allow for card-free access. The access controlled reader is to also be capable of requiring one valid access event before beginning a scheduled unlock period.

Any access control point is to be capable of requiring a valid card as well as a PIN code via keypad on a scheduled basis for high security areas. The use of PIN via keypad functions must not reduce the number of card readers or alarm points available in the ACU(s). Any designated alarm input must be able to be scheduled Secured and Accessed. Any relay output must be capable of scheduled ON and OFF periods to allow for automatic input and output system control.

2.4.1.5 Maximum User Capability

Up to 64,000 individual users may be given access cards or codes and have their access controlled and recorded.

2.4.1.6 Access Groups

Each system user must be assignable to a maximum of 4 of 256 possible access groups. An access group is defined as one or more people who are allowed access to the same areas at the same days and time periods.

2.4.1.7 Active and Expire Dates

Any card or user may be configured with activation and expiration dates. The card can be assigned to any valid access group and will be activated and expired according to the specified dates.

2.4.1.8 Maximum Use Settings

Any card or user may be configured with maximum number of uses for that card. The card can be assigned to any valid access group and will be expired according to the specified number of card uses.

2.4.1.9 Door Outputs

Provide each access control reader with dedicated relay outputs. Both relays are to provide Normally Open and Normally Closed contacts. Use the first relay for electric lock control while the second is software configurable to activate for door forced open, door left open too long, duress, passback violations, invalid access attempts and valid unlock conditions. Allow for both relays to be separately programmable for energize times from 1 second to 10 minutes. The second relay must allow a delay time to be specified, causing its activation to be delayed after an activating condition occurs.

2.4.1.10 User List or Who's In (Muster Reports)

Provide the capability to generate dynamic lists of users in certain access-controlled areas, based either upon selected users or selected areas. The lists must have the option of automatically refreshing after a user-selected interval of time.

2.4.1.11 Crisis Mode

Provide support for a "crisis mode", in which user-selected alarm point activations cause changes to user access privileges. The changes to user access privileges must be configurable to restrict normal access to no access or limited access.

2.4.1.12 Door Groups

Allow up to 256 door groups to be configured. Doors belonging to the same group are be able to be locked, unlocked, disabled, and enabled on command from the ACS.

2.4.1.13 Door Interlocking

Allow a group of doors to be software configured so that if any door in the group is unsecure, all other doors are automatically disabled. This feature is also known as a "mantrap" configuration. The interlocking features must not require the ACS to be on-line for proper operation.

2.4.1.14 PIN Required

Provide support for the required use of a keypad code, in addition to a valid credential during user-selected schedules.

2.4.1.15 Remote Door Control

Provide the ESS operator the capability of manually controlling any access point by issuing a simple command from the ACS. Provide the operator the ability to lock, unlock, enable, and disable any door or Door Group in this manner. This activity is to cause an entry to be logged displaying the door name, number and time that it was performed.

2.4.1.16 Key Control

When interfaced with an approved key-control system, the system is to allow users to deny access to certain doors for any users who have keys in their possession.

2.4.1.17 Guard Tour

Provide support for user-defined guard tours configurable in a set pattern of tour points, or following a mode in which all tour points can be visited in any order within an allotted time. Allow for a tour to be started by ACS command, by use of a selected card at a selected reader, or by use of a selected keypad code at a selected keypad. Detect guard late-to-point, point missed, and point out-of-sequence events. Generate a report at tour completion.

2.4.1.18 Reader Disable

Provide support for disabling readers in reaction to a user-selected number of invalid access attempts. Locate a camera to view the card reader and interface to record the events of invalid access attempts.

2.4.1.19 Disable Event Messages

Allow users to disable user-selected event messages (Door Forced Open, Door Open Too Long, Door Closed, Request to Exit) for user-selected doors. Allow users to disable certain messages (Door Forced Open, Door Open Too Long) according to a user-selected schedule.

2.4.1.20 Input and Output Groups

Allow for up to 256 user-defined (input and output) groups to be defined. Each Input device is to be able to be linked to these groups for arming, disarming, shunting and unshunting as well as output control.

2.4.1.21 Delays

Each alarm device must allow a delay to be specified which is either an entry type or a dwell type. An entry-type delay is to prevent the input from issuing an alarm event until the delay elapses. If unarmed during the delay period, the alarm is to be ignored. A dwell-type delay requires the input to remain in the alarm state for the full delay duration before issuing an alarm.

2.4.1.22 Output Configuration

Allow each output relay to be software configurable as:

(1) Follows

(2) Latch

(3) Timeout

(4) Scheduled

(5) Timeout Re-triggerable

(6) Limit

(7) Counter

Allow for a time schedule to automatically control the activation and de-activation of the Scheduled type with all other types configured to activate based on input and output group conditions. Additionally, a time schedule must be specified to configure when the output is to actively monitor the input and output groups.

2.4.1.23 Remote Output Control

Provide the operator the capability of manually controlling any output point by issuing a simple command from the SCC. Based upon the output type, provide the ESS operator the ability to ENABLE, DISABLE, turn ON and turn OFF any output in this manner. A FOLLOWS type output must not be capable of being turned OFF or ON. Log an entry when this activity is performed displaying the output name and time performed. Manual control of outputs are not permissible in ICS 705-1 applications.

2.4.1.24 Remote Reset Command

Provide the capability for any ACU to reset manually or by command issued from the ACS with the option of simulating the ACU reset settings, or forcing a reset type as specified by the user. The remote reset command is not to cause the ACU to degrade its level of protection to any access points defined.

2.4.1.25 Time Zone

Allow the user to select the time zone in which the ACU is located, so that event times displayed for that ACU will match the local time where the ACU is located.

2.4.1.26 User-Selected LED Behavior

Allow the user to select different behaviors for the LEDs of each access controlled reader.

2.4.1.27 Traced Cards

Provide the capability of selecting any number of cardholders for the purpose of limiting reports to only traced users displaying all traced cardholder events in a user-selected alternate color.

2.4.1.28 Badge Print Tracking

Support setting a print limit for any badge. The software will track the number of times any badge has been printed, as well as display the date and time of the most recent printing.

2.4.2 Error and Throughput Rates

Rates must be portal to portal performance averages obtained when processing individuals one at a time. Features are not to reduce capability to meet throughput requirements when serial verification techniques or multiple attempts are required to satisfy error performance requirements.

A Type I error denies access to an authorized enrolled individual. A Type II error grants access to an unauthorized individual. Subsystem Type I and Type II error rates must both be less than 0.1 percent. At the error rates, subsystem access throughput rate must be minimum of 12 individuals per minute through one card reader and keypad access control device.

2.4.3 Access Control System Central Processing

a. Provide serial management and control of system processing. Provide a microprocessor control device able to monitor and control units and up to 32 card reader and keypad access control devices. Central processor must interrogate and receive responses from each ACU within 100 milliseconds. Failure to respond to an interrogation is to cause an alarm.

b. Provide the central processor with a Ethernet interface port to communicate with the printer. Provide an operator interface to control system operating functions. Provide the central processor with a facility-tailorable data base for a minimum of 1000 cardholders with by-name alphanumeric printout, and for automated monitoring, management, and control functions.

c. Provide enrollment equipment as required in paragraph ENROLLMENT CENTER EQUIPMENT.

d. Provide system configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the central processor. Components are not to be accessible to operations personnel and must be tamper alarmed.

2.4.4 Access Control Unit(ACU)

UL 294. Provide micro-processor based ACU with all access and input and output decisions to be made by the individual ACU(s). Provide modular solution which will allow for present security requirements and the capability to expand. Configure all field ACU panels to intercommunicate via RS-422/485 or RS-232 hardwired, TCP/IP or fiber-optic communication. Equip all field ACU(s) with a tamper contact.

Designate one ACU as "Primary", responsible for all ACS-to-ACU communications. All other ACU(s) up to a maximum of 256 are to be designated as "Secondary" and communicate with the "Primary" via an RS-422/485 hardwire, TCP/IP network or fiber-optic configuration. Provide ACU capable of, but not limited to, the following:

a. Built-in surge suppression circuitry on plug-in modular circuit boards with surge suppression, configured as an integral component of the system and self-sacrificing in the event of extreme surges or spikes.

b. Capable of supporting at least 2 ports and be expandable in increments of two ports up to a maximum of 16 ports per ACU.

c. Each port configured by ACS to support any one of the following peripheral devices:

(1) Card reader

(2) Alarm Monitoring Module

(3) Output Relay Module

(4) Elevator Reader

(5) Elevator Output Module

Any device combination can be supported on each ACU, up to a total of 16 devices per ACU.

d. Capability of supporting multiple card reader technologies simultaneously, including:

(1) Keypad

(2) Card and Keypad

(3) CAC compatible

(4) Biometrics

This capability must be an integral part of the ACU and will not require special external equipment.

e. Built-in battery back-up of programmed information sustainable for a period of at least 90 days.

f. Powered by a 24 VDC power source rated at a minimum of 2 amperes with a battery back-up for complete system operation in the event of power failure. Provide battery backup for all ACU(s) to sufficiently power the ACU for 8 hours continuous service.

g. Electric strikes, other locking devices and ancillary peripherals on a separate power supply with battery back-up for continued operation in the event of power failure as specified in paragraph "Backup Power".

h. A minimum of a 10,300 event log buffer per ACU to record and hold access and alarm activity information until the ACS is connected and receives the information. Provide a software-configurable warning log buffer filling notification for ACU(s) configured with network switch capabilities.

2.4.5 Access Control Devices

UL 294. The card, card reader, and panels must meet encryption requirements that are specified in paragraph DATA ENCRYPTION. Devices are to be tamper alarmed, tamper and vandal resistant, and solid state, containing no electronics which could compromise the access control subsystem should the subsystem be attacked.

2.4.5.1 Card Readers

Provide surface, semiflush, pedestal, or weatherproof mountable card readers as indicated for each individual location. Provide contact type card readers capable of reading CAC cards type of access control cards.

Keypads must contain an alphanumeric and special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence . Provide keypad as a stand-alone device or integrated into the card reader.

2.4.5.1.1 Contact Card Readers

Provide contact card readers that can read credential CAC cards whose characteristics of size and technology meet those defined by ANSI ISO/IEC 7816 and are in compliance with NIST FIPS 201-2.

Provide readers with "flash" download capability to accommodate card format changes and the capability of reading the card data and transmitting the data, or a portion thereof, to the ESS control panel.

2.4.5.1.2 Contactless Card Readers

Provide contactless card readers that can read credential CAC cards whose characteristics of size and technology meet those defined by ANSI ISO/IEC 7816 in close proximity to the card reader and are in compliance with NIST FIPS 201-2.

Provide readers with "flash" download capability to accommodate card format changes and the capability of reading the card data and transmitting the data, or a portion thereof, to the ESS control panel.

2.4.5.1.3 Card Reader Display

Provide card readers with an LED or other visual indicator display which indicate power ON and OFF and whether user passage requests have been accepted or rejected.

2.4.5.1.4 Card Reader Response Time

The card reader is to respond to passage requests by generating a signal to the local processor.

2.4.5.1.5 Card Reader Power

Power the card reader from the source as shown on the drawings. The card reader must not dissipate more than 5 Watts.

2.4.5.1.6 Card Reader Mounting Method

Provide card readers suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.

2.4.5.2 Keypads

Entry control keypads are to use unique alphanumeric and other symbol combinations as an identifier. Keypads must contain an integral alphanumeric and special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence . Communications protocol is to be compatible with the local processor.

2.4.5.2.1 Keypad Display

Keypads are to include an LED or other type of visual indicator display and provide visual and audible status indications indicating power ON and OFF and whether user passage requests have been accepted or rejected.

The maximum horizontal and vertical viewing angles are to be limited by the keypad display or enclosure. The maximum horizontal viewing angle must be no more than plus and minus 5 degrees off a vertical plane perpendicular to the plane of the face of the keypad display. The maximum vertical viewing angle must be no more than plus and minus 15 degrees off a horizontal plane perpendicular to the plane of the face of the keypad display.

2.4.5.2.2 Keypad Response Time

The keypad is to respond to passage requests by generating a signal to the local processor.

2.4.5.2.3 Keypad Power

Power the keypad from the source as shown on the drawings. The keypad must not dissipate more than 5 Watts.

2.4.5.2.4 Keypad Mounting Method

Provide keypads suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.

2.4.5.2.5 Keypad Duress Codes

Provide a means for users to indicate a duress situation by entering a special code into the keypad.

2.4.5.3 Card Readers with Integral Keypad

Equip contact and contactless card readers with integral keypads as specified in paragraph "Keypads".

2.4.5.4 Access Control Cards

Provide cards with the capability of modification and lamination during enrollment process without readability reduction for use as a picture and identification badge. Cards must contain binary coded data arranged in a scrambled pattern as a unique identification code stored on or within the card and of the type readable by the subsystem card readers. Include a non-duplicated unique facility access control subsystem identification code common to access control cards within the card binary data. Configure cards for use as a photo identification card suitable for lamination.

2.4.5.4.1 Credential Card Modification

Provide entry control cards that can be modified by lamination or direct print process during the enrollment process for use as a picture and identification badge as needed for the site without readability reduction. Credential cards must allow adding at least one slot or hole for a clip affixing the credential card to the type badge holder used at the site.

2.4.5.4.2 Card Size and Dimensional Stability

Provide credential cards that are 2-1/8 x 3-3/8 inches. The credential card material must be dimensionally stable so that an undamaged card with deformations resulting from normal use is readable by the card reader.

2.4.5.4.3 Card Materials and Physical Characteristics

Provide credential cards that are abrasion resistant, non-flammable, and present no toxic hazard to humans when used in accordance with manufacturer's instructions. The credential card are to be impervious to solar radiation and the effects of ultra-violet light.

2.4.5.4.4 Card Construction

Provide credential cards of core and laminate or monolithic construction. Hot stamp into material or direct print onto lettering, logos and other markings. Provide a means to allow onsite assembly and credential cards lamination by Government.

2.4.5.4.5 Card Durability and Maintainability

The credential cards must yield a useful lifetime of at least 5 years. The credential card must be able to be cleaned by wiping the credential card with a sponge or cloth wet with a soap and water solution.

2.4.5.4.6 Warranty

Include a minimum 3-year warranty.

2.4.5.5 Portal Control Devices

Portal control devices must meet the requirements in Section 08 71 00 DOOR HARDWARE.

2.4.5.5.1 Push-Button Switches

a. Provide momentary contact, back lit push buttons and stainless steel switch enclosures for each push button. Provide switch enclosures suitable for flush or surface mounting as required and push buttons suitable for flush mount in the switch enclosures. The push button switches are to meet the requirements of NEMA 250 for the area in which they are to be installed.

b. Where multiple pushbuttons are housed within a single switch enclosure stack vertically with each push button switch labeled with 1/4 inch high text and symbols. The push button switches are to be connected to the local processor associated with the portal to which they are applied and operate the appropriate electric strike, electric bolt or other facility release device.

c. The continuous current of the IDS circuit is to be no more than 50% of the continuous current rating of the device supplied. Provide push button switches with double-break silver contacts that will make 720 VA at 60 amperes and break 720 VA at 10 amperes.

2.4.5.5.2 Panic Bar

Include panic bar emergency exit hardware on emergency exit doors as indicated. Provide an alarm shunt signal from the panic bar emergency exit hardware to the appropriate local processor. Provide panic bar compatible with mortise- mount door hardware and operate by retracting the bolt.

2.4.5.5.2.1 Emergency Egress With Alarm

Include a conspicuous warning sign with 1 inch high, red lettering notifying personnel that an alarm will be annunciated if the panic bar is operated.

Panic bar hardware operation is to generate an intrusion alarm. The panic bar must depend upon a mechanical connection only and not depend upon electric power for operation, except for local alarm annunciation and alarm communications.

2.4.5.5.2.2 Normal Egress

Panic bar hardware operation is not to generate an intrusion alarm. The panic bar must depend upon a mechanical connection only when exiting. Provide the exterior, non-secure side of the door with an electrified thumb latch or lever to provide access after the credential I.D. authentication by the ESS.

Signal Switches: Strikes/bolts are to include signal switches indicating to the system when the bolt is not engaged or the strike mechanism is unlocked. The signal switches are to report a forced entry to the system.

2.4.5.5.2.3 Delay Egress With Alarm

Include a conspicuous warning sign with 1 inch high, red lettering notifying personnel that an alarm will be annunciated if the panic bar is operated.

Delay operation 15 seconds after initiation for portal control devices.

2.4.5.5.3 Electric Door Strikes and Bolts

Configure electric door strikes and bolts to release automatically in case of power failure using DC power to energize the solenoids. Incorporate end-of-line resistors to facilitate line supervision by the system. Install metal-oxide varistors (MOVs) to protect the controller from reverse current surges if not incorporated into the electric strike or local controller. Electric strikes must have a minimum forcing strength of 2300 pounds.

2.4.5.5.3.1 Solenoid

The actuating solenoid for the strikes and bolts furnished must not dissipate more than 12 Watts and operate on 12 VDC. The inrush current must not exceed 1 ampere and the holding current must not be greater than 500 milli-amperes. The actuating solenoid must move from the fully secure to fully open positions in not more than 500 milliseconds.

2.4.5.5.3.2 Signal Switches

Strikes and bolts are to include signal switches indicating to the system when the bolt is not engaged or the strike mechanism is unlocked. The signal switches are to report a forced entry to the system.

2.4.5.5.3.3 Tamper Resistance

The electric strike and bolt mechanism is to be encased in hardened guard barriers to deter forced entry.

2.4.5.5.3.4 Size and Weight

Electric strikes and bolts are to be compatible with standard door frame preparations.

2.4.5.5.3.5 Mounting Method

Provide electric strikes and bolts suitable for use with single and double door installations, with mortise- type hardware as indicated, and compatible with right or left hand mounting.

2.4.5.5.3.6 Astragals

See Section 08 71 00 DOOR HARDWARE for Astragal lock guards.

2.4.5.5.4 Electrified Mortise Lock

Configure electrified mortise locks to remain secure in case of power failure using DC power to energize the solenoids. Provide solenoids rated for continuous duty. Incorporate end-of-line resistors to facilitate line supervision by the system. Install metal-oxide varistors (MOVs) to protect the controller from reverse current surges if not incorporated into the electric strike or local controller.

2.4.5.5.4.1 Solenoid

The actuating solenoid for the mortise locks furnished must not dissipate more than 12 Watts and operate on 12 VDC. The inrush current must not exceed 1 ampere and the holding current must not be greater than 500 milli-amperes. The actuating solenoid must move from the fully secure to fully open positions in not more than 500 milliseconds.

2.4.5.5.4.2 Signal Switches

The mortise locks are to include signal switches indicating to the system when the locks are not engaged. The signal switches are to report a forced entry to the system.

2.4.5.5.4.3 Hinge

Provide an electric transfer hinge with each mortise lock in order to get power and monitoring signals from the lockset to the door frame.

2.4.5.5.4.4 Size and Weight

Electrified mortise locks are to be compatible with standard door preparations.

2.4.5.5.4.5 Mounting Method

Provide electrified mortise locks suitable for use with single and double door installations. The lock would be in the active leaf and the fixed leaf would be monitored in double door installations.

2.4.5.5.5 Electromagnetic Lock

Electromagnetic locks are to contain no moving parts and depend solely upon electromagnetism to secure a portal by generating at least 1200 pounds of holding force. Interface the lock with the local processors without external, internal or functional local processor alteration. Incorporate an end-of-line resistor to facilitate line supervision by the system. Install MOVs to protect the controller from reverse current surges if not incorporated into the electromagnetic lock or local controller. Provide in accordance of ANSI/BHMA A156.23.

2.4.5.5.5.1 Armature

The electromagnetic lock is to contain internal circuitry to eliminate residual magnetism and inductive kickback. The actuating armature must operate on 12 VDC and not dissipate more than 12 Watts. The holding current must be not greater than 500 milli-amperes. The actuating armature must take not more than 300 milli-seconds to change the status of the lock from fully secure to fully open or fully open to fully secure.

2.4.5.5.5.2 Tamper Resistance

The electromagnetic lock mechanism is to be encased in hardened guard barriers to deter forced entry.

2.4.5.5.5.3 Mounting Method

Provide electromagnetic lock suitable for use with single and double door installations with mortise- type hardware as indicated, and compatible with right or left hand mounting.

2.4.5.5.6 Entry Booth

a. Entry booths are to be constructed as an integral part of the physical structure of the boundary for the area or facility to which entry is being controlled. The entry booth is to automatically lock the high security side door's electrified mortise lock or other facility interface release device and automatically open the low security side door's electric strike or other facility interface release device in case of power failure.

b. Connect entry booths to the SCC and include a local processor. The entry booth local processor subsystem are to support paired card readers on a single entry booth for anti-pass back functions.

c. Provide the entry booth with egress capabilities.

2.4.5.5.6.1 Local Alarm Annunciation

Provide local alarm annunciation for all system equipment located within the entry booth itself and its associated portals or zones and terminal devices and a means to enable and disable this feature from the SCC under operator control.

2.4.5.5.6.2 Terminal and Facility Interface Device Support

The entry booth local processor subsystem is to support the full range of system terminal and facility interface devices as specified.

2.4.5.5.6.3 Response Times

The entry booth local processor subsystem must respond to a SCC interrogation within 100 milliseconds. The entry booth local processor is to respond to valid passage requests from its associated terminal devices by generating a signal to the appropriate electrified mortise lock within 100 milliseconds after verification.

2.4.5.5.6.4 Autonomous Local Control

In the event of a communication loss, the entry booth local processor subsystem must automatically convert to autonomous local control and monitoring of its associated card readers, keypads, electrified mortise lock and automatically revert to central control upon communication restoration. Transactions occurring during the communications outage are to be recorded and retained in local memory and reported to the central database files upon communication restoration within 10 seconds.

2.4.5.5.6.5 Entry Booth Local Processor Subsystem Capacities

As a minimum, the entry booth local processor subsystem is to have sufficient capacity to control and monitor a combination of 6:

a. Card readers

b. Keypads

c. Electric strikes and bolts

d. Electrified mortise lock

e. Electromagnetic lock

All entry control identification decisions and controls are to be performed by the local processor subsystem. The entry booth local processor subsystem must provide a local transaction history file with capacity to store at least 1000 entry control transactions without losing any data.

2.4.5.5.6.6 Diagnostics

Provide built-in diagnostics implemented in software, firmware, or hardware. The booth is to automatically execute a series of built-in tests and report equipment malfunctions, configuration errors, and inaccuracies to the SCC each time the entry booth local processor subsystem is started up or re-booted. The system must annunciate a fail-safe alarm if the local processor fails the built-in diagnostics. Provide diagnostic aids within the entry booth local processor subsystem to aid in system set-up, maintenance, and troubleshooting.

2.4.5.5.6.7 Memory Type and Size

Data entered is to be stored for a minimum of 1 year in the absence of power from external source to the entry booth.

2.4.5.5.6.8 Tamper Protection

The local processor subsystem is to monitor all service entry panels for tamper. Tamper lines must not be accessible except through tamper protected entry panels. Provide entry panels with key locks. Provide the capability to take the booth off-line for service.

2.4.5.5.6.9 Entry Booth Configuration

Provide a closed-in structures suitable for occupancy by 1 person with a personnel passage area, equipment storage, a low security entry or exit door and a high security entry or exit door. Configure with paired card readers , 1 each, on the high security entry or exit door and low security entry or exit door; a key release switch outside the low security door; a glass break type emergency release switch. Both doors to the entry booth are to be normally secured.

2.4.5.5.6.10 Entry Booth Operation

a. Configure to allow passage requests to be initiated from only 1 door at a time. During emergency situations both doors must have the capability to able to be opened at the same time. The person is to be allowed entry to the booth by presenting valid credential card to the card reader or keypad identification code data to the keypad device. An unsuccessful attempt to enter the booth are to generate an entry denial alarm.

b. Incorporate a personal identity verification device as specified, and grant the person egress from the booth after successful personal identity verification. The entry booth is to confine the person and generate an entry control alarm if the person fails the personal identity verification test. The local processor is to grant the person's passage request if all provided data is valid.

c. The person is to be confined if a tamper alarm is generated by any of the equipment associated with the subject entry booth while a person is inside. Operating the glass break type emergency release switch is to command the entry door electrified mortise lock release to the fully open position or with a delay after the egress door has been confirmed secured. The person may exit through the door used for entry once inside the entry booth and prior to personal identity verification test initiation.

2.4.5.5.6.11 Display Type

Include an LED or other type of visual indicator display and provide visual status indications and person prompts. The display is to indicate power on/off, and whether enrollee passage requests have been accepted or rejected. Provide 3 status lights outside each door indicating entry booth status by marking:

a. Green light indicates READY

b. Amber light indicates BUSY

c. Red light indicates INOPERATIVE

2.4.5.5.6.12 Lighting

Provide lights recessed above an acrylic light diffuser in the ceiling of the entry booth. Provide a separate light source within the overhead lighting fixture assembly to provide emergency lighting in case of a power failure.

2.4.5.5.6.13 Heating and Ventilation Equipment

Include built-in heating and cooling equipment to sustain the specific operating temperature range for the electronic equipment installed.

2.4.5.5.6.14 Entry Booth Wall and Frame Construction

Provide a rigid structure with the strength of the walls greater than or equal to 12-gauge steel with 1 inch standing seams. All glass is to be at least 5/16 inch laminated, annealed glass and meeting UL 972 certification requirements. The entry booth must meet flame spread rating 25 or less, fuel contribution of 50 or less, smoke development of 50 or less, in accordance with test method ASTM E84.

Provide entry booths constructed to minimize the heating effects of solar radiation, by using the manufacturer's standard clear, tinted or bronzed glass with over-hanging roofs or other structural means to shade the windows.

2.4.5.5.6.15 Entry Booth Doors

Doors must be at least 35 inches wide, by 79 inches high with glass panels at least 31 inches wide, by 74 inches high. Provide door hinges and closers with adjustments for vertical, horizontal, and torque. Provide an inside push bar, and an outside mechanical pull handle. Aluminum parts are to be anodized finish.

2.4.5.5.6.16 Entry Booth Floor Construction

Provide entry booth with a rigid floor covered by a rubber mat or indoor or outdoor carpeting. The rubber mat or carpet must be at least 1/16 inch thick and provide a continuous floor covering without seams.

2.4.5.5.6.17 Electrical Requirements

The entry booth, including associated terminal and facility interface and other type of devices housed within the entry booth must not dissipate more than 1500 Watts. Provide booth with an integral battery back-up system. The battery back-up system must power the entry control devices and electrified mortise lock for at least 30 minutes. The doors to the booth are to be secured , and the booth must go into an inoperative status if AC power is not restored to the booth within 30 minutes. Upon AC power restoration, the booth is to upload all entry transactions from the local processor subsystem to the SCC.

2.4.5.5.6.18 CCTV Camera

Design and configure the CCTV camera for continuous operation and transmit video information to the SCC and local video recorder as specified and designed.

2.4.5.5.6.19 Weight Check Monitor

Provide a weight check monitor which continuously monitors the weight of the booth plus any occupant. The weight check monitor is to consist of synchronized, matched, electronic load cells located at the base of the entry booth and be connected to the local processor subsystem. The weight check monitor must be accurate to within plus or minus 5 pounds. Configure the entry booth to compensate for side loading to prevent damage to the load cells by the passage of equipment through the booth. Include individual weights for each user in the reference database files as part of the enrollment process. Provide a method to enter a custom, predefined tolerance on valid weights of authorized persons.

Automatically update each person's weight profile based upon the last three uses of entry control booths. Generate an entry control alarm for any passage attempt for which the person's weight does not agree with system reference database file data and confine the person. The weight check monitor is not to increase the portal door threshold height by more than 1/4 inch.

2.4.5.5.6.20 Double Occupancy Sensor

Incorporate a sensor connected to the local processor subsystem which monitors the entire occupant area to detect attempts at double occupancy. A double occupancy sensor activation is to generate a system alarm and confine the enrollees.

2.4.5.5.6.21 Intercom

Provide three combination speaker and microphones to provide 2-way communications at each speaker and microphone location. The speakers must be at least 4 inches in diameter. Locate two of the speakers and microphones at the high and low security entry or exit doors, behind louvered panels, to provide communications for people outside the booth. The third speaker and microphone is to be located inside the booth behind a perforated metal screen above the personal identity verification device to provide communications for people inside the booth. Connect each of the speakers and microphones to the operator console at the SCC and to the voice prompt system as indicated.

2.4.5.5.6.22 Voice Prompts

Include a voice prompt system using human voice commands to speed up the entry control process and improve throughput rate. This audible prompt system is to respond to the next sequential activity requirement as each employee accesses the booth. All commands are to be stored in electrically programmable read only memory chips located in the local processor subsystem. The voice prompts are to only be directed to the speaker and microphone nearest the employee. Use the voice prompts only if the employee does not perform the next step in the entry booth entry control process within a 5 second time window. The SCC must be able to enable and disable of voice prompts and adjustment of the time window under operator control.

2.4.5.5.7 Vehicle Gate Operator

Provide vehicle gate operators suitable for connection to, monitoring, and control by the system's local processors and include all additional equipment and wiring to be an operable system. Provide a hand crank for the manual vehicle gate operator and a solenoid actuated brake operation to prevent gate coasting.

Provide an auto reverse time delay of at least 1 second and not more than 3 seconds to minimize shock loads on vehicle gate operator drive components. Include a contactor type motor starter that is appropriate for the gate operator motor.

2.4.5.5.7.1 Input Power

Provide vehicle gate operator that operates from the voltage source as shown on the drawings. Include manual reset type thermal and electrical overload devices.

2.4.5.5.7.2 Audible Warning

Provide an audible warning system to signal personnel in the vicinity of the vehicle gate operator that an opening or closing is about to commence. The audible warning must sound at least 2 seconds and no more than 5 seconds before movement begins.

2.4.5.5.7.3 Maximum Run Timer

The vehicle gate operator must incorporate an internal maximum run timer which limits the motor run time. The maximum run time is to be operator adjustable for at least the maximum amount of time gate opening or closing takes during normal operation.

2.4.5.5.7.4 Adjustable Load Monitor for Obstruction Sensing

Provide operator adjustable load monitor that senses obstructions in the path of the gate and automatically reverses the vehicle gate operator drive motor. Do not allow the gate to open once the gate has reached the limit switch.

2.4.5.5.7.5 Operator Override Controls

Provide the vehicle gate operator with an interface to a three pushbutton control station located within an entry controlled area. The three pushbutton switches are to be labeled and function as Open, Close, and Stop controls, and meet the requirements of paragraph Pushbutton Switches.

2.4.5.5.7.6 Limit Switches

Provide adjustable limit switches to define the range of gate travel and provide a means to securely lock the switches in place after adjustment.

2.4.5.5.7.7 Type of Gate

Provide the vehicle gate operators to be compatible with cantilever, roller, v-track, overhead, slide, and swing gates.

2.4.5.5.7.8 Safety

Provide safety compatible with paragraph "Type of Gate" for entrapment protection.

2.4.6 Elevator Control

2.4.6.1 Control Elevator Operation with Entry Control Terminal Devices

The elevator's standard control equipment, components, and actuators have to serve as the facility interface. System components and subsystems must interface with standard elevator control equipment without elevator control equipment modification. The system is to provide a means to define access controlled floors of a facility, deny access to these floors by unauthorized individuals, and implement all other system functions as specified.

2.4.6.2 Floor Tracking

Deploy the elevator control system in such a manner as to provide "floor tracking" reports where the system records the individual's floor selection when elevator control is in effect.

2.5 CLOSED-CIRCUIT TELEVISION (CCTV) SYSTEM

Select system components that conform to the Open Network Video Interface Forum (ONVIF) specification. Provide compatible UL listed CCTV components to provide visual assessment of ESS alarms automatically upon alarm or upon SCC operator selection. Otherwise, the subsystem is to continuously display the coverage area. Display alphanumeric camera location ID on all monitors. Provide the number of alarm monitors as required. The scene from each camera must appear clear, crisp, and stable on the respective monitor during both daytime and nighttime operation. Provide component equipment that minimizes both preventive and corrective maintenance. Provide components from a single manufacturer or justify mixing manufacturer components and demonstrate compatibility in submittal information.

2.5.1 Cameras

2.5.1.1 CCTV Camera

Provide cameras of digital fixed, pan-tilt-zoom (PTZ), or panoramic type as identified on the drawings.

a. Day-Night Color fixed, PTZ or panoramic cameras are to be used in all outdoor environments. Standard fixed, PTZ, or panoramic cameras are to be used for all indoor applications except when backlighting issues are observed. Use Day-Night cameras or standard cameras with backlighting compensation for backlighting or high contrast applications.

b. Provide PTZ cameras with a direct drive motor assembly. Belt driven PTZ camera units are not acceptable. Equip PTZ cameras with a slip ring assembly having an optical interface and be rated for continuous duty. PTZ cameras have to be fully integrated units. The pan-tilt mechanism must be an integral part of the camera.

c. Provide cameras that operate over a voltage range as required 60 Hz Power over Ethernet (PoE) IEEE 802.3.

d. All cameras must be constructed to provide rigid support for electrical and optical systems so that unintentional changes in alignment or microphonic effects do not occur during operation, movement, or lens adjustments.

e. Video Frame Rate: 30 frames per second (fps)

f. Minimum essential requirements for cameras include the following:

2.5.1.1.1 Sensitivity

Minimum Illumination: 0.08 foot-candles at F1.4 color mode; 0.01 foot-candles at F1.4 in the B&W mode.

2.5.1.1.2 Signal-To-Noise Ratio

Show a signal-to-noise ratio of not less than 50 decibels (dB) at Automatic Gain Control (AGC) "Off", weight "On".

2.5.1.1.3 Resolution

Provide a minimum of 2.1 megapixel resolution. The imager must have a minimum of 1920 horizontal x 1080 picture in progressive scan format. Resolution is to be maintained over the specified input voltage and frequency range, and not vary from minimum specification over the specified operating temperature range.

2.5.1.1.4 Synchronization

Provide cameras that have internal and line lock.

2.5.1.1.5 Low Light Level

Provide Day-Night cameras that have a B-W mode that may be automatically engaged on low light level and permit the use of an external infrared illuminator. Electronic removal of the color signal is not acceptable. The camera must have an infrared cut filter capable of being removed automatically upon low light threshold or manually.

2.5.1.2 Camera Lenses

Camera lenses are to be all glass with coated optics. Provide lens mount that is , compatible with the cameras selected . Provide lens with the camera that have a maximum f-stop opening of f/1.2 or the maximum available for the focal length specified. The lens is to have an auto-iris mechanism unless otherwise specified. Lenses having auto iris, manual iris, or zoom and focus functions are to be supplied with connectors, wiring, receiver and driver units, and controls as needed to operate the lens functions. Provide lenses with sufficient circle of illumination to cover the image sensor evenly. Lenses are not to be used on a camera with an image format larger than the lens is configured to cover. Provide lens with focal lengths as indicated or specified in the manufacturer's lens selection tables.

2.5.1.3 Camera Housing and Mounts

The camera and lens are to be enclosed in a tamper resistant housing installed on a camera support. Any ancillary housing mounting hardware needed to install the housing at the camera location is to be provided as part of the housing. The camera support must be capable of supporting the mounted equipment and withstanding wind and ice loads normally encountered at the site.

2.5.1.3.1 Environmentally Sealed Camera Housing

The housing is to provide an environment needed for camera operation and be condensation free; dust and water tight; keep the viewing window free of fog, snow, and ice, and be fully operational in 100 percent condensing humidity. Provide housing equipped with a sunshield. Both the housing and sunshield are to be white. Purge the housing of atmospheric air and pressurized with dry nitrogen, equipped with a fill valve, overpressure valve, and include a humidity indicator visible from the exterior. Housing must not have a leak rate greater than 2 psi at sea level within a 90 day period.

Provide housing equipped with supplementary camera mounting blocks or supports needed to position the camera and lens to maintain the proper optical centerline. All electrical and signal connections required for camera and lens operation are to be supplied. Provide a mounting bracket as part of the housing which allows weight adjustment to center the weight of the assembly.

2.5.1.3.2 Indoor Camera Housing

Provide housing with a tamper resistant enclosure for indoor camera operation and with the proper mounting brackets for the specified camera and lens. The housing and appurtenances color are not to conflict with the building interior color scheme.

2.5.1.3.3 Interior Mount

Provide camera mount suitable for either wall or ceiling mounting and have an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum or steel with a corrosion-resistant finish. Provide adjustable head with 360 degrees of pan and plus or minus 90 degrees of tilt.

2.5.1.3.4 Low Profile Ceiling Mount

Provide tamperproof ceiling housing which is low profile and suitable for use in 2 by 2 foot ceiling tiles. The housing must be equipped with a camera mounting bracket and allows a 360 degree viewing setup.

2.5.1.3.5 Interior Dome Housing

The dome housing is to be capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings. The lower dome is to be black opaque acrylic and have a light attenuation factor of not more than 1 f-stop. Provide housing with:

a. Integral pan-tilt complete with wiring

b. Wiring harnesses

c. Connectors

d. Receiver-driver

e. Pan-tilt control system

f. Pre-position cards

g. Heavy duty bearings

h. Hardened steel gears

i. Permanent lubrication

j. Motors that are thermally or impedance protected against overload damage.

k. Any other hardware and equipment as needed to provide a fully functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

2.5.1.3.6 Exterior Dome Housing

Provide dome housing capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings and constructed to be dust and water tight, and fully operational in 100 percent condensing humidity. Purge the housing of atmospheric air and pressurize with dry nitrogen. Provide a fill valve and overpressure valve with a pressure indicator visible from the exterior. The housing is to be equipped with supplementary camera mounting blocks or supports as needed to position the specified camera and lens to maintain the proper optical centerline.

Provide all electrical and signal connections required for camera and lens operation. The housing is to provide the environment needed for camera operation. The lower dome is to be black opaque acrylic with a light attenuation factor of not more than 1 f-stop. Provide housing with:

a. Integral pan-tilt complete with wiring

b. Wiring harnesses

c. Connectors

d. Receiver-driver

e. Pan-tilt control system

f. Pre-position cards

g. Heavy duty bearings

h. Hardened steel gears

i. Permanent lubrication

j. Motors that are thermally or impedance protected against overload damage.

k. Any other hardware and equipment as needed to provide a fully functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

2.5.1.3.7 Exterior Wall Mount

Provide exterior camera wall mount that is 36 inches long, and has an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum, stainless steel, or steel with a corrosion-resistant finish. Provide adjustable head for at least plus and minus 90 degrees of pan, and at least plus and minus 45 degrees of tilt. If to be used in conjunction with a pan-tilt, provide bracket without the adjustable mounting head, and a bolt hole pattern to match the pan-tilt base.

2.5.1.3.8 Pan-Tilt Mount

a. Provide pan-tilt mount capable of supporting the camera, lens, and housing specified that is weatherproof and sized to accommodate the camera, lens and housing weight plus maximum wind loading encountered at the installation site if the pan-tilt is to be mounted outdoors. Provide pan-tilt with:

   (1) Heavy duty bearings

   (2) Hardened steel gears

   (3) Externally adjustable limit stops for pan and tilt

   (4) Mechanical, dynamic, or friction brakes

   (5) Permanent lubrication

   (6) Motors that are thermally or impedance protected against overload damage.

b. Provide pan movement of 360 degrees pan rotation, a minimum tilt movement of plus and minus 90 degrees. Manual pan speed must be a minimum of 0 to 80 degrees per second , and a minimum tilt speed of 10 degrees per second . A minimum automatic pan speed of 280 degree per second and tilt speed of 160 degree per second .

c. The pan-tilt is to be supplied complete with wiring, wiring harnesses, connectors, receiver-driver, pan-tilt control system, pre-position cards, or any other hardware and equipment as needed to provide a fully functional pan-tilt mount to fulfill the site design requirements.

2.5.1.3.9 Explosion Proof Housing

The explosion proof housing must meet the requirements in paragraph "Component Enclosure" for hazardous locations. Configure housing to provide a tamper resistant enclosure and supply with the proper mounting brackets for the specified camera and lens.

2.5.2 Thermal Imaging System

IP Thermal Cameras

a. Provide an integrated thermal imaging device in an environmental enclosure.

b. Provide a native digital image from the image sensor to the IP video stream.

c. Provide of an uncooled, sun-safe amorphous silicon micro bolometer, long-wavelength infrared (LWIR) camera capable of 640 x 480 and 384 x 288 resolution formats.

d. Provide a temporal Noise Equivalent Temperature Difference (NETD) below 50mK at f/1.0 capable of multiple display formats including white hot, black hot, and rainbow.

e. Allow for input voltage of , , a selectable power source of 120 VAC.

f. Provide a built-in heater and defroster and sun shroud in accordance of paragraph "Component Enclosure".

g. Support two simultaneous, configurable video streams. MJPEG and H.264 compression formats that are available for primary and secondary streams with selectable Unicast and Multicast protocols. The streams are to be configurable in a variety of frame rates, bit rates, and group of pictures (GOP) structures.

h. Use a standard Web browser interface for remote administration and camera parameter configurations.

i. Provide a 100Base-TX network port for live streaming to a standard Web browser.

j. Provide built-in video analytics.

2.5.3 Video Analytics (VA)

2.5.3.1 Software

Provide capability range from basic activity detection to the search through databases to pre-empt serious incidents. The VA is to provide graphic identified movement identification, user-selectable monitored areas, compensation for environmental movement, and other features specified. Provide the following features:

2.5.3.1.1 Basic Motion Detection

a. Adaptive Motion

b. Abandoned Object

c. Object Removal

d. Camera Sabotage

e. Directional Motion

f. Object Counting

g. Loitering Detection

h. Stopped Vehicle

2.5.3.1.2 Advanced VA

2.5.3.1.2.1 Intruder Identification

This refers to identifying unauthorized humans in specified areas within the field of view.

2.5.3.1.2.2 Environmental Compensation

Recognizing and ignoring wind-blown debris, animals, background traffic, and so on.

2.5.3.1.2.3 Counting

This refers to recognizing a quantity of a particular object moving or activity performed.

2.5.3.1.2.4 Directional Identification

This refers to the ability to ignore objects moving in one direction, while alarming for objects moving in unauthorized directions.

2.5.3.1.2.5 Item Recognition

This refers to activation when specific user-selected items are removed from, placed in, or passed through the field of view.

2.5.3.1.2.6 Subject Tracking

Highlighting and following a specific person or item as it moves about the field of view, or from the field of view of one camera to another.

2.5.3.1.2.7 Multiple Subject Tracking

Highlighting and following multiple persons or items simultaneously as they move about the field of view, or from the field of view of one camera to another.

2.5.3.2 Embedded VA

2.5.3.2.1 Intelligent Video Analysis

a. Provide camera capable of processing and analyzing video within the camera itself, with no extra hardware required.

b. The camera is to be capable of detecting and sending alarms for abnormal events.

c. The camera is to be configurable to analyze up to 10 different scenes for one or more of the following events:

(1) Line Crossing

(2) Loitering

(3) Idle Object

(4) Removed Object

(5) Conditional Change

(6) Trajectory Tracking

(7) Filters

d. The camera is to allow users to set up to 10 separate profiles and switch profiles based on a day, night, or holiday schedules.

e. The camera is to support scene tours that automatically reposition the camera to each scene for a specified duration.

f. The camera is to incorporate an Alarm Rule Engine, enabling abnormal events that VA detects to prompt the camera to take one or more actions:

(1) Trigger a relay connected to an alarm siren, strobe, or both.

(2) Trigger a visual alert to be displayed on the operator's screen.

(3) Go to a specified scene (preset position).

2.5.3.2.2 Motion Tracking with PTZ Cameras

a. The camera is to offer Intelligent Tracking to continuously track an object using pan, tilt, and zoom actions.

b. The camera is to provide automatic motion tracking using intelligent video analytics.

c. Provide camera with the ability to follow an object continually when passing behind a privacy mask.

d. Provide camera with the ability to restart tracking if a target starts moving in the same area where the initial target stopped moving or if the camera detects an object moving along the last known trajectory.

e. The camera is to allow an operator to select an object to track in the live image view.

2.5.4 Color Video Monitors

Except as specified, provide video monitors that:

a. Are rated for continuous operation and incorporate printed circuit board modular construction.

b. Have printed circuit modules that are easily replaceable.

c. Use solid-state devices for electronic circuits.

d. Are constructed to provide rigid support for electrical systems so that unintentional changes in alignment or microphonic effects will not occur during operation or movement.

e. Incorporate circuit safety margins of not less than 25 percent where possible, with respect to power dissipation ratings, voltage ratings, and current carrying capacity.

f. Have a diagonal viewing angle that nominally measures [19] [24] [42] [50] [_____] inches for monitors, [LCD] [LED] displays.

g. Provide adequate safeguards to protect personnel from exposure to line voltage during operation or adjustment.

h. Have at least the following essential requirements:

(1) Resolution for [LCD] [LED] monitors to be: 17 inch monitors - 1280x1024, 500 TV lines (maximum); 20.1 inch monitors - 1600x1200 (maximum)

(2) Geometry: No point in the active raster is to deviate from its correct position by more than 2 percent of raster height.

2.5.4.1 Mounting and Identification

a. Mount monitors and other devices to facilitate easy replacement.

b. The printed circuit board functions and component numbers or markings are to be easily read.

c. Mount monitors in a [19 inch rack] [desk top console].

d. Protect monitors from circuit overloads by fuse or fuses in the power source line. Mount power source line fuses in finger-operated extractor fuse posts. Fuse holders are to be located in a readily accessible position.

2.5.4.2 Video and Signal Input

Monitors are to operate with video input requiring a one HDMI nominal composite video signal switchable to either loop-through or internal 75-ohm terminating impedance.

Signal input connectors must be HDMI type.

2.5.5 Ancillary Equipment

Equipment is to consist of the items specified below:

2.5.5.1 Video Date and Time Generator

The video time and date is to originate from either the camera, video, video recorder, [or time server].

2.5.5.2 Camera Identifiers

Label video signal from each camera using alphanumeric identifiers. Camera alphanumeric identifiers may originate from either the camera or the video recorder.

2.5.5.3 Video Recording

2.5.5.3.1 Digital Video Recorder (DVR)

Provide DVR with [4] [8] or [16] [_____] video channels. The DVR will record all cameras onto a hard drive and allow remote network viewing via [internet] [intranet] browser. Hard drive capability must be sized to store all cameras recording 24 hour a day, 7 days a week at [3] [6] [9] [15] [ ] frames per second per camera for [1] [2] [4] [_____] weeks.

2.5.5.3.2 Hybrid Video Recorder (HVR)

Provide HVR with a maximum of [8] [16] [24] or [32] [_____] analog video channels and a maximum [24] or [32] analog and IP cameras. The HVR will record all cameras onto a hard drive and allow remote network viewing via [internet] [intranet] browser. Hard drive capability must be sized to store all cameras recording 24 hours a day, 7 days a week at [3] [6] [9] [15] [_____] frames per second per camera for [1] [2] [4] [ ] weeks.

2.5.5.3.3 Network Video Recorder (NVR)

a. Provide NVR with an integral software ESS-CCTV server function. Dedicated CCTV monitors and authorized computers networked to the NVR are to be capable of viewing recorded and live video from the network. The NVR is to be able to record and transmit video with up to 30 fps at maximum camera resolution. The NVR is to network with and utilize smaller, non-server computers at off-site camera locations as local recorders.

b. Provide NVR with the capability to de-warp live and recorded images.

c. The storage memory capacity of the NVR (including local recorders) is to be sufficient to store a minimum of [7] [14] [30] [_____] days of video at [3] [6] [9] [15] [_____] fps, [2.1] [_____] megapixel resolution and be expandable for an increased capacity of [_____] [GB] [TB] and be capable of including Redundant Array of Independent Disc (RAID) arrays [0] [1] [5] [10] [_____].

d. The NVR must have the capacity to address and process up to [8] [16] [24] [32] or [128] [_____] dual-streaming cameras. The NVR must record all cameras onto a hard drive and allow remote network viewing via [internet] [intranet] browser. Hard drive capability must be sized to store all cameras recording 24 hours a day 7 days a week at [3] [6] [9] [15] [_____] frames per second per camera for [1] [2] [4] [ ] weeks.

2.5.5.3.4 Video Recording Performance

The video recording performance is to be as follows:

a. The [DVR] [HVR] [NVR] is to use modular hard disk media, with a digital format capacity of [160GB] [250GB] [_____] per module.

b. Provide a [4] [9] [16] [_____] channel triplex video multiplexer capable of performing encoding, recording and multiscreen viewing modes simultaneously. Provide [4] [9] [16] channels of live, simultaneous video images in which all [__] channels are refreshed at [__] frames per second.

c. Provide a [10-100Base-T] [_____] connection for record review and camera view and control that is compatible for a PC workstation equipped with latest [Microsoft Windows [_____] Professional operating system software], [Microsoft Internet Explorer version [_____]] [Internet Browser Software].

d. PC workstation Viewing: Include direct access from the ESS PC workstations to each [DVR] [HVR] [NVR] via a Microsoft Internet Explorer Web Browser. All necessary descriptive bookmarks and shortcuts are to be prepared on each PC workstation to allow this direct access. All functions are to be accessible through HTML commands from a user's web browser interface. Pictures are to be available for attachment via a user-provided SMTP-based e-mail transport system, and included capability for 16 users and 3 user access levels (admin, control and user).

e. Include sampling at 720(H) by 480(V) and 320(H) by 240(V) (Pixel Memory) with [___] frames per second and 3-D scan conversion to enable jitter-free stabilized pictures in a single frame. Modes include:

(1) Emergency

(2) Event

(3) Schedule

(4) Manual Recording

f. Each camera is to support individual Recording Rate and Image Quality settings for each mode (Emergency, Event, Schedule and Manual Recording). This array of Camera Recording Rate and Image Quality settings by the Recording Modes is to form one of four Program Actions. The Program Action is to be assignable to a Time Table to form one of 16 Independent Recording Profiles. Allow each Recording Profile to be manually activated, activated via RS-232C interface, automatically activated by Time Table, or activated by separate alarm or emergency inputs.

g. Digital display on the monitor and also recording of the following information to included:

(1) Year

(2) Month

(3) Day

(4) Hour

(5) Minute

(6) Second

(7) Alphanumeric camera location ID up to 8 characters. The [DVR] [HVR] [NVR] is to feature video loss detection on all channels.

h. Pre-event recording: Buffer at least 20 seconds of pre-event pictures simultaneously for all individual camera channels.

i. Motion-based Recording: Advanced integrated VMD is to be used to detect a specific area, direction and motion duration for each camera channel, independently and simultaneously. Motion Search may be executed for a single camera channel for a selected area on the image.

j. Disk Partitioning: Provide within the [DVR] [HVR] [NVR] an automated disk management and a RTOS (real-time operating system) platform to include a minimum of [4.8] [_____] TB of digital video storage on a single partition.

The video recording system is to provide a choice of Physical Partitioning as RAID [0] [1] [5] [10] [_____] or Disk Mirroring redundant array recording. Allow the operator to be able to partition the available recording areas in a Virtual Partition by Regular, Event, and Copy Partitions. Manually and Scheduled recorded video information is to be assigned to a Regular Recording Partition, which may be overwritten. Event and Emergency Recording Data is to be assignable to an Event Partition, where image overwriting is be prohibited. Any copied data is to be able to be assigned to the Copy Partition, which may be overwritten or saved as required.

k. Playback: Permit direct camera selection for recording playback of any of [4] [9] [16] [_____] video sources at the same time as multiscreen viewing and multiplexed camera encoding (triplex multiplexer capability).

l. Multiplexer Functions: Include an integral, programmable switcher with programmable dwell time and camera order that automatically switches multiple camera images to enable sequential spot monitoring and simultaneous field recording. Provide switcher with separate spot, multiscreen, multiscreen-RGB, and cascaded video monitor outputs. The unit must have full screen, [4] [7] [9] [10] [13] [16] multiscreen monitoring modes.

m. Outputs

(1) Provide via BNC female connections [4] [9] [16] [_____] looping outputs for all video source connections to external monitoring systems including multiscreen and spot monitor video outputs.

(2) Provide via RCA phone jacks [four] [_____] channels of audio connection, including audio loop through.

(3) Provide via High Speed (480 Mbps) serial interface [one] [_____] External Storage connection.

(4) Provide via High Speed (480 Mbps) serial interface [one] [_____] External Copy connection.

(5) Provide [two] [_____] independent Video Outputs assignable to [Multiscreen] [Spot functions].

(6) Provide [one] [_____] Cascade output for connecting [3] [_____]

additional digital video recorders for centralized control using a single video monitor.

(7) Provide virtual camera number programming capability to support 64 camera channels on a single system.

(8) Provide [one] [_____] independent RGB Video output, capable of monitoring all DVR functions.

n. All camera selection buttons are to have Tri-State Indication, corresponding to Recording, Viewing and Control functions on actual [DVR] [HVR] [NVR] hardware. PC emulation is not an acceptable alternative. Furnish the following indicators:

(1) Alarm

(2) Alarm Suspend

(3) Operate

(4) HDD1, Hard drive identifier

(5) Timer and Error indicators

(6) Camera Selection

(7) Iris

(8) Preset

(9) Camera Automatic Mode

(10) Pan-Tilt

(11) Set

(12) Jog Dial

(13) Shuttle Dial

(14) Setup-Esc

(15) Record

(16) Search

(17) Play-Pause

(18) Pan-Tilt Slow

(19) Stop

(20) Pan-Tilt Go to Last

(21) Zoom-Focus

(22) A-B

(23) Repeat

(24) Shift

(25) Alarm Reset Buttons

o. Networking: All [DVR] [HVR] [NVR] recording, review, playback, camera control and setup are to be available via the internally mounted Network Interface. A [10-100Base-T] [_____] connection for record review and camera view and control will be required on a personal computer equipped with Internet Browser Software and an Ethernet 100Base-T connection. Permit direct camera selection for recording playback of any of [4] [9] [16] [_____] video sources at the same time as multiscreen viewing and multiplexed camera encoding (triplex multiplexer mode). Support a minimum of [8] [_____] simultaneous clients viewing and [2] [ ] simultaneous FTP sessions.

p. Power: The video recording equipment must have a power source of [120] [230] VAC at [50] [60] Hz.

2.5.5.4 Camera Control

Provide access to camera functions and control for all cameras via the multiplexer for all camera control, set-up and alarm functions, including preset sequence, digital motion detector mask set, and back light compensation set-up. Controllable camera functions are to be accessible via front panel controls or the optional system controller. These functions are to include:

(1) Direct access of preset position

(2) Zoom (near/far)

(3) Focus (near/far)

(4) Iris (open/close)

(5) Pan (left/right)

2.5.6 Camera Mounting Structures

Provide camera mounting structures designed specifically for CCTV cameras. The structure is to accommodate appropriate wiring pathways for power and communication as well as proper grounding and surge protection. Design loads for the camera mounting structure must conform to TIA-222 and all applicable addendums of the TIA standard. Allowable pole deflection is determined from the point of the camera mount and must not exceed 0.5 percent of the pole height under adjusted maximum wind load conditions. Adjusted maximum wind load conditions for deflection calculations must be 30 miles per hour (mph) or 35 percent of the basic wind speed as determined by TIA-222, whichever is greater. Confirm compliance to TIA standards by structure manufacturer data or by analysis. Provide additional measures as required to stabilize the camera if placed in an environment that is subject to induced vibrations such as heavy winds or excessive traffic.

2.6 SECURITY COMMAND CENTER (SCC)

The SCC must integrate all subsystems and communications, and provide operator control interface to the ESS system. The components are as follows:

a. ESS Software

b. Monitoring Display Software

c. Graphical Map Software

d. Printers

e. Controls and Display Integration

f. Enrollment Center Equipment

2.6.1 ESS Software

a. Provide commercial off-the-shelf ESS software that utilizes a single database for the subsystem integrations provided under a single operating environment. The system is to archive all events in a database stored either on a local hard drive or a networked database server. The software has to support configuration and simultaneous monitoring of all subsystems.

b. Allow the networked PC workstation configurations connected via a TCP/IP network. Administrative tasks including configuration, monitoring, schedules, report generation and graphic display are provided from any PC workstation on the network. All system programming data must be instantly accessible to every PC Workstation connected to the network. The system is to utilize a non-proprietary SQL-based, ODBC-compliant database, managed by Sybase Adaptive Server Anywhere, Microsoft SQL Server, or Oracle.

c. Utilize a preemptive multi-tasking operating system, such as the latest Microsoft Windows [_____] Professional environment, that is multitasking, with many processes running at the same time without interference with each other and with higher priority tasks taking precedence over lower priority tasks.

d. Provide capabilities to define visual exclusion areas.

[e. Provide de-warping software for panoramic cameras.

]2.6.1.1 Alarm Call up

Support responses to alarms entering the system with each alarm capable of initiating one or more of the following actions:

a. Sending alarm commands to a CCTV system interface

b. Triggering [DVR] [HVR] [NVR] event recording

c. Activating output devices

d. Playing PC audio files

e. Controlling doors

f. Display graphical maps associated with the alarm device

Provide mode of system operation that requires an operator to acknowledge any alarm. While alarm is still active, the alarm cannot be cleared.

2.6.1.2 Programming

Provide the capability of, but not limited to, the following programming and functionality:

2.6.1.2.1 Daylight Savings Time Adjustment

The ACU(s) and PCU(s) must not need to be connected to the ESS in order for the adjustment to occur.

2.6.1.2.2 Operator Privileges

Support an unlimited number of system operators, each with a unique login and password combination. Operators are to be assigned privileges based on the loops, commands, or programming features that are available to each individual operator.

2.6.1.2.3 Alarm Priorities

Provide the ability for each alarm device to be user configured to belong to one of [10,000] [_____] priority levels which are assigned to an alarm based on alarm importance. These priorities are to define which alarm events to display on individually specified ESS workstations.

2.6.1.2.4 Reports

Include integrated reporting capabilities as well as the ability to run [Crystal Report] [_____] templates.

2.6.1.2.5 User Interface

The ESS programming is to be menu-driven, with "wizards" to assist with software configuration, and include 'Help' information.

2.6.1.2.6 Messages

Permit the use of user-selected colors for event messages.

2.6.1.2.7 Graphics

Provide the capability to display a floor-plan graphic for card activity and alarm events as part of the ESS integration.

2.6.1.2.8 Device Status

Provide the capability to display the dynamic status of a user-selected list of devices, including doors, inputs, and outputs.

2.6.1.2.9 Diagnostics

Include diagnostic software tools that interface and query the hardware for information and to issue commands.

2.6.1.2.10 Mandatory Data Fields

Require any cardholder data field to be selected by the user as mandatory.

2.6.1.2.11 User Defined Data Fields

Provide [20] [_____] unassigned data fields for storing user-defined data that support user-defined labels, and are user-configurable as plain text fields or drop-down selection lists.

2.6.1.2.12 Archive Database

Include a connection to an archive database which stores purged events and deleted programming and which can be accessed for reporting.

2.6.1.2.13 Programmable Database Backup

Include the capability of performing user-scheduled database backups without the use of third-party backup software.

2.6.1.2.14 Programmable Database Purging

Include the capability of performing user-scheduled database purging, moving selected events to an archive database when the events have aged a user-specified number of days.

2.6.1.2.15 Database Importing

Include the capacity to import user data from an ODBC data source (Access, Excel, text).

2.6.1.2.16 Data Exporting

Include the capacity to export data from any table in the database to either a [text] [HTML] [Excel] [Access] file in any user-selected order.

2.6.1.2.17 Event Log Output

Include the capacity to send a continuous stream of user-selected types of event messages to a text file, serial port, or TCP/IP address.

2.6.1.2.18 Data Audit Trail

Record changes to programming, recording the date and time stamp of the change, the name of the operator making the change, and the nature of the change. This data audit is to be available in history for reporting.

2.6.2 ESS Monitor Display Software

ESS Monitor display software is to provide for text and graphic map displays that include zone and device status integrated into the display. Different colors are to be used for the various components and real time data. Colors must be uniform on all displays. Follow the color coding as follows.

a. FLASHING RED to alert an operator that a zone has gone into an alarm or that primary power has failed.

b. RED to alert an operator that a zone is in alarm and that the alarm has been acknowledged.

c. YELLOW to advise an operator that a zone is in access.

d. GREEN to indicate that a zone is secure or that power is on.

2.6.3 Graphical Map Software

a. ESS graphical map software is to show the [graphic and] visual data of all subsystem devices. Use a [19] [21] [30] [42] [_____] inches, [LCD] [LED] flat screen display with messages displayed in the English language. Provide graphical maps showing a layout of all the protected facilities. Highlight zones corresponding to those monitored by the ESS on the graphical maps. Display status of each zone using graphical icons as required within each designated zone.

b. Provide capability for graphical maps to be linked together using a layered tree structure. For example, a top-level map might be a top view of the site and its buildings, the next level the individual buildings floor, followed by a map of the area on a floor containing the device in alarm. Allow for [3] [6] [_____] layers of maps to be defined for any given ESS device. To speed an incident location, each map level contains a clearly visible indicator as to which sub map the operator should select next to find the device that is in alarm.

c. The ESS may also be configured to display a map automatically on a new alarm presentation, providing the operator with prompt visual indication that an alarm has occurred.

d. The status of intrusion devices, access control readers, doors, auxiliary monitor points, and auxiliary outputs is to be able to be requested from any map by simply selecting the icon representing the device and its current state will be displayed. CCTV camera control, digital video review, alarm panel transactions and intercom requests are to be available for inclusion on the map with the associated management module installed.

e. Allow for SCC operators to change a current setting by pressing the right mouse button anywhere on the screen or on a specific system device icon. Pressing the right mouse button is to cause the appropriate command options list to appear for selection. Confirmation is provided by reflecting the change in status on the display after a command is selected.

f. The display of intrusion or auxiliary door alarms may be automatically enabled or disabled by the use of timed commands, either by device or by a group of devices. This may be used, for example, to disable all door alarms on internal doors, during normal office hours.

g. Create maps using standard office tools allowing drawings to be imported in Jpeg, Bitmap, Windows metafile, PDF or DXF file formats to provide maximum flexibility.

2.6.4 Printers

2.6.4.1 Report Printer

Provide a laser text printer to generate reports that is a [USB] [wired network (RJ45)] interface dry-type laser process printer. Provide a printer with the capability of holding a minimum of 500 pages. The unit must print a minimum of 30 pages per minute at 600 dpi resolution.

2.6.4.2 Alarm Printer

Provide an alarm printer interconnected to the SCC equipment with a minimum print rate of 30 characters per second to produce hard copy of system events. Printer meet requirements per paragraph REPORT PRINTER.

[2.6.4.3 Badge Printer

Provide a dye-sublimation or resin thermal transfer type image printer for Badge Identification credentials that is capable of printing two sides, edge to edge, directly onto a white-unfinished 0.030 PVC, PVH or PVCH card at a rate of approximately 80 seconds per card. [Provide an encoder to be an integral part of the printer with encoding conforming to ABA Track II and ANSI specifications].

]2.6.5 Control and Display Integration

Integrate human engineer SCC controls so the entire SCC can be operated by a single or multiple operator(s). Integrate switching and monitoring components of the assessment subsystem with the SCC so that SCC operator(s) can effectively monitor, assess alarms and control the ESS. [Method of system integration must be as a single console. Provide chassis, and modules required for console SCC configuration.]

2.6.6 Enrollment Center Equipment

Provide enrollment stations to enroll personnel into, and disenroll personnel from, the system database. The enrollment equipment is to only be accessible to authorized entry control enrollment personnel. Provide credential cards for all personnel to be enrolled at the site plus an extra [25] [_____] percent for future use. The enrollment equipment is to include subsystem configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the SCC. Provide a printer for the enrollment station which meets the requirements of paragraph "Report Printer.

2.6.6.1 Enrollment Center Accessories

a. Provide a steel desk-type console and equipment racks. The console is to be as specified in ECIA EIA/ECA 310-E and as indicated.

b. Rack-mount all equipment in the console and equipment racks, except for printer. Color coordinate the console and equipment racks and cabinets, obtaining approved by the Contracting Officer.

c. Provide a locking cabinet approximately 6 feet high, 3 feet wide, and 2 feet deep with three adjustable shelves, and two storage racks for storage of CDs, DVDs, printouts, printer paper, ink/toner, manuals, and other documentation.

2.6.6.2 Enrollment Center I.D. Production

a. Equip the enrollment center with a high-resolution digital camera structurally mounted, or provided with a reliable tripod. The camera model is to be as recommended by the manufacturer of the ESS. Provide commercial off-the-shelf components.

b. Design and provide a lighting system sufficient for quality, still-video capture.

c. Equip the enrollment center with a die-sublimation [_____] printer capable of printing directly to the access control or I.D. credential. Provide printer toner kits and other printing supplies to complete the initial enrollment by 200 percent.

2.6.6.3 Enrollment Center Software

Provide database management functions for the system, and allow an operator to change and modify the data entered in the system as needed. The enrollment station is not to have any alarm response or acknowledgment functions as a programmable system function. Multiple, password-protected access levels are to be provided at the enrollment station. Database management and modification functions are to require a higher operator access level than personnel enrollment functions. Provide a means for disabling the enrollment station when it is unattended to prevent unauthorized use.

Provide a method to enter personnel identifying information into the entry control database files through enrollment stations to include a credential unit in use at the installation. In the case of personnel identity verification subsystems, this data is to include biometric data. Allow entry of this data into the system database files through the use of simple menu selections and data fields. The data field names is to be customized to suit user and site needs. All personnel identity verification subsystems selected for use with the system are to fully support the enrollment function and be compatible with the entry control database files.

2.7 COMMUNICATIONS

a. Communications are to link together subsystems of the ESS and be in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. Interfaces between subsystems cannot be accomplished by use of an electro-mechanical relay assembly. Communications links must be supervised. Provide common communications interface devices throughout the ESS. Provide dry contact sensor to control unit interface that is normally OPEN or normally CLOSED, except as specified otherwise.

b. Use digital, asynchronous, or multiplexed data control unit for central alarm reporting and display processor interface. Group individual data bits into word format and transmit as coded messages. Implement interface with network switches which function as a communications controller, perform data acquisition and distribution, buffering message handling, error checking, and signal regeneration as required to maintain communications.

c. Provide totally automatic status changes communication, commands, field initiated interrupts, and any other communications required for proper system operation. Do not require system communication operator initiation or response. System communication is to return to normal after any partial or total network interruption including power loss or transient upset. Automatically annunciate communication failures to the operator with communication link identification that has experienced a partial or total failure.

2.7.1 Link Supervision

2.7.1.1 Hardwire Direct Current Line Supervision

Provide only for the sensor to control unit links which are within the ESS protected area. Supervise circuits by monitoring changes in the current that flows through the detection circuit and a terminating resistor of at least 2.2 K ohms. Supervision circuitry is to initiate an alarm in response to opening, closing, shorting, or grounding of conductors by employing Class C standard line security. Class C circuit supervisor units are to provide an alarm response in the annunciator in not more than one second as a result of the following changes in normal transmission line current:

a. Five percent or more in normal line signal when it consists of direct current from 0.5 through 30 milliamperes.

b. Ten percent or more in normal line signal when it consists of direct current from 10 microamperes to 0.5 milliamperes.

c. Five percent or more of an element or elements of a complex signal upon which security integrity of the system is dependent. This tolerance will be applied for frequencies up to 100 Hz.

d. Fifteen percent or more of an element or elements of a complex signal upon which the security integrity of the system is dependent. This tolerance will be applicable for all frequencies above 100 Hz.

2.7.1.2 Hardwire Alternating Current Supervision

Supervision is not to be capable of compromise by use of resistance, voltage, or current substitution techniques. Use this method on circuits which employ a tone modulated frequency-shift keying (FSK), interrogate-and-reply communications method. Supervisory circuit are to be immune to transmission line noise, crosstalk, and transients. Terminate detection circuit by complex impedance. Maintain line supervision by monitoring current amplitude and phase. Size complex impedance so that current leads or lags the driving voltage by 45 plus or minus 5 degrees.

Alarm when rms current changes by more than 5 percent, or phase changes by more than 5 degrees for supervision current of 0.5 to 30 milliamperes rms. Alarm when rms current changes by more than 10 percent, or phase changes by more than 8 degrees for lines with supervision currents of 0.01 to 0.5 milliamperes. Identified line supervision alarm must be communicated within one second of the alarm.

2.7.1.3 Hardwire Digital Supervision

Local processors are to exchange digital data to indicate secure or alarm at least every 2 seconds. Alarm if data is missed for more than one second for passive supervisory circuits. Coding used for data cannot be decipherable by merely viewing data on an oscilloscope. Supervisory circuits are to asynchronously transmit bursts of digital data for transponder schemes. Data pattern is to be random in nature. Remote detectors are to receive data and encode a response based on a proprietary coding scheme.

Provide a unique encoding scheme; [an industry-wide or vendor standard is not acceptable.] Transmit encoded response back to supervisory circuit. Supervisory circuit is to compare the response to an anticipated response. Alarm on failure of the detector to return a data burst or return an incorrect response.

2.7.2 Hardwire

2.7.2.1 Electrical Conductor Lines

a. Use electrical conductor lines for hardwire that rely on current path except for electrical wires; neutral conductors of electrical distribution systems cannot be used as signal transmitters.

b. Conductors outside the protected area are to be [shielded cable] [buried] [[installed in rigid galvanized steel conduit] [installed in electrical metallic tubing (EMT)] as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM]. Supervision circuitry is not to initiate nuisance alarms in response to normal line noise, transients, crosstalk, or in response to normal parametric changes in the line over a temperature range of minus 30 to 125 degrees F.

c. Ambient current levels chosen for line supervision must be sufficient to detect tampering and be within the normal operating range of electrical components. Report line supervision and tamper alarms regardless of mode of operation.

d. Provide hardwire links as specified in UL 1076 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM for interior applications with additions and modifications specified. Conductors are to be copper. Conductors for links which also carry AC voltage, are to be No. 12 AWG minimum; single conductors for low-voltage DC links are to be No. [14] [16] AWG minimum. Conductors are to be color coded. Conceal wiring in finished areas of new construction and wherever practical in existing construction if not otherwise precluded by the Government.

e. Identify conductors within each enclosure where a tap, splice, or termination is made. Identify conductors by plastic-coated, self-sticking, printed markers or by heat-shrink type sleeves. Connect sensors, control units, and communication devices so that removal will cause a tamper alarm to sound. Pigtail or "T" tap connections are not acceptable. Each conductor used for identical functions is to be distinctively color-coded. Each circuit color-coded wire is to remain uniform throughout circuit. Tamper switches meet requirements of paragraph TAMPER SWITCHES.

2.7.2.2 Communication Link

a. Provide a dedicated circuit communication link from sensor to control unit. Opening or closing a relay contact will indicate an alarm. Convert analog signals to digital values or a relay closure or opening within 250 feet of the sensing point. Communications from control unit to central alarm reporting and display processor are to operate in a continuous interrogation and response mode, using time-multiplexed digital communications techniques at a data rate of [5.12] [10.24] [_____] kilobaud.

b. Interrogation and response communications between the control unit and central processor is to be half-duplex and bidirectional on one dual twisted pair cable (one pair for interrogation and one for response), which may have one or more parallel branches. Individual control unit lines are to be at least 22 AWG wire. Connect control wires in parallel to the hardwire link. Communication system is to provide as many as [255] [_____] control unit connections.

c. The communication system must maintain specified performance over a link length of 7500 feet when operating without line repeaters or other signal regenerating or amplifying devices. The communications system must maintain specified performance over a link length of 75,000 feet when operating with signal-regenerating line repeaters.

d. Control unit to central alarm reporting and display processor communications link is to also be capable of operating over a maximum of [two] [four] [_____] standard voice grade telephone leased or proprietary lines. Link is to be capable of operating half duplex over a Type 3002 data transmission pair and be capable of modular expansion. Telephone lines will be provided by the Government. Coordinate and check out system operation. General characteristics and telephone line service are to be as follows:

Connections	Two- or four-wire
Impedance at 1000 Hz	600 ohms
Transmitting level	0 to 12 dBm
Transmitting level adjustment	3 dB increments
Type	Data
Direction	Two-way alternate (half duplex)
Maximum speed	[1.2] [5.12] [10.24] [_____] kilobaud
Maximum loss at 1000 Hz	33 dB

2.7.3 Radio Frequency Link

a. Provide a full duplex, supervised RF, polling system specifically used for alarm data communications with components manufactured by one manufacturer operating in the VHF, [134 to 154 MHz] [_____] band. System is to interface directly with ESS hardwire data link from control unit to central alarm reporting and display location and is to translate (reduce) the data rate for RF transmission, modulate and demodulate the data signal, and transmit and receive ESS data.

b. Provide a factory-tested complete RF link which both automatically and upon operator command transmits a signal with a unique identification from the central alarm monitoring location to the control unit locations. Message receipt at control unit location is to be ignored by all units except the addressee. Unit with the correct address is to decode the interrogation signal and respond to the interrogation with the status of the reporting sensors. Re-interrogate when the addressee fails to respond. Alarm upon failure to respond a second time.

c. Remote units in the RF system are to be individually polled in turn. Polling response time and transmission data rate, data error rate, and equipment reliability is to ensure that overall ESS alarm annunciation time reliability and Pd is not degraded.

d. Provide RF transmitters, receivers, or transceivers in sufficient quantities to meet specified requirements. RF link transmissions are to be on one or more of the frequencies within the specified band as required to meet specified requirements and neither interfere with other ESS components nor any facility electronic components. Provide transmitters which are in accordance with applicable requirements of 47 CFR 15.

e. Message types and content are to be identical to those transmitted by other portions of the ESS data communications subsystem. ESS alarms sent by RF link are not to fail, and are to be transmitted by the RF link due to event occurrence during "off air" periods. RF link is to provide message transmission priority in the following order:

   (1) Intrusion alarms

   (2) Tamper alarms

   (3) Access denial alarms

   (4) Other alarms on a first-in, first-out basis including loss of communication signal, fail-safe, low battery, and power loss.

f. Provide [omnidirectional, coaxial, half-wave dipole] [_____] antennas for alarm transmitters and transceivers with a driving point impedance to match transmission output. Provide antennas and antenna mounts that are corrosion resistant and able to withstand wind velocities of [100] [_____] mph and physical damage caused by vandalism. Antennas cannot be mounted directly to any facility fence or roofing system.

g. Provide antennas from the same manufacturer as the rest of the RF link. Provide coaxial cable in lengths as required. Cables are to use PL-type fittings or connectors, properly protected against moisture. Cables must match transmitter output impedance.

2.7.4 Data Encryption

Incorporate data encryption equipment on data transmission circuits as shown on the drawings. The algorithm used for encryption must be the [Advanced Encryption Standard (AES) algorithm described in NIST FIPS 197] of [TDES], ASC/X9 X9.52, as a minimum. Data encryption must be in accordance with NIST FIPS 140-2.

2.7.5 Network Switch

The small form-factor pluggable (SFP) is to provide full-duplex 1000/100/10-Mbps connectivity between switches over [multimode fiber (MMF)] [single mode (SM)] infrastructures. Provide mounting accessories for a typical [field distribution box] [cabinet] [rack]. Rack requirements as specified in paragraph EQUIPMENT RACK.

2.7.5.1 Inside Plant

Provide a network switch for ESS system with [8] [12] [24] [48] [_____] SFP Ethernet ports. Allow dynamic port base security and rapid spanning tree protocol with VLAN assignments for specific users regardless of where the switch is connected. The switch will use AC input voltage nominal of [120] [230] VAC at [50] [60] Hz. The switch is to be less than 2 Rack Units (RU) and Layer 3 capable. The switch is to have the capability of commanding a self-healing ring configuration. 1000Base-LX SFP Fast Ethernet Interface Converter is to be a hot swappable device that plugs into a Gigabit fiber SFP uplink port on the switch. The switch is to be a fully managed power over Ethernet (PoE) to all ports. Provide switch capable of using a Layer 3 (routed) port to connect to a LAN gateway port for Internet and web base access. The Mean Time Between Failure (MTBF) must be greater than 210,000 hours.

2.7.5.2 Outside Plant

Provide hardened managed Ethernet switch with a minimum of [6] [8] [12] 10/100/1000 switched RJ-45 ports and two 1000 Mb fiber ports designed for unconditioned outdoor applications. The switch is to be sealed, conduction cooled, use a rugged case with no fans and no air vent openings. The ambient operating temperature range is 40 to 170 degree F. The software includes SNMP, QoS, Telnet, Security, STP, VLAN, BootP / DHCP.

2.7.6 Video and ESS Transmission

Transmission is to be by optical fiber dedicated to the associated circuit. Video and ESS transmission cables must conform to the industry standards in [Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM] [Section 27 21 10.00 40 FIBER OPTIC DATA TRANSMISSION SYSTEM] [33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP)].

Install interior cable in [Rigid Metal Conduit (RMC)] [Electrical Metallic Tubing (EMT)] conduit unless indicated otherwise. Cable is to be rated for the installation method intended. Install exterior cable underground installed in [Schedule 40] [Schedule 80] Polyvinyl chloride (PVC) conduits.

2.7.7 Wire and Cable

Provide all wire and cable not indicated as Government-furnished equipment. Wiring must meet NFPA 70 standards and as indicated in the Wire and Cable Data Sheets Attachment at the end of this section.

2.7.8 Digital Data Interconnection Wiring

Interconnecting cables carrying digital data between equipment located at the SCC or at a secondary control and monitoring site is to be optical fiber cable. Interconnecting cables conform to the industry standards in [Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM] [Section 27 21 10.00 40 FIBER OPTIC DATA TRANSMISSION SYSTEM] [33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP)].

2.7.9 Aboveground Sensor Wiring

Sensor wiring is to be 20 AWG minimum, twisted and shielded, 2, 3, 4, or 6 pairs to match hardware. Provide multiconductor wire with a PVC outer jacket.

2.7.10 Direct Burial Sensor Wiring

Sensor wiring is to be 20 AWG minimum, twisted and shielded, 2, 3, 4, or 6 pairs to match hardware.

2.7.11 Local Area Network (LAN) Cabling

Cabling must be in accordance with TIA-568.2, Category 6.

2.7.12 Cable Construction

Provide all cable components that will withstand the environment in which the cable is installed for a minimum of 20 years.

2.8 SECURITY LIGHTING INTERFACE

Provide an interface for control of the security lighting system as specified in [Section 26 55 53.00 40 SECURITY LIGHTING] [Section 26 56 00 EXTERIOR LIGHTING] and as shown on the drawings.

[2.9 MEDICAL FACILITY SYSTEM

2.9.1 Infant Protection Alarm System (IPAS) Performance Requirements

a. Fully integrate the IPAS with the ESS system. Infant abduction alarms (exit alarms and tag tamper alarms) from the IPAS are to be received and processed the same as all other alarms and concurrently routed in real time to all Operator Workstations. Send notifications via radio page or other wireless Personal Communications device to the security unit staff, and paged to the nursing staff in the alarmed unit.

b. The IPAS is to detect and report alarms if an attempt is made to remove an infant tag from the secured nursing area (exit alarm) or of an unauthorized removal of a tag strap from an infant (tag tamper alarm).

c. Wireless readers are to adequately cover all areas of the secured nursing units.

2.9.2 IPAS Major Components

Major components of the IPAS include:

a. Network Adapters

b. Infant Protection Workstations

c. RF Readers

d. Infant Tags

e. Tag Straps

f. External Relay Boxes

g. Door Position Switches

h. Dome Lights with Buzzer Device

i. Electromagnetic Locks & Power Supplies (part of Door Hardware)

j. Card Readers

(1) Remote Display Units (RDU)

(2) Infant Protection Software

2.9.3 Infant Protection Operator Workstations

a. Operation, management and monitoring of the Infant Protection Alarm

Systems are to be performed from Infant Protection Workstations located in the [Nurse Stations] [Labor and Delivery] [Mother Baby Units] for the patient care units served. Locate an additional monitoring workstation at the [Nurse Team Center] [_____] of the [Med Surge Unit] [_____]. Functions performed at these workstations include:

(1) Management of the subsystem for the protected unit

(2) Infant Tag inventory, activation and assignment, and deactivation

(3) Strap inventory and use

(4) Infant data, tag and strap assignment, and discharge

(5) Alarm event reporting and monitoring

(6) Activity and event reports

(7) Display of alarm receivers and status

(8) Video display of alarmed cameras

b. The infant protection operator workstations include:

(1) CPU

(2) Computer keyboard

(3) Mouse

(4) Two video monitors

(5) Printer

(6) Removable media storage unit that provides for offline storage and retrieval of event activity

2.9.4 Remote Display Unit

Locate a RDU and an associated card reader near the secure side of each designated [exit door] [and elevator] to allow authorized staff to quickly suspend an infant tag, so that an infant can be taken out of the secured nursing unit without generating an exit alarm. Allow authorized staff to reactivate the infant tag when the infant is returned to the secured nursing unit. The RDU is to be inoperative until activated by the associated card reader when the card reader senses an access control card from a staff member that is authorized to take the infant out of the secured nursing unit. The RDU is to remain active for a programmed short period of time to allow the transaction to occur and then the RDU is to automatically become inactive.

2.9.5 Operator Interface

The IPAS operator workstations is to enable the real-time display of any alarms on graphical floor plans. Provide graphical display with the ability to select the following views:

a. All tags in the system, or

b. A specific tag

The system operator interface is to enable tags to be easily added or deleted from the system, by either using a button press to identify the tag ID code, or by typing in the tag ID code.

2.9.6 Alarm Management

The IPAS is to support several different types of alarms for the tags, including:

2.9.6.1 Tamper Alarm

This indicates a strap attaching a baby tag has been tampered or disconnected. Display the tag's name, description, and location in the alarm line.

2.9.6.2 Near Exit Alarm

This indicates a tag has moved into the proximity of a monitored exit door or elevator. The tag name, description, and location is to be displayed within 0.5 seconds on the IPAS Operator Workstation, transmit the alarm to radio pagers carried by on-duty security and nursing staff, and transmit the alarm to the system database and system Operator Workstations.

The IPAS is to activate the electrical locks on the doors to the protected area. The doors will automatically unlock either upon the staff clearing the alarm, a power outage to the electrical lock control, an independent activation of the smoke alarm system, or water flow in the sprinkler system. The staff is to have the ability to unlock the doors at any time from inside the unit. The alarm event is to also activate a dome light and buzzer at the door until the alarm is acknowledged. Activation of IPAS will prevent the elevator from opening or stopping on the event floor.

2.9.6.3 Battery Alarm

This indicates the battery of a tag is low and should be replaced. Display the tag name, description, and its location in the alarm line.

2.9.6.4 Failed Communications Alarm

This indicates the network is not working or the database server has been shut down. No tag location or alarm can be performed while this alarm is active.

2.9.6.5 Lost Alarm

This indicates the tag cannot be detected by any reader in the system. Display the tag name, description, and its last-known location in the alarm line.

2.9.7 IPAS Area Wireless Tag Readers

The IPAS area wireless tag readers are to be able to be mounted either in the ceiling or on the walls. Provide readers with 360 degree coverage and an effective read range as required by the IPAS. The system is to assign the tag to the reader with the highest signal strength if more than one area wireless reader detects the tag signal. Multiple area wireless readers are to be able to be installed in a single room to narrow the location down to areas as small as a 10 foot radius using signal strength levels. The area wireless readers are to operate at an unlicensed radio frequency and have all necessary regulatory approvals.

2.9.8 IPAS Door Wireless Reader

The IPAS door wireless readers are to be able to be mounted either in the ceiling or walls. The readers are to transmit within an adjustable range (distance from and width of exit door) of each exit door to limit ifant tags detection within a very short distance of the exit door. The readers are to support wireless fields synchronization if multiple door wireless readers are used to cover a large entry area. The transmission field generated by the door wireless reader is to include an encrypted ID code that can be decoded by tags that enter the field.

2.9.9 Infant Tags and Straps

2.9.9.1 Tag Characteristics

Technology	Very low power wireless transmission
Power Battery	Rechargeable lithium battery with 5 year life
Transmission Rates	As required
LED Indication	Low battery, transmission
Tag ID	Unique factory programmed
Water Resistance	Water proof and completely sealed housing

2.9.9.2 Tag Features

a. Automatically activate when attached to a baby

b. Manufactured with latex free adjustable strap made from skin safe material that includes a soft pad to prevent skin irritation

c. Have a re-adjustable strap to suit ankle shrinkage

d. Be easy to clean

e. Be manufactured with disposable parts, ensuring re-use of tag up to 1000 times without compromising hygiene level

f. Be rechargeable by placing them in a desktop charger that is supplied with the system. Multiple tags can be recharging simultaneously

2.9.10 IPAS Dome Lights

Mount a dome light configured with indicator lamps and a tone device over exit doors from areas equipped with an IPAS. A red light is to illuminate and the tone sound when an exit alarm is activated. The light and tone are to remain on until the exit alarm is acknowledged.

[2.9.11 Radio Page Interface

a. Unit is to interface with the radio page system capability of Section 27 52 24 NURSE CALL SYSTEM. This interface must be a hardwired connection to an input port on the radio page encoder.

b. Route all alarms to the radio page system for transmission to alphanumeric pagers carried by the security staff.

c. Transmitted alphanumeric alarm information is to include the type, location, date, and time of the alarm event.

d. Infant protection alarm event is to be radio paged to the nursing staff in the patient care area where the alarm originated.

]]2.10 SURVEILLANCE AND DETECTION EQUIPMENT

2.10.1 Article Surveillance and X-Ray

Provide X-ray package search system suitable for [automated] [manual] detection and material density identification. The article surveillance is to function as a sensor or detector subsystem and connect to the local processors and alarm monitoring.

The article surveillance and X-ray device are to provide adjustable contrast and a surface area threshold setting. Incorporate a long-term image storage system to document subsystem operations. The article surveillance and X-ray device must have a minimum throughput rate of 600 packages per hour and be rated for continuous operation. The article surveillance and X-ray device must meet the requirements of 21 CFR 1020, Section 1020.40.

2.10.1.1 Size and Weight

The article surveillance and X-ray device is not to exceed 120 inches long, by 40 inches wide, by 60 inches high and not weigh more than 2000 pounds.

2.10.1.2 Local Audible Alarms

Provide local audible alarm annunciation and automatic threat alert based upon an adjustable contrast and a surface area threshold setting. Immediately communicate to and annunciate alarms generated by the article surveillance and X-ray device at the SCC.

2.10.1.3 Maximum Package Size

Allow inspection of packages and other articles up to 15 inches tall, by 24 inches wide, and 60 inches long.

2.10.1.4 X-Ray Tube

Output from the X-ray tube is to be able to penetrate steel up to 1/8 inch thick.

2.10.1.5 Electrical

The article surveillance and X-ray device is to operate from the power source as indicated.

2.10.1.6 Safety

Include dual lead-lined curtains at the entrance and exit to the conveyer system package scanning region. The radiation exposure to operator for each package inspection must be no more than 0.2 milli-roentgens. The article surveillance and X-ray device is not to adversely affect magnetic storage media as it is passed through the device.

2.10.1.7 Display

Use a standard 525 line [LCD] [LED] monitor to present X-ray data to the article surveillance and X-ray device operator. Configure the article surveillance and X-ray device to provide at least 64 gray scale shades or at least 64 distinct colors. The article surveillance and X-ray device is to provide:

a. Image enhancement

b. Zoom

c. Pan

d. Split screen

e. Freeze-frame capabilities

2.10.1.8 Conveyor

Provide article surveillance and X-ray device with a conveyor system with foot switch controls. The conveyor is to be reversible and suitable for intermittent operation with a minimum speed range of 0 to 35 feet per minute.

2.10.1.9 Material Identification and Resolution

The article surveillance and X-ray device is to be able to detect and identify the full range of ferrous and non-ferrous metals, plastics, and other contraband as required. The device resolution, including its display, is to be sufficient to identify a 30 AWG solid copper wire.

2.10.2 Metal Detector

a. The metal detector is to function as a sensor or detector subsystem and connect to the local processors and alarm monitoring. The metal detector is to be rated for continuous operation. The metal detector is to use an active pulsed or continuous wave induction detection field.

b. The metal detector is to create a field detection pattern with no holes or gaps from top to bottom and across the passage area, and provide 100 percent Faraday shielding of the sensor coil. The metal detector is to incorporate measures to minimize false alarms from external sources. Provide a synchronization module to allow simultaneous multiple metal detection subsystem operation, with no sensitivity or function degradation, when separated by 5 feet or more.

c. The metal detector is not to adversely affect magnetic storage media.

d. When incorporated into an entry booth, the metal detector is to be physically compatible with the entry booth configuration and connected to the entry booth local processor subsystem.

2.10.2.1 Size and Weight

Freestanding metal detectors are not to exceed 40 inches deep, by 50 inches wide, by 90 inches high and weigh 350 pounds or less. Metal detectors to be used in entry control booths may have dimensions as needed to fit inside the entry control booth.

2.10.2.2 Local Alarms

Provide metal detector with local audible and visual alarm annunciation that are also immediately communicated to and annunciated at the SCC.

2.10.2.3 Material Identification and Sensitivity

Provide metal detector with a continuously adjustable sensitivity control which allows it to be set to detect 100 grams of ferrous or non-ferrous metal placed anywhere on or in an individual's body.

2.10.2.4 Traffic Counter

Include a built-in traffic counter with manual reset capability. The traffic counter is to be sensor actuated and automatically increment each time a person passes through the metal detector. The metal detector is also to provide visual prompts directing the individual to proceed through the metal detector at the proper time or to wait until the metal detector is reset and ready for another scan.

2.10.2.5 Electrical

The metal detector must not dissipate more than 250 Watts. Neither the metal detector's sensitivity nor its functional capability is to be adversely affected by power line voltage variations of plus or minus 10 percent or less from nominal values.

2.11 BACKUP POWER

a. Intrusion alarms are not to be generated as a result of power switching; however, Provide a power switching indication and on-line source at the alarm monitor.

b. The system is to automatically switch back to the primary source upon primary power restoration. Detect and report failure of an on-line battery as a fault condition. Power products must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

c. Provide backup power to the primary power by [backup batteries in each element or subsystem] [uninterruptible power supply (UPS)].

[2.11.1 Uninterruptible Power Supply (UPS)

Backup power required for uninterrupted ESS operation [until a diesel engine generator set can assume the full load] is to be provided by a UPS.

The UPS is to consist of a rectifier, battery and support racks, a static inverter, static switch transfer, and a manual bypass switch. Provide UPS with a continuous output to supply the maximum load requirements of the ESS. Size the battery to sustain the UPS at full rated load [for [8] [24] [_____] hours] [for 15 minutes] [until diesel engine generator set can assume the load] [_____]. [The UPS is to be in accordance with Section

26 33 53 STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS).]

][2.11.2 Batteries

Provide backup by dedicated batteries in remotely located system elements including individual sensors or control units. Batteries are to be an integral part of dispersed system elements when radio frequency (RF) operation is required. Batteries are to be capable of operation in any position and be protected against venting caustic chemicals or fumes within an equipment cabinet. Provide batteries capable of continuous operation for up to [8] [24] [_____] hours without recharge or replacement.

]2.12 SURGE SUPPRESSION DEVICES

Comply with requirements in Section 33 82 00 TELECOMMUNICATION OUTSIDE PLANT (OSP).

2.13 COMPONENT ENCLOSURE

Alarm enclosures with a tamper switch(es). Refer to paragraph "Tamper Switch". Enclosures is to be formed and assembled to be sturdy and rigid. These include:

a. Consoles

b. Annunciator housings

c. Power supply enclosures

d. Sensor control and terminal cabinets

e. Control units

f. Wiring gutters

g. Other component housings

2.13.1 Interior Sensor

Provide sensors to be used in an interior environment with a housing that provides protection against dust, falling dirt, and dripping noncorrosive liquids. Refer to paragraph "Interior Enclosures" for enclosure ratings.

2.13.2 Exterior Sensor

Provide sensors to be used in an exterior environment with a housing that provides protection against windblown dust, rain and splashing water, and hose directed water. Sensors are not to be damaged by the ice formation on the enclosure. Refer to paragraph "Exposed-to-Weather Enclosures" and "Corrosion-Resistant Enclosures" for enclosure ratings.

2.13.3 Interior Enclosures

Enclosures to house equipment in an interior environment must meet the requirements of NEMA 250 Type [12] [1] [____].

2.13.4 Exposed-to-Weather Enclosures

Enclosures to house equipment in an outdoor environment must meet the requirements of NEMA 250 Type [3R] [4] [4X] [____].

2.13.5 Corrosion-Resistant Enclosures

Enclosures to house equipment in a corrosive environment must meet the requirements of NEMA 250 Type 4X.

2.13.6 Hazardous Environment Equipment

All system electronics to be used in a hazardous environment must be housed in a metallic enclosure which meets the requirements of paragraph "Hazardous Locations."

2.13.7 Metal Thickness

Thicknesses of metal in cast and sheet metal enclosures of all types must be not less than those listed in Tables 8.1, 8.2, and 8.3 of UL 1610 for alarm components, and NEMA ICS 2 and NEMA ICS 6 for other enclosures. Sheet steel used in enclosure fabrication is to be at least 16 gage; consoles are to be at least 18 gage.

2.13.8 Doors and Covers

a. Doors and covers are to be flanged. Provide tight pin hinges or the ends of hinge pins are to be tack welded to prevent ready removal where doors are mounted on hinges with exposed pins.

b. Provide doors having a latch edge length of less than 24 inches with a single lock. Provide the door with a three-point latching device with lock where latch edge of a hinged door is 24 inches or more in length; or alternatively with two locks, one located near each end.

c. The covers of provided junction boxes to facilitate initial system installation are to be held in place by tack welding, brazing, or one-way screws.

2.13.9 Ventilation

Ventilation openings in enclosures and cabinets must conform to requirements of UL 1610.

2.13.10 Mounting

Sheet metal enclosures are to be rated for wall mounting with top hole slotted, unless otherwise indicated. Mounting holes are to be in positions which remain accessible when major operating components are in place and door is open, and be inaccessible when door is closed.

2.13.11 Labels

Label boxes containing connections that they contain ESS connections and indicate that the box is part of the ESS system.

2.13.12 Test Points

Provide readily visible and accessible with minimum disassembly of equipment to test points, controls, and other adjustments inside enclosures. Test points and other maintenance controls must be readily accessible to operator personnel.

2.14 EQUIPMENT RACK

Provide standard 19 inch electronic rack cabinets conforming to UL 50 for the ESS system at the SCC and remote control and monitoring sites as shown on the drawings. Equipment rack must be in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.14.1 Labels

Provide a labeling system for cabling as required by TIA-606 and UL 969. Provide stenciled lettering for voice and data circuits using [thermal ink transfer process][laser printer] [_____].

2.15 LOCKS AND KEY LOCK

2.15.1 Lock

Provide locks on system enclosures for maintenance purposes that meet UL 437 and are [round-key type, with three dual, one mushroom, and three plain pin tumblers] [or] [conventional key type lock having a five cylinder pin and five-point three position side bar combination]. Keys must be stamped "U.S. GOVT. DO NOT DUP.". Keys are only to be withdrawn when in the locked position. Key all maintenance locks alike and furnish only two keys for all of these locks.

2.15.2 Key-Lock Operated Switches

All key-lock-operated switches required to be installed on system components are to be UL 437, [with three dual, one mushroom, and three plain pin tumblers,] [or] [conventional key type lock having a five cylinder pin and five-point three position side bar combination]. Keys must be stamped "U.S. GOVT. DO NOT DUP.". Key-lock-operated switches are to have two positions, with the key removable in either position. Key all key-lock-operated switches differently and furnish only two keys for each key-lock-operated-switch.

2.15.3 Construction Locks

Use a set of temporary locks during installation and construction. Do not include any of the temporary locks in the final set of locks installed and delivered to the Government.

2.16 FIELD FABRICATED NAMEPLATES

Nameplates must comply with ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription is to identify the function and, when applicable, the position.

Nameplates are to be melamine plastic, 0.125 inch thick, white with [black] [_____] center core. Surface is to be matte finish. Corners are to be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 1 by 2.5 inches. Provide lettering a minimum of 0.25 inch high normal block style. Nameplates are not be required for devices smaller than 1 x 3 inches.

2.16.1 Manufacturer's Nameplate

Each item of equipment is to have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.17 FACTORY APPLIED FINISH

Electrical equipment is to have factory-applied painting systems which meets the requirements of the NEMA 250 corrosion-resistance test as a minimum.

PART 3 EXECUTION

3.1 INSTALLATION

Install the system in accordance with safety and technical standards NFPA 70, UL 681, UL 1037, and UL 1076. Configure components within the system with appropriate service points to pinpoint system trouble in less than 20 minutes.

Install all system components, including any equipment that is furnished by the Government, and appurtenances in accordance with the manufacturer's instructions, IEEE C2 and as shown on the drawings, and furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

3.1.1 Existing Equipment

Connect to and utilize existing equipment, control signal transmission lines, and devices as shown on the drawings. Any equipment and signal lines that are usable in their original configuration without modification may be reused with Government approval.

Make written requests and obtain approval prior to disconnecting any signal lines and equipment that creates equipment outage. Such work can proceed only after receiving Government approval of these requests. If any device fails after work has commenced on that device, signal, or control line, diagnose the failure and perform any necessary corrections to the equipment. The Government is responsible for maintenance and repair of Government equipment. The Contractor will be held responsible for repair costs due to negligence or abuse of Government equipment on their part.

3.1.2 Software Installation

Load software as specified and required for an operational system, including databases and specified programs. Provide original and backup copies on [optic discs] [_____] of all accepted software, including diagnostics, upon successful endurance test completion.

3.1.3 Enclosure Penetrations

Enclosures are to be penetrated from the bottom unless shown otherwise. Penetrations of interior enclosures having transitions of conduit from interior to exterior, and penetrations of exterior enclosures are to be sealed with rubber silicone sealant to preclude the entry of water. Terminate conduit risers in a hot-dipped galvanized metal cable terminator that is filled with a sealant as recommended by the cable manufacturer, and in a manner that does not damage the cable.

3.1.4 Cable and Wire Runs

Perform required cable and wire routings per NFPA 70 [and] [Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM,] [ICS 705-1], and as specified. Terminate conduits including flexible metal and armored cable in the sensor or device enclosure. Fit ends of conduit with insulated bushings. Exposed conductors at ends of conduits external to sensors and devices are not acceptable.

3.1.5 Soldering

Soldered electrical connections must use composition Sn60, Type AR or S, for general purposes; use composition Sn62 or Sn63, Type AR or S, for special purposes. Flux must conform to ASTM B32 when Type S solder is used for soldering electrical connections.

3.1.6 Galvanizing

Ferrous metal is to be hot-dip galvanized in accordance with ASTM A123/A123M. Provide screws, bolts, nuts, and other fastenings and supports that are corrosion resistant.

Field welds or brazing on factory galvanized boxes, enclosures, conduits, and so on, are to be coated with a cold galvanized paint containing at least 95 percent zinc by weight.

3.1.7 Conduits

Install interior conduits in accordance with NFPA 70, Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and ICS 705-1. Install exterior conduits in accordance with NFPA 70, Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and ICS 705-1.

3.1.8 Underground Cable Installation

Install underground conductors connecting protected structures and objects to the central alarm updating and display unit as direct burial or in conduit as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Coaxial cable cannot be spliced.

3.1.9 Exterior Fences

Prepare [existing fence] [new fence installation] to ensure a rigid fence system for fence-mounted detection system installation or a detection system where loose fence fabric might prove troublesome. A rigid fence and fence fabric must be provided to minimize nuisance alarms. Fences are to be additionally braced, provided with fabric ground anchors or curbs, tensioning devices, top or bottom rails or both, soft-seated gate latches, and re-anchored outriggers for barbed wire to ensure a vibration-free installation. Relocate large, fence-supported signs to separate support posts to preclude interference with fence detection systems.

3.1.10 Camera Housings, Mounts, and Poles

a. Provide a foundation for each camera pole as specified and designed.

b. Provide a ground rod for each camera pole and connect the camera pole to the ground rod [as shown on the drawings] [as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.]

3.1.11 Field Applied Painting

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting must be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 ADJUSTMENT, ALIGNMENT, SYNCHRONIZATION, AND CLEANING

a. Clean each system component of dust, dirt, grease, or oil incurred during and after installation or accrued subsequent to installation from other project activities subsequent to installation.

b. Prepare for system activation by manufacturer's recommended procedures for adjustment, alignment, or synchronization.

c. Prepare each component in accordance with appropriate provisions of component installation, operations, and maintenance manuals.

d. Remove large vegetation that may sway in the wind and touch fencing.

e. Adjust sensors so that coverage is [overlapping and] maximized without mutual interference.

3.3 SYSTEM STARTUP

Do not apply power to the system until after:

a. Set up system equipment items and communications in accordance with manufacturer's instructions.

b. Conduct a system visual inspection to ensure that defective equipment items have not been installed and that there are no loose connections.

c. Test and verify system wiring as correctly connected.

d. Verify system grounding and transient protection systems as properly installed.

e. Verify the correct voltage, phasing, and frequency of the system power supplies.

Satisfaction of the requirements above does not relieve the contractor of responsibility for incorrect installations, defective equipment items, or collateral damage as result of Contractor work or equipment.

3.4 SUPPLEMENTAL CONTRACTOR QUALITY CONTROL

Provide the services of technical representatives who are familiar with all components and installation procedures of the installed system; and are approved by the Contracting Officer. These representatives are to be present on the job site during the preparatory and initial phases of quality control to provide technical assistance. These representatives are also to be available on an as needed basis to provide assistance with follow-up phases of quality control. These technical representatives are to participate in the system testing and validation and provide certification that their respective system portions meet the contractual requirements.

The above requirements supplement the quality control requirements specified elsewhere in the contract.

3.5 ESS SYSTEM TESTING

All ESS Testing requirements are specified in Section 28 08 10 ELECTRICAL SECURITY SYSTEM ACCEPTANCE TESTING.

3.6 ESS TRAINING

Conduct training courses for [10] [_____] designated personnel in system maintenance and operation. Coordinate training with the Government. The training is to be oriented to the specific system being installed. Training content is to include training manuals and audio-visual materials. Deliver training manuals for each trainee with 2 additional copies delivered for archiving at the project site. The manuals are to include an agenda, defined objectives for each lesson, and a detailed subject matter description for each lesson.

Furnish audio-visual equipment and other training materials and supplies. Deliver copies of the audio-visual materials to the Government either as a part of the printed training manuals or on the same media as that used during the training sessions when course portions are presented using audio-visual material.

3.6.1 ESS Training Outline

Submit a training plan for the training phases, including type of training to be provided, outline of training manuals, training course agendas, and a list of reference material, for Government approval.

3.6.2 Typical Training Day

A training day is defined as:

a. Eight hours of classroom instruction, with

    (1) Two 15-minute breaks

    (2) One hour lunch break

b. Conducted:

    (1) Monday through Friday

    (2) During the daytime shift in effect at a Government-provided training facility

For guidance in planning the required instruction, assume that attendees will have a high school education or equivalent, and are familiar with ESS. Approval of the planned training schedule is to be obtained from the Government at least 30 days prior to the training.

3.6.3 ESS Administrator Training

a. ACS and IDS Administrator Training includes:

    (1) [Two] [_____] eight-hour on-site training sessions

(2) Operating system procedures and configuration

(3) Operator functions

(4) Database functions and setup

(5) Card holder input and deletion procedures

(6) Report generation

(7) Applications programs (as applicable)

(8) Graphics generation and manipulation

(9) Items unique to the ACS and IDS interfaces with other systems

(10) System backup and restore

b. CCTV System Administrator Training includes:

(1) [One] [_____] eight-hour session on site

(2) Training is to include all administrator and operator functions, and items unique to the installed CCTV System, and interfaces with other systems.

3.6.4 ESS Operator Training

Coordinate the operator training syllabus with the Government prior to conducting operator training.

a. ACS and IDS Operator Training includes:

(1) [Four] [_____] (one-day) [8] [_____] hour on-site training sessions

(2) System operating procedures

(3) System configuration orientation

(4) Alarm acknowledgment

(5) Alarm response logging

(6) Graphics functionality

(7) Items unique to the ACS and IDS interfaces with other systems

b. CCTV Operator Training includes:

(1) [Two] [_____] (one-day) [8] [_____] hour on-site training sessions

(2) System operating procedures

(3) System configuration

(4) Video call-up

(5) Camera and monitor control

(6) Graphics functionality

(7) Basic device terminology and troubleshooting

3.6.5 Maintenance Personnel Training

The system maintenance course is to be taught at the project site after endurance test completion for a period of five training days. A maximum of [five] [_____] personnel, designated by the Government, will attend the course. The training includes:

a. Physical layout of each piece of hardware.

b. Troubleshooting and diagnostics procedures.

c. Component repair and replacement procedures.

d. Maintenance procedures and schedules to include system testing after repair.

e. Calibration procedures. Upon course completion, the students are to be proficient in system maintenance.

f. Review of site-specific drawing package, device location, communication, topology, and flow.

3.6.6 Follow-up Training

a. Provide [One] [two] [_____] hour training session each month for [two] [_____] months after initial training.

b. Follow-up training is to begin one month after initial training.

c. Training is to include testing for system competence.

3.7 NAMEPLATE MOUNTING

Provide nameplate number, location, and letter designation as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or rivets.

-- End of Section --

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SECTION 28 31 02.00 20

FIRE ALARM REPORTING SYSTEMS - DIGITAL COMMUNICATORS
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

FM GLOBAL (FM)

FM APP GUIDE (updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1 (2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1 (2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)

ANSI C80.3 (2020) American National Standard for Electrical Metallic Tubing (EMT)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

NFPA 72 (2022) National Fire Alarm and Signaling Code

UNDERWRITERS LABORATORIES (UL)

UL 467 (2022) UL Standard for Safety Grounding and Bonding Equipment

UL 514A (2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes

UL 514B (2012; Reprint May 2020) Conduit, Tubing

	and Cable Fittings
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 DESCRIPTION OF WORK

Work includes provision of labor, material, tools and equipment necessary for and incidental to the provision of a complete and usable base-wide digital alarm communicator fire alarm system. The system shall be in accordance with NFPA 72 and as specified herein. Materials and equipment furnished under this contract shall be the current products of one manufacturer regularly engaged in production of such equipment. Electronics shall be solid state. The system shall be listed by the Underwriters' Laboratories (UL) or approved by Factory Mutual Engineering and Research (FM) as a public fire reporting system, in accordance with NFPA 72. Equipment used to interconnect the system with local building fire alarm systems shall be UL listed or FM approved, in accordance with NFPA 72. As an alternate to the above listing requirements, all equipment shall be UL Fire Prot Dir listed or FM APP GUIDE approved as a proprietary protective signaling system in accordance with NFPA 72, provided the system meets the requirements as specified herein without violating such listing or approval. The system shall conform to the Federal Communications Commission's rules and regulations concerning connection of telephone equipment, systems, and protective apparatus to the public switched telephone network. In the National Fire Protection Association (NFPA) publications referred to herein, the advisory provisions shall be considered mandatory, as though the word "shall" had been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" shall be interpreted to mean the Fire Protection Engineer

1.3 SYSTEM DESCRIPTION

1.3.1 SYSTEM DESIGN

System shall be a complete base-wide public fire reporting system, complying with NFPA 72, except as modified herein. The exterior fire alarm reporting and receiving system shall comply with NFPA 72 . The system shall consist of digital alarm communicator transmitters (DACT) at each protected premise and digital alarm communicator receivers (DACR) at the fire alarm receiving station . The system shall be supervised such that any telephone line connected to a DACT which fails due to loss of line voltage shall be annunciated at the receiving station. The system shall be designed to operate from direct current supplied from a rectifier and from storage batteries. The system shall be designed to record alarm and trouble information from each DACT as well as supervisory alarms received at the DACR. Provide spare DACRs in accordance with NFPA 72. Connect system to existing [and new] local building fire alarm systems, as shown to form auxiliary alarm systems in accordance with NFPA 72.

1.3.2 Power Calculations

Submit design calculations to substantiate battery capacity exceeds supervisory and alarm power requirements for digital alarm communicator transmitters, receiving consoles and interface panels (if provided).

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

The Fire Protection Engineer, will review and approve all submittals in this section requiring Government approval.

SD-02 Shop Drawings

System Floor Plans; G

System Wiring Diagrams; G

SD-03 Product Data

Digital alarm communicator transmitter (DACT); G

Digital alarm communicator receiver (DACR); G

Wiring; G

Battery Power Supply; G

Printers; G

For digital alarm communicator transmitters, submit data for each configuration required by this section.

SD-05 Design Data

Power Calculations; G

SD-06 Test Reports

Preliminary Testing; G

Final Acceptance Test; G

Submit for inspections and tests specified under paragraph titled "Field Quality Control."

SD-07 Certificates

Qualifications of installer; G

Qualifications of system technician; G

System UL Listing or FM Approval; G

SD-10 Operation and Maintenance Data

Digital alarm system, Data Package 5; G

Submit in accordance with Section 01 78 23 OPERATIONAND

MAINTENANCE DATA.

SD-11 Closeout Submittals

System As-built Drawings

1.5 QUALITY ASSURANCE

1.5.1 Qualifications of Installer

The Contractor or installer shall have satisfactorily installed fire alarm reporting systems of the same type and design as specified herein and shall be UL certified for the installation and testing of fire alarm systems.

Prior to commencing fire alarm reporting system work, submit data showing that the Contractor or installer has satisfactorily installed three fire alarm systems of the same type and design as specified herein within the past 3 years. Submit proof of UL certification and a list of installer's personnel.

For each system installed, submit the following:

a. A detailed summary of the type and design of the system;

b. The contract name or number, completion date of the project, and total cost of the system;

c. The name and telephone number of the facility or installation for whom the work was performed; and

d. The name and telephone number of a supervisory level point of contact at the facility or installation who has knowledge of the performance of the Contractor's or installer's work.

1.5.2 Manufacturer's Representative

Provide the services of a qualified manufacturer's representative or technician, experienced in the installation and operation of the type of system being provided to supervise the installation, testing (including final testing), and adjustment of the system. Ensure that the installer is UL certified for the installation and testing of the fire alarm systems. Provide proof of this listing. A list of installers personnel shall be provided as part of the submittal package under the subparagraph titled "SD-07, Certificates."

1.5.3 Qualifications of System Technician

Installation drawings, shop drawings, and as-built drawings shall be prepared by, or under the supervision of, a qualified technician. Qualified technician shall be an individual who is certified by the National Institute for Certification in Engineering Technologies (NICET) as an engineering technician with minimum Level III certification in fire alarm system program. Contractor shall submit data showing the names and certification of the technician at or prior to submittal of drawings.

1.5.4 Regulatory Requirements

Materials and equipment for fire alarm service shall be listed UL Fire Prot Dir or approved by FM APP GUIDE. Provide current materials and equipment of one manufacturer regularly engaged in production of such equipment, and provide items that have performed satisfactorily for at least 2 years prior to bid opening.

1.5.5 Drawing Requirements

1.5.5.1 System Floor Plans

Submit shop drawings of the system floor plans showing locations of fire alarm equipment and devices. Show wire color coding, wire counts, and device wiring order.

1.5.5.2 System Wiring Diagrams

Submit complete wiring diagrams of the system showing points of connection and terminals used for electrical connections in the system. Show modules, relays, switches, and lamps within the equipment.

1.5.5.3 System As-built Drawings

Upon completion, and before final acceptance of the work, furnish to the Contracting Officer 3 complete sets of as-builts drawings, including complete as-built circuit diagrams of the system. The as-built drawings shall be "D" size 850 by 550 reproducible drawings on mylar film drawn to the same scale as the contract drawings and with tile block similar to contract drawings. The as-built drawings shall be furnished in addition to the record drawings required by Division 01.

1.5.6 System UL Listing or FM Approval

Submit copies of current UL Fire Prot Dir listings or FM APP GUIDE approvals for the system in configurations offered, with copies of the actual UL or FM test reports.

1.6 MAINTENANCE

1.6.1 Spare Parts

Furnish the following spare parts:

a. 5 complete sets of system keys

b. 3 sets of fuses of each type and size

1.6.2 Manuals

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Inscribe the following identification on the cover: the words OPERATION AND MAINTENANCE MANUAL, the location of the building, the name of the Contractor, system manufacturer and the contract number. The instructions shall be legible and easily read, with large sheets of drawings folded in. The manual shall include: circuit drawings; wiring and control diagrams with data to explain detailed operation and control of each item of equipment; a control sequence describing start-up, operation and shutdown instructions; installation instructions; maintenance instructions; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts list.

PART 2 PRODUCTS

2.1 DIGITAL ALARM COMMUNICATOR TRANSMITTER (DACT)

Each digital alarm communicator transmitter shall be completely assembled, tested at the factory, and delivered ready for installation and operation. The transmitter electronics package shall be contained within the housing as a complete assembly, removable to facilitate servicing and replacement. The DACT shall be capable of seizing a telephone line at the protected premise and sending digital alarm or trouble information over the telephone network to a DACR. Provide interface device for digital alarm communicator transmitter to be compatible with existing system.

2.1.1 Transmitter Identity Code

Each DACT shall include a unique identity code as part of each transmission. Setting the code shall be readily accomplishable in the field. The specific code number for each DACT shall be as shown on the drawings. Submit in writing, within 30 calendar days after award, the specific code number for each DACT. Obtain the code numbers from the Federal Fire Department, Telephone No. (808) 474-2222.

2.1.2 Transmission Confirmation

Each DACT shall produce an audible or visual indication that the transmitter is operating and a signal is being sent, when the transmission is initiated by an alarm condition or manual test switch.

2.1.3 Automatic DACT Test

Each DACT shall automatically transmit a test message at least once in each 24 hour period. Test message shall also allow manual actuation by means of a secured (not publicly accessible) switch. Automatic actuation shall be initiated by a solid state programmable electronic device. Stability of the electronic device shall be plus or minus one minute per month or better. Test time(s) shall be programmable without removing the DACT from the enclosure.

2.1.4 Battery Supervision

Each DACT shall constantly monitor and supervise its battery power supply. A low battery or trouble message shall be transmitted when battery voltage under load falls below 85 percent of the rated battery voltage, but in any case prior to the point at which the battery will fail to operate the transmitter. This message shall be included as part of every subsequent transmission until the problem is corrected if the battery is the primary source of energy powering the DACT.

2.1.5 Trouble Supervision

Disarrangement of the DACT wiring which prevents proper operation of the DACT, or the abnormal position of any switch shall cause transmission of a trouble message and actuation of a local audible trouble alarm. DACT shall have a switch to silence the audible trouble alarm, however, while the audible alarm is silenced an amber trouble lamp shall remain lit. Upon correction of the trouble conditions, the audible alarm shall again sound until the silencing switch is returned to normal, or the silencing switch may be the momentary action, self-resetting type.

2.1.6 DACT Power Supplies

Each DACT shall be powered by locally available 120 VAC power. Upon loss of AC power, the transmitter shall automatically and instantaneously switch to standby battery power, without loss of any alarm signals. Loss of AC power shall also cause the local audible trouble alarm to sound and a trouble message to be transmitted if power is not restored within 5 minutes. Upon restoration of AC power, transfer back to AC operation and silencing of audible trouble alarm shall be automatic. Power supply filtering shall prevent false message transmissions caused by transient or steady-state electrical disturbances.

2.1.6.1 Battery Power Supply

Batteries shall be spillproof, sealed lead acid or lead calcium. The battery package shall be capable of supplying power requirements of the DACT. DACT standby battery capacity shall provide sufficient power to operate the transmitter in a normal standby status for a minimum of 60 hours and be capable of transmitting an alarm signal at the end of that period. Batteries shall be located within the DACT housing.

Converter/float charger: Under presence of 120 VAC power, DACT batteries shall be charged through a converter/float charger. Charger shall recharge a fully discharged battery in not more than 48 hours while the transmitter is operating under normal conditions (presence of 120 VAC power), or provide a charger which maintains a battery at full charge under normal daily testing load and provide batteries having capacity for 6 months field service without recharge.

2.2 OVERVOLTAGE AND SURGE PROTECTION

2.2.1 Power Line Surge Protection

Protect equipment connected to AC circuits from power line surges. Equipment shall meet the requirements of IEEE C62.41.1 and IEEE C62.41.2.

2.2.2 Communications Link Surge Protection

Protect communications equipment against surges induced on communications links. Install surge protection circuits at each end of cables and conductors, except fiber optics, which serve as communications links, to meet the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Provide protection at the equipment. Install additional triple electrode gas surge protectors, rated for the applications, on each wireline circuit within 3 feet of the building entrance. Do not use fuses for surge protection.

2.2.3 Sensor Wiring Surge Protection

Protect digital and analog inputs and outputs against surges induced by sensor wiring installed outdoors and as shown. Test inputs and outputs with the following waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Do not use fuses or surge protection.

2.3 DIGITAL ALARM COMMUNICATOR RECEIVER (DACR)

Provide two identical DACRs or control consoles. Install both consoles at the main fire alarm watch office as indicated. Each system console shall be completely assembled, wired, and tested at the factory, and delivered ready for installation and operation. Each base station console (system) shall perform the receipt, processing, and display of emergency and non-emergency messages transmitted by the DACTs specified herein, independently of the other console. Each console shall contain a complete independent receiving system, decoder, audio devices, visual display, clock, printer, primary and emergency power supplies, power supply monitors, memory devices, and interconnecting cable. If the automatic DACT tests specified under paragraph titled "Automatic DACT Test" are initiated by a polling (interrogation) device located at the base station, then each of the two required consoles shall have its polling device. One such device shall always be active, with the other in standby status. Failure of the active device shall automatically cause the second device to take over the polling (interrogation) function. Each DACR shall be capable of receiving signals from a minimum of four separate telephone circuits.

2.3.1 Display

Each console shall do the following:

a. Display incoming alarms in alphanumeric format, by means of a light emitting diode, illuminated dot matrix, or cathode ray tube.

   (1) Indicate the identity with a minimum of a four digit 0002-9999, time, date, and type of signal (alarm, trouble) code number assigned to the originating transmitter.

   (2) Include a message of a minimum of 3 lines of 20 characters each for each transmission (minimum 500 transmitter capacity). The message shall be operator-programmable into the memory through a keyboard which shall be provided.

b. Include a means to manually clear and reset the display. If the display is not reset at the time additional alarms are received, the additional alarms shall be retained in memory and a distinctive audible or visual indication given to the operator that additional alarms are waiting to be acknowledged.

   Alarms shall be printed immediately upon receipt.

2.3.2 Memory

Provide each console with a programmable memory capable of retaining at least 500 transmitter codes, together with specific messages, total number of zones possible, and related information associated with each of the 500 transmitters. If memory is operator-programmable, restrict access into the memory for the purpose of making additions or deletions by the use of a key switch for access code to prevent unauthorized changes. Memory shall not be lost in the event of a total loss of primary and emergency power supplies.

2.3.3 Digital Clock

Each console shall incorporate an electronic digital clock. Clock shall display the current time expressed in 24-hour time and date (day and month) and shall transmit to each interconnected printer the time and date that signals are received. Provide manual means of resetting the clock.

2.3.4 Printers

Provide printers of high speed, computer compatible, low noise design, capable of printing incoming messages with no messages being lost. Upon reception of an alarm, each printer shall print on paper the required visually displayed data, including the date and time received. Provide standard size paper for recording messages, commercially available from three or more manufacturers, usable on a computer printer or adding machine, and continuous feed. Include paper take-up devices for storing printouts. Print alarms in a manner to make them readily distinguishable from acknowledgments and routing messages, or by use of a different color, typeface, type size, or other distinguishable means.

2.3.5 Audible Trouble and Alarm Devices

The audible alarm device used to indicate the receipt of alarms shall produce a sound distinct from other audible trouble signals. The device shall be internally mounted in the console, and activated upon receipt of an alarm. The audible sounds used to indicate trouble messages shall be separate and distinct from the sound used to denote receipt of alarm messages.

2.3.6 Power Supplies

For each console, primary power supply shall be 120 V, 60 Hz AC. Emergency backup power shall be supplied by batteries capable of powering the system for a minimum of 48 hours. The 120 V, 60 Hz AC power supply for each console shall be obtained from the building emergency service circuit as shown through a lockable fused disconnect switch. Provide a separate disconnect switch for each console.

2.3.7 Emergency Power Source

Emergency backup power shall be supplied by lead acid type batteries having plastic cases and explosionproof vents. Batteries shall be of sufficient capacity to operate all functions of the console for no less than 48 continuous hours, in the event of loss of AC power. Batteries shall be mounted on rack(s) designed for that purpose. A termination cabinet shall be part of the rack. Battery rack(s) shall be located where shown.

2.3.7.1 Emergency Power Switchover

In the event of loss of normal AC power, transfer to the emergency power mode shall be automatic and without interruption or loss of console memory. When AC power is restored, transfer back to normal mode shall also be automatic.

2.3.8 Console Battery Charger

Battery chargers shall be self-regulating. Each charger shall have the capacity to completely recharge its associated batteries from full discharge within 48 hours with the console fully operational on primary AC power. The console shall remain operational on AC power with the batteries removed.

2.3.9 Console Supervision

Supervisory controls shall provide constant supervision of the operating condition of the console. Individual indicators shall be provided for each major component, and an audible signal shall be produced in the event of failure of any major component. This audible signal shall be distinctly different from the signal used to annunciate alarms. A switch shall be provided to silence the audible trouble signal.

2.3.10 Power Supervision

Each console shall continuously monitor its primary and emergency power supplies. Any malfunction shall be indicated visually and audibly. In the event of a primary power supply failure, the console shall automatically and without interruption switch to battery backup and indicate the failure within 15 seconds. An "open" in the battery circuit or standby battery voltage below 85 percent of rated voltage (while on AC power) shall cause activation of console trouble signals.

2.3.11 Electrical Connections

Consoles shall be designed with modular components to allow interchange of components for maintenance purposes. Interconnecting cables and connectors shall be compatible with computer quality signal data transmission.

2.4 CONDUIT

2.4.1 Rigid Steel Conduit (Zinc-Coated)

ANSI C80.1.

2.4.2 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.4.3 Electrical Metallic Tubing (EMT)

ANSI C80.3.

2.5 OUTLET BOXES

UL 514A, zinc-coated steel. Fittings for conduit and outlet boxes UL 514B, zinc-coated steel.

2.6 WIRING

NFPA 70 and NFPA 72. Wire for 120 V circuits shall be No. 12 AWG minimum. Wire for low voltage DC circuits shall be No. 14 AWG minimum. Color code wiring.

2.7 GROUND RODS

UL 467. Rods shall be the sectional type, copper-encased steel, with a minimum diameter of 3/4 inch and a minimum length of 10 feet. The rods shall have a hard, clean, smooth, continuous copper surface, and the proportion of copper shall be uniform throughout the length of the rod. The copper shall have a minimum wall thickness of .013 inch at any point on the rod. Ground rods shall not protrude more than 6 inches above grade. Non-current carrying metallic parts associated with new fire alarm equipment shall have maximum resistance to solid "earth" ground not to exceed the following values:

Digital Alarm Communicator Transmitter	10 ohms
Digital Alarm Communicator Receiver	10 ohms
Interface Panels	10 ohms

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall be in accordance with the requirements of NFPA 70 and NFPA 72. Wire for 120 V circuits shall be No. 12 AWG minimum. Wire for low voltage DC circuits shall be No. 14 AWG minimum. Color code wiring. Wiring shall be in rigid steel conduit, intermediate metal conduit, or electrical metallic tubing. Circuit conductors shall be identified within each enclosure where a tap, splice, or termination is made. Conductor identification shall be by plastic coated, self-sticking printed markers or by heat-shrink type sleeves. The markers shall be attached in a manner that will permit accidental detachment. Control circuit terminations shall be properly identified. Unless indicated otherwise, wiring and conduit shall be new. Do not run fire alarm circuits in the same conduit as non-fire alarm circuits. Do not run AC circuits in the same conduit with DC circuits.

3.1.1 Continuity of Protection

During the installation of this system, there shall be no loss of function of the existing base fire alarm system, or of the local building alarm systems connected thereto. Transfer of local alarm system connections from the existing base alarm system shall not result in loss of alarm transmitting or receiving capability. Temporary interruption of individual building alarm connections, not to exceed 8 hours duration, will be permitted at the discretion of the Contracting Officer. No interruption of alarm or communications functions at the fire alarm watch office will be permitted.

3.2 FIELD QUALITY CONTROL

3.2.1 Preliminary Testing

Conduct the following tests during installation of wiring and system components. Correct any deficiency pertaining to these requirements prior to final functional and operational tests of the system.

a. Ground resistance: The resistance of each connection to ground shall be measured and shall not exceed 10 ohms.

b. Each cable shall be checked at the transmitter or receiver connection for continuity, shorts, and grounds on the conductor and on the shield prior to connection to equipment. Assemblies failing these tests shall not be connected to equipment.

c. Operation of each digital alarm communicator transmitter function.

d. Operation of each interface device (where interface panels are provided).

e. Operation of each local alarm system zone.

f. Operation of each initiating device circuit if connected directly to the digital alarm communicator transmitter.

g. Operation of supervisory features.

h. Operation of all features of each digital alarm communicator receiver.

Tests of system components shall be conducted both with normal power on and with emergency (battery) power on and normal power off.

3.3 FINAL ACCEPTANCE TEST

The system shall have been in service for at least 30 days prior to the final inspection. The Contractor shall notify the Contracting Officer in writing when the system is ready for final acceptance tests. Notification shall be at least 15 days prior to the date of the final acceptance test. The system shall be considered ready for such testing only after necessary preliminary tests have been made and deficiencies found have been corrected to the satisfaction of the equipment manufacturer's technical representative. The system shall be tested for approval in the presence of representative of the manufacturer, the Contracting Officer, and the Division Fire Protection Engineer. The Contractor shall furnish instruments, labor, and materials required for the tests, and the technician who supervised the installation shall conduct the tests. Any deficiencies found shall be corrected and the system retested at no cost to the Government. Tests specified in paragraph entitled "Tests During Installation" shall be repeated as directed by the Division Fire Protection Engineer during the conduct of final acceptance tests.

3.4 ADDITIONAL TESTS

When deficiencies, defects, or malfunctions develop during the tests required, further testing of the system shall be suspended until proper adjustments, corrections, or revisions have been made to ensure proper performance of the system. If these adjustments, corrections, or revisions require more than a nominal delay, the Contracting Officer shall be notified when the additional work has been completed to arrange a new final inspection and test of the fire alarm system. Tests required shall be repeated prior to final acceptance, unless directed otherwise.

3.5 MAINTENANCE INSTRUCTIONS

Furnish to the Contracting Officer prior to final testing of the system a complete set of reproducible as-built approved wiring diagrams with six sets of copies.

3.6 INSTRUCTION OF GOVERNMENT PERSONNEL

Upon completion of the work and at a time designated by the Contracting Officer, Government personnel at the activity shall receive a complete training session of 40 hours, comparable to the equipment manufacturer's factory training procedure. The training shall include an explanation and review of the theory of operation, the function, the description, and analysis; and the troubleshooting of equipment provided. Training shall include a review of manuals, drawings, and lists supplied, together with any clarifications required. At least one period of 8 hours shall be spent demonstrating routine maintenance procedures and troubleshooting equipment with actual faults being introduced for training purposes. The instructional personnel providing requirements above shall be factory certified by the related equipment manufacturer to provide instruction services. The training shall take place at the site.

-- End of Section --

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SECTION 28 31 76

INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE
08/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2 (2020) American National Standard Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

ASTM INTERNATIONAL (ASTM)

ASTM F402 (2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

FM GLOBAL (FM)

FM APP GUIDE (updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1 (2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 4 (2018) Standard for Integrated Fire Protection and Life Safety System Testing

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

NFPA 72 (2022) National Fire Alarm and Signaling Code

NFPA 90A (2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NFPA 170	(2021) Standard for Fire Safety and Emergency Symbols

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-601-02	(2021) Fire Protection Systems Inspection, Testing, and Maintenance
UFC 4-010-06	(2016; with Change 1, 2017) Cybersecurity of Facility-Related Control Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices
47 CFR 90	Private Land Mobile Radio Services

UNDERWRITERS LABORATORIES (UL)

UL 228	(2006; Reprint Mar 2022) UL Standard for Safety Door Closers-Holders, With or Without Integral Smoke Detectors
UL 268	(2016; Reprint Nov 2021) UL Standard for Safety Smoke Detectors for Fire Alarm Systems
UL 268A	(2008; Reprint Oct 2014) Smoke Detectors for Duct Application
UL 464	(2016; Reprint Sep 2017) UL Standard for Safety Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
UL 497A	(2001; Bul. 2019) UL Standard for Safety Secondary Protectors for Communications Circuits
UL 497B	(2004; Reprint Feb 2022) UL Standard for Safety Protectors for Data Communications and Fire Alarm Circuits
UL 521	(1999; Reprint Mar 2021) UL Standard for Safety Heat Detectors for Fire Protective Signaling Systems
UL 864	(2014; Reprint May 2020) UL Standard for Safety Control Units and Accessories for Fire Alarm Systems
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 1480	(2016; Reprint Sep 2017) UL Standard for

	Safety Speakers for Fire Alarm and Signaling Systems, Including Accessories
UL 1638	(2016; Reprint Sep 2017) UL Standard for Safety Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
UL 1971	(2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
UL 2017	(2008; Reprint Dec 2018) UL Standard for Safety General-Purpose Signaling Devices and Systems
UL 2034	(2017; Reprint Apr 2022) UL Standard for Safety Single and Multiple Station Carbon Monoxide Alarms
UL 2075	(2013; Bul. 2019) UL Standard for Safety Gas and Vapor Detectors and Sensors
UL 2572	(2016; Bul. 2018) UL Standard for Safety Mass Notification Systems
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 SUMMARY

1.2.1 Scope

a. This work includes designing and [providing a new, complete,][modifying the existing] fire alarm and mass notification (MNS) system as described herein and on the contract drawings[for the _____________]. Include system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, initiating devices, notification appliances, supervising station fire alarm transmitters/mass notification transceiver, and other accessories and miscellaneous items required for a complete operational system even though each item is not specifically mentioned or described. Provide system[s] complete and ready for operation.[Existing interior fire alarm system was manufactured by [_____].] Design and installation must comply with UFGS 25 05 11, UFC 4-010-06 and AFGM 2019-320-02.

b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with NFPA 72, except as modified herein. [The system layout on the drawings show the intent of coverage and suggested locations. Final quantity, system layout, and coordination are the responsibility of the Contractor.]

[c. Each remote fire alarm control unit must be powered from a wiring riser specifically for that use or from a local emergency power panel located on the same floor as the remote fire alarm control unit. Where remote fire control units are provided, equipment for notification appliances may be located in the remote fire alarm control units.

][d. Where a fire pump is provided, the fire alarm and mass notification system must monitor and transmit the fire pump controller signals in accordance with the provisions of NFPA 72.

][e. Where an emergency generator provides standby power supply for life safety system circuits, the generator must be monitored by the FMCU and transmit emergency generator signals in accordance with NFPA 72.

] f. The fire alarm and mass notification system must be independent of the building security, building management, and energy/utility monitoring systems other than for control functions.

1.2.2 Qualified Fire Protection Engineer (QFPE)

Services of the QFPE must include:

a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification. Construction (shop) drawings and calculations must be prepared by, or prepared under the immediate supervision of, the QFPE. The QFPE must affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting the shop drawings to the DFPE.

b. Providing a letter documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting any outstanding comments.

c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).

d. Witnessing pre-Government [and final Government]functional performance testing and performing a final installation review.

e. Signing applicable certificates under SD-07.

1.3 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions must be defined as follows:

1.3.1 Interface Device

An addressable device that interconnects hard wired systems or devices to an analog/addressable system.

1.3.2 Fire Alarm and Mass Notification Control Unit (FMCU)

A master control unit having the features of a fire alarm control unit (FACU) and an autonomous control unit (ACU) where these units are interconnected to function as a combined fire alarm/mass notification system. The FACU and ACU functions may be contained in a single cabinet or in independent, interconnected, and co-located cabinets.

1.3.3 Remote Fire Alarm and Mass Notification Control Unit

A control unit, physically remote from the fire alarm and mass notification control unit, that receives inputs from automatic and manual fire alarm devices; may supply power to detection devices and interface devices; may provide transfer of power to the notification appliances; may provide transfer of condition to relays or devices connected to the control unit; and reports to and receives signals from the fire alarm and mass notification control unit.

1.3.4 Local Operating Console (LOC)

A unit designed to allow emergency responders and/or building occupants to operate the MNS including delivery of recorded messages and/or live voice announcements, initiate visual, textual visual, and audible appliance operation and other relayed functions.

1.3.5 Terminal Cabinet

A steel cabinet with locking, hinge-mounted door where terminal strips are securely mounted inside the cabinet.

1.3.6 Control Module and Relay Module

Terms utilized to describe emergency control function interface devices as defined by NFPA 72.

1.3.7 Designated Fire Protection Engineer (DFPE)

The DoD fire protection engineer that oversees that Area of Responsibility for that project. This is sometimes referred to as the "cognizant" fire protection engineer. Interpret reference to "authority having jurisdiction" and/or AHJ in referenced standards to mean the Designated Fire Protection Engineer (DFPE). The DFPE may be responsible for review of the contractor submittals having a "G" designation, and for witnessing final inspection and testing.

1.3.8 Qualified Fire Protection Engineer (QFPE)

A QFPE is an individual who is a licensed professional engineer (P.E.), who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval.

Shop drawings (SD-02), product data (SD-03) and calculations (SD-05) must be prepared by the fire alarm designer and combined and submitted as one complete package. The QFPE must review the SD-02/SD-03/SD-05 submittal package for completeness and compliance with the Contract provisions prior to submission to the Government. The QFPE must provide a Letter of Confirmation that they have reviewed the submittal package for compliance with the contract provisions. This letter must include their registered professional engineer stamp and signature. Partial submittals and submittals not reviewed by the QFPE will be returned by the Government disapproved without review.

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualified Fire Protection Engineer (QFPE); G

Fire alarm system designer; G

Supervisor; G

Technician; G

Installer; G

Test Technician; G

Fire Alarm System Site-Specific Software Acknowledgement; G

SD-02 Shop Drawings

Nameplates; G

Instructions; G

Wiring Diagrams; G

System Layout; G

Notification Appliances; G

Initiating devices; G

Amplifiers; G

Battery Power; G

Voltage Drop Calculations; G

SD-03 Product Data

Fire Alarm and Mass Notification Control Unit (FMCU); G

Local Operating Console (LOC); G

Amplifiers; G

Tone Generators; G

Digitalized voice generators; G

LCD Annunciator; G

Manual Stations; G

Smoke Detectors; G

Duct Smoke Detectors; G

Heat Detectors; G

Carbon monoxide detector; G

Addressable Interface Devices; G

Addressable Control Modules; G

Isolation Modules; G

Notification Appliances; G

Textual Display Sign Control Panel; G

Textual Display Signs; G

Batteries; G

Battery Chargers; G

Surge Protective Devices; G

Alarm Wiring; G,

Back Boxes and Conduit; G

Ceiling Bridges for Ceiling-Mounted Appliances; G

Terminal Cabinets; G

Digital Alarm Communicator Transmitter (DACT); G,

Automatic Fire Alarm Transmitters (including housing); G

Radio Transmitter and Interface Panels; G

Mass Notification Transceiver; G

Electromagnetic Door Holders; G

Environmental Enclosures or Guards; G,

Firefighter Telephone; G

Printer; G

Document Storage Cabinet; G

SD-05 Design Data

Air Sampling Smoke Detection System Calculations; G

SD-06 Test Reports

Test Procedures; G

SD-07 Certificates

Verification of Compliant Installation; G

Request for Government Final Test; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G

Instruction of Government Employees; G

SD-11 Closeout Submittals

As-Built Drawings

Spare Parts

1.5 SYSTEM OPERATION

Fire alarm system/mass notification system including textual display sign control panel(s), components requiring power, except for the FMCU(s) power supply, must operate on 24 volts DC unless noted otherwise in this section.

The interior fire alarm and mass notification system must be a complete, supervised, noncoded, analog/addressable fire alarm and mass notification system conforming to NFPA 72, UL 864, and UL 2572. Systems meeting UL 2017 only are not acceptable. The system must be activated into the alarm mode by actuation of an alarm initiating device. The system must remain in the alarm mode until the initiating device is reset and the control unit is reset and restored to normal. The system may be placed in the alarm mode by local microphones, LOC, FMCU, or remotely from authorized locations/users.

[]1.6 TECHNICAL DATA AND SITE-SPECIFIC SOFTWARE

Technical data and site-specific software (meaning technical data that relates to computer software) that are specifically identified in this project, and may be required in other specifications, must be delivered, strictly in accordance with the CONTRACT CLAUSES. The fire alarm system manufacturer must submit written confirmation of this contract provision as "Fire Alarm System Site-Specific Software Acknowledgement". Identify data delivered by reference to the specification paragraph against which it is furnished. Data to be submitted must include complete system, equipment, and software descriptions. Descriptions must show how the equipment will operate as a system to meet the performance requirements of this contract. The site-specific software data package must also include the following:

a. Items identified in NFPA 72, titled "Site-Specific Software".

b. Identification of programmable portions of the system equipment and capabilities.

c. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.

d. Provision of operational software data on all modes of programmable portions for fire alarm and mass notification.

e. Description of Fire Alarm and Mass Notification Control Unit equipment operation.

f. Description of auxiliary and remote equipment operations.

g. Library of application software.

h. Operation and maintenance manuals.

1.7 EXISTING EQUIPMENT

a. Equipment and devices must be compatible and operable with the existing fire alarm/mass notification system and must not impair reliability or operational functions of existing supervising station fire alarm system..

b. Equipment and devices must be compatible and operable with the existing building fire alarm/mass notification system. Equipment must not impair reliability or operational functions of the existing system.

c. Equipment and devices must be compatible and operable with the existing installation-wide mass notification system and must not impair reliability or operational functions of the existing system.

1.8 QUALITY ASSURANCE

1.8.1 Submittal Documents

1.8.1.1 Preconstruction Submittals

Within 36 days of contract award but not less than 14 days prior to commencing any work on site, the Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications of the fire alarm subcontractor and QFPE must be returned disapproved without review. All resultant delays must be the sole responsibility of the Contractor.

1.8.1.2 Shop Drawings

Shop drawings must not be smaller than ANSI D. Drawings must comply with the requirements of NFPA 72 and NFPA 170. Minimum scale for floor plans must be 1/8"=1'.

1.8.1.3 Nameplates

Nameplate illustrations and data to obtain approval by the Contracting Officer before installation.

1.8.1.4 Wiring Diagrams

2 copies of point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FMCU and remote FMCU, initiating circuits, switches, relays and terminals, including pathway diagrams between the control unit and shared communications equipment within the protected premises. Point-to-point wiring diagrams must be job specific and must not indicate connections or circuits not being utilized. Provide complete riser diagrams indicating the wiring sequence of all devices and their connections to the control equipment. Include a color-code schedule for the wiring.

1.8.1.5 System Layout

2 copies of plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, conduit sizes, wire counts, conduit fill calculations, wire color-coding,

circuit identification in each conduit, and circuit layouts for all floors. Indicate candela rating of each visual notification appliance. Indicate the wattage of each speaker. Clearly identify the locations of isolation modules. Indicate the addresses of all devices, modules, relays, and similar. Show/identify all acoustically similar spaces. Indicate if the environment for the FMCU is within its environmental listing (e.g. temperature/humidity).

Provide a complete description of the system operation in matrix format similar to the "Typical Input/Output Matrix" included in the Annex of NFPA 72.

1.8.1.6 Notification Appliances

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances. Annotate data for each circuit on the drawings.

1.8.1.7 Initiating Devices

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings.

1.8.1.8 Amplifiers

Calculations and supporting data to indicate that amplifiers have sufficient capacity to simultaneously drive all notification speakers at tapped settings plus 25 percent spare capacity. Annotate data for each circuit on the drawings.

1.8.1.9 Battery Power

Calculations and supporting data as required in paragraph Battery Power Calculations for alarm, alert, and supervisory power requirements. Calculations including ampere-hour requirements for each system component and each control unit component, and the battery recharging period, must be included on the drawings.

1.8.1.10 Voltage Drop Calculations

Voltage drop calculations for each notification circuit indicating that sufficient voltage is available for proper operation of the system and all components, at a minimum rated voltage of the system operating on batteries. Include the calculations on the system layout drawings.

1.8.1.11 Product Data

2 copies of annotated descriptive data to show the specific model, type, and size of each item. Catalog cuts must also indicate the NRTL listing. The data must be highlighted to show model, size, and options that are intended for consideration. Data must be adequate to demonstrate compliance with all contract requirements. Product data for all equipment must be combined into a single submittal.

Provide an equipment list identifying the type, quantity, make, and model number of each piece of equipment to be provided under this submittal. The equipment list must include the type, quantity, make and model of spare equipment. Types and quantities of equipment submitted must coincide with the types and quantities of equipment used in the battery calculations and those shown on the shop drawings.

1.8.1.12 Operation and Maintenance (O&M) Instructions

Six copies of the Operation and Maintenance Instructions. The O&M Instructions must be prepared in a single volume or in multiple volumes, with each volume indexed, and may be submitted as a Technical Data Package. Manuals must be approved prior to training. The Interior Fire Alarm And Mass Notification System Operation and Maintenance Instructions must include the following:

a. "Manufacturer Data Package five" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA.

b. Operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual must include the manufacturer's name, model number, service manual, parts list, and preliminary equipment list complete with description of equipment and their basic operating features.

c. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals must include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.

d. Complete procedures for system revision and expansion, detailing both equipment and software requirements.

e. Software submitted for this project on CD/DVD media utilized.

f. Printouts of configuration settings for all devices.

g. Routine maintenance checklist. The routine maintenance checklist must be arranged in a columnar format. The first column must list all installed devices, the second column must state the maintenance activity or state no maintenance required, the third column must state the frequency of the maintenance activity, and the fourth column provided for additional comments or reference. All data (devices, testing frequencies, and similar) must comply with UFC 3-601-02.

h. A final Equipment List must be submitted with the Operating and Maintenance (O&M) manual.

1.8.1.13 As-Built Drawings

The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of the as-built (marked-up) drawings must be provided at the time of, or prior to the final Government test.

1.8.2 Qualifications

1.8.2.1 Fire Alarm System Designer

The fire alarm system designer must be certified as a Level [III][IV] (minimum) Technician by National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection

Engineering Technology or meet the qualifications for a QFPE.

1.8.2.2 Supervisor

[A NICET Level [III][or][IV] fire alarm technician must supervise the installation of the fire alarm/mass notification system[, including the air sampling smoke detection system].][A fire alarm technician with a minimum of eight years of experience must supervise the installation of the fire alarm/mass notification system.] The fire alarm technicians supervising the installation of equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.3 Technician

Fire alarm technicians with a minimum of four years of experience must be utilized to install and terminate fire alarm/mass notification devices, cabinets and control units. The fire alarm technicians installing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings[, and must be thoroughly experienced in the installation of air sampling detection systems].

1.8.2.4 Installer

[Fire alarm installer with a minimum of two years of experience utilized to assist in the installation of fire alarm/mass notification devices, cabinets and control units] [NICET Level II technician to assist in the installation of fire alarm/mass notification devices, cabinets and control units]. A licensed electrician must be allowed to install wire, cable, conduit and backboxes for the fire alarm system/mass notification system. The fire alarm installer must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.5 Test Technician

Fire alarm technicians with a minimum of eight years of experience and NICET Level [III][or][IV] utilized in testing and certification of the installation of the fire alarm/mass notification devices, cabinets and control units. The fire alarm technicians testing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment installed as part of this project.

1.8.2.6 Manufacturer

Components must be of current design and must be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm system, complete, conforming to NFPA 72, except as specified herein.

1.8.3 Regulatory Requirements

Equipment and material must be listed or approved. Listed or approved, as used in this section, means listed, labeled or approved by a Nationally Recognized Testing Laboratory (NRTL) such as UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described must not be construed as waiving this requirement. All listings or approvals by testing laboratories must be from an existing ANSI or UL published standard. The recommended practices stated in the manufacturer's literature or documentation must be considered as mandatory requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

PART 2 PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment must be listed for use under the applicable reference standards. Interfacing of UL 864 or similar approved industry listing with Mass Notification equipment listed to UL 2572 must be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory and listed for fire protection service when so required by NFPA 72 or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for any particular classification of materials. Material and equipment must be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening.

2.2.2 Nameplates

Major components of equipment must have the manufacturer's name, address, type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new name plate permanently affixed to the item or equipment. Major components include, but are not limited to, the following:

a. FMCU

Nameplates must be etched metal or plastic, permanently attached by screws to control units or adjacent walls.

2.2.3 Keys

Keys and locks for equipment, control units and devices must be identical. .

2.2.4 Instructions

Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a conspicuous location observable from the FMCU. The card must show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions must also include procedures for operating live voice microphones. The instructions and their mounting location must be approved by the

Contracting Officer before being posted.

2.3 FIRE ALARM AND MASS NOTIFICATION CONTROL UNIT

Provide a complete fire alarm and mass notification control unit (FMCU) fully enclosed in a lockable steel cabinet as specified herein. Operations required for testing or for normal care, maintenance, and use of the system must be performed from the front of the enclosure. If more than a single unit is required at a location to form a complete control unit, the unit cabinets must match exactly. The system must be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling such as waterflow switches, valve supervisory switches, fire pump monitoring, independent smoke detection systems, relays for output function actuation.

a. Each control unit must provide power, supervision, control, and logic for the entire system, utilizing solid state, modular components, internally mounted and arranged for easy access. Each control unit must be suitable for operation on a 120 volt, 60 hertz, normal building power supply. Provide each control unit with supervisory functions for power failure, internal component placement, and operation.

b. Visual indication of alarm, supervisory, or trouble initiation on the FMCU must be by liquid crystal display or similar means with a minimum of 80 characters. The mass notification control unit must have the capability of temporarily deactivate the fire alarm audible notification appliances while delivering voice messages.

c. Provide secure operator console for initiating recorded messages, strobes and displays; and for delivering live voice messages. Provide capacity for at least eight prerecorded messages. Provide the ability to automatically repeat prerecorded messages. Provide a secure microphone for delivering live messages. Provide adequate discrete outputs to temporarily deactivate fire alarm audible notification, initiate/synchronize strobes and initiate textual visual notification appliances. Provide a complete set of self-diagnostics for controller and appliance network. Provide local diagnostic information display and local diagnostic information and system event log file.

2.3.1 Cabinet

Install control unit components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of control units as well as field wiring. The cabinet must be a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and semi-recessed mounting provisions. The enclosure must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must say "Fire Alarm and Mass Notification control unit" and must not be less than 1-inch high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches.

2.3.2 Silencing Switches

2.3.2.1 Alarm Silencing Switch

Provide an alarm silencing switch at the FMCU that must silence the audible and visual notification appliances. Subsequent activation of initiating devices must cause the notification appliances to re-activate.

2.3.2.2 Supervisory/Trouble Silencing Switch

Provide supervisory and trouble silencing switch(es) that must silence the audible trouble and supervisory signal(s), but not extinguish the visual indicator. This switch must be overridden upon activation of a subsequent supervisory or trouble condition. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated if the supervisory or trouble condition still exists.

2.3.3 Non-Interfering

Power and supervise each circuit such that a signal from one device does not prevent the receipt of signals from any other device. Initiating devices must be manually reset by switch from the FMCU after the initiating device or devices have been restored to normal.

2.3.4 Audible Notification System

The Audible Notification System must comply with the requirements of NFPA 72 for Emergency Voice/Alarm Communications System requirements, except as specified herein. The system must be a one-way, multi-channel voice notification system incorporating user selectability of a minimum eight distinct sounds for tone signaling, and the incorporation of a voice module for delivery of recorded messages. Audible appliances must produce a three-pulse temporal pattern for three cycles followed by a voice message that is repeated until the control unit is reset or silenced. For carbon monoxide detector activation, audible appliances must produce a four-pulse temporal pattern for three cycles followed by a voice message that is repeated until the control unit is reset or silenced. Automatic messages must be broadcast through speakers throughout the building/facility but not in stairs or elevator cabs. A live voice message must override the automatic audible output through use of a microphone input at the control unit or the LOC.

a. When using the microphone, live messages must be broadcast selectable by zone, or all call. The system must be capable of operating all speakers at the same time. Activation of the public address microphone must not initiate activation of visual notification appliances or LED text displays.

b. The microprocessor must actively interrogate circuitry, field wiring, and digital coding necessary for the immediate and accurate rebroadcasting of the stored voice data into the appropriate amplifier input. Loss of operating power, supervisory power, or any other malfunction that could render the digitalized voice module inoperative must automatically cause the three-pulse temporal pattern to take over all functions assigned to the failed unit in the event an alarm is activated.

2.3.4.1 Outputs and Operational Modules

All outputs and operational modules must be fully supervised with on-board diagnostics and trouble reporting circuits. Provide form "C" contacts for system alarm and trouble conditions. Provide circuits for operation of auxiliary appliance during trouble conditions. During a Mass Notification event, the control unit must not generate nor cause any trouble alarms to be generated with the Fire Alarm system.

2.3.4.2 Mass Notification

a. The system must have the capability of utilizing an LOC with redundant controls of the FMCU. Notification Appliance Circuits (NAC) must be provided for the activation of strobe appliances. Audio output must be selectable for line level. A hand-held microphone must be provided and, upon activation, must take priority over any tone signal, recorded message or PA microphone operation in progress, while maintaining the strobe NAC circuit activation.

b. The Mass Notification functions must override the manual or automatic fire alarm notification,[and public address (PA) functions]. Other fire alarm functions including transmission of a signal(s) to the fire department must remain operational. When a mass notification announcement is disengaged and a fire alarm condition still exists, the audible and visual notification appliances must resume activation for alarm conditions. The fire alarm message must be of lower priority that all other messages (except any "test" messages) and must not override any other messages.

[c. Messages must be recorded professionally utilizing standard industry methods, in a professional [male][female] voice. Message and tone volumes must both be at the same decibel level. Messages recorded from the system microphone must not be accepted. A 1000 Hz tone (as required by NFPA 72) must precede messages and be similar to the following unless Installation or Facility specific messages are required:

(1) "May I have your attention please. May I have your attention please. [Insert installation specific message here.]" (Provide a [2][_____] second pause.) "May I have your attention please, (repeat the tones and message [on a continuous loop][[_____] times]).

(2) Carbon Monoxide: "May I have your attention please. May I have your attention please. Carbon monoxide has been detected in the building. Please walk to the nearest exit and leave the building." (Provide a [2][_____] second pause.) "May I have your attention please, (repeat the tones and message [on a continuous loop][[_____] times])."

(3) Fire: "May I have your attention please. May I have your attention please. A fire emergency has been reported in the building. Please leave the building by the nearest exit[or exit stairway].[Do not use the elevators.]" (Provide a [2][_____] second pause.) "May I have your attention please, (repeat the tones and message on a continuous loop)."

(4) Test: "May I have your attention please. May I have your attention please. This is a test of the building mass notification system. Please continue your normal duties. This is only a test." (Provide a [2][_____] second pause.)

(5) All Clear: "May I have your attention please. May I have your attention please. An all clear has been issued, resume normal activities." (Provide a [2][_____] second pause.)

] d. Auxiliary Input Module must be designed to be an outboard expansion module to either expand the number of optional LOC's, or allow a telephone interface.

[2.3.4.3 Installation-Wide Control

If an installation-wide control system for mass notification exists on the Base, the autonomous control unit must communicate with the central control unit of the Installation-wide system. The autonomous control unit must receive commands/messages from the central control unit and provide status information.

]2.3.5 Memory

Provide each control unit with non-volatile memory and logic for all functions. The use of long life batteries, capacitors, or other age-dependent devices must not be considered as equal to non-volatile processors, PROMS, or EPROMS.

2.3.6 Field Programmability

Provide control units and control units that are fully field programmable for both input and output of control, initiation, notification, supervisory, and trouble functions. The system program configuration must be menu driven. System changes must be password protected. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system must be provided as part of this contract.

2.3.7 Input/Output Modifications

The FMCU must contain features that allow the bypassing of input devices from the system or the modification of system outputs. These control features must consist of a control unit mounted keypad[and a keyboard]. Any bypass or modification to the system must indicate a trouble condition on the FMCU.

2.3.8 Resetting

Provide the necessary controls to prevent the resetting of any alarm, supervisory, or trouble signal while the alarm, supervisory or trouble condition on the system still exists.

2.3.9 Walk Test

The FMCU must have a walk test feature. When using this feature, operation of initiating devices must result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated in the history log[and on the system printer], but no other outputs occur.

2.3.10 History Logging

The control unit must have the ability to store a minimum of 400 events in a log. These events must be stored in a battery-protected memory and must remain in the memory until the memory is downloaded or cleared manually. Resetting of the control unit must not clear the memory.

2.3.11 Manual Access

An operator at the control unit, having a proper access level, must have the capability to manually access the following information for each initiating device.

a. Primary status.

b. Device type.

c. Present average value.

d. Present sensitivity selected.

e. Detector range (normal, dirty).

[2.3.12 Heat Detector Self-Test Routines

Automatic self-test routines must be performed on each detector that will functionally check detector sensitivity electronics and ensure the accuracy of the value being transmitted. Any detector that fails this test must indicate a trouble condition with the detector location at the control unit.

]2.4 LOCAL OPERATING CONSOLES (LOC)

2.4.1 General

The LOC must consist of a remote microphone station incorporating a push-to-talk (PTT) hand-held microphone and system status indicators. The LOC must have the capability of being utilized to activate prerecorded messages. The unit must incorporate microphone override of any tone generation or recorded messages. The unit must be fully supervised from the FMCU. The housing for the LOC must not be lockable.[The LOC must have public address capability with the provision of a separate microphone. The PA paging function must not override any alarm or notification functions. The PA microphone must be [desktop][hand-held][_____] style. Hand-held microphones must be housed in a separate protective cabinet. The cabinet must be accessible without the use of a key. The location of the microphone[s] must be approved by the [_____] Designated Fire Protection Engineer (DFPE). Activation of the PA microphone must not initiate activation of visual notification appliances or LED text displays. The PA paging function must not override any alarm or notification functions.]

2.4.2 Multiple LOCs

When an installation has more than one LOC, the LOCs must be programmed to allow only one LOC to be available for paging or messaging at a time. Once one LOC becomes active, all other LOC's will have an indication that the system is busy (Amber Busy Light) and cannot be used at that time. This is to avoid two messages being given at the same time. It must be possible to override or lockout the LOC's from the FMCU.

2.5 AMPLIFIERS, PREAMPLIFIERS, TONE GENERATORS

Any amplifiers, preamplifiers, tone generators, digitalized voice generators, and other hardware necessary for a complete, operational, textual audible circuit conforming to NFPA 72 must be housed in a remote FMCU, terminal cabinet, or in the FMCU. Individual amplifiers must be 100 watts maximum.

2.5.1 Operation

The system must automatically operate and control all building speakers[except those installed in the stairs][and within elevator cabs].[The speakers in the stairs[and elevator cabs] must operate only when the microphone is used to deliver live messages.]

2.5.2 Construction

Amplifiers must utilize computer grade solid state components and must be provided with output protection devices sufficient to protect the amplifier against any transient up to 10 times the highest rated voltage in the system.

2.5.3 Inputs

Equip each system with separate inputs for the tone generator, digitalized voice driver and control unit mounted microphone [Public Address Paging Function]. Microphone inputs must be of the low impedance, balanced line type. Both microphone and tone generator input must be operational on any amplifier.

2.5.4 Tone Generator

The tone generator must produce a three-pulse temporal pattern and must be constantly repeated until interrupted by either the digitalized voice message, the microphone input, or the alarm silence mode as specified. The tone generator must be single channel with an automatic backup generator per channel such that failure of the primary tone generator causes the backup generator to automatically take over the functions of the failed unit and also causes transfer of the common trouble relay. The tone generator must be provided with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces.

2.5.5 Protection Circuits

Each amplifier must be constantly supervised for any condition that could render the amplifier inoperable at its maximum output. Failure of any component must cause illumination of a visual "amplifier trouble" indicator on the control unit, appropriate logging of the condition in the history log[and on the system printer], and other actions for trouble conditions as specified.

[2.6 VIDEO DISPLAY UNIT (VDU)

a. The VDU must be the secondary operator-to-system interface for data retrieval, alarm annunciation, commands, and programming functions. The desk mounted VDU must consist of a LCD monitor and a keyboard. The VDU must have a [12][17][_____]-inch minimum [touch]screen, capable of displaying 25 lines of 80 characters each. Communications with the FMCU must be supervised. Faults must be recorded in the history log[and on the printer]. Power required must be 120 VAC, 60 Hz from the same source as the FMCU.

b. To eliminate confusion during an alarm situation, the screen must have dedicated areas for the following functions:

(1) Alarm and return to normal.

(2) Commands, reports, and programming.

(3) Time, day, and date.

c. Use full English language throughout to describe system activity and instructions. Full English language descriptors defining system points must be 100 percent field programmable by factory trained personnel, alterable and user definable to accurately describe building areas.

d. Alarms and other changes of status must be displayed in the screen area reserved for this information. Upon receipt of alarm, an audible alarm must sound and the condition and point type must flash until acknowledged by the operator. Return to normal must also be annunciated and must require operator acknowledgment. The following information must be provided in full English:

(1) Condition of device (alarm, trouble, or supervisory).

(2) Type of device (for example, manual pull, waterflow)

(3) Location of device plus numerical system address.

e. The system must have multiple levels of priority for displaying alarms to conform with UL 864. Priority levels must be as follows:

(1) Level 1 - Mass Notification Signals

(2) Level 2 - Fire Alarm Signals

(3) Level 3 - Carbon Monoxide Alarm Signals

(4) Level 4 - Supervisory Signals

(5) Level 5 - Trouble Signals

f. Provide the system with memory so that no alarm is lost. A highlighted message must advise the operator when unacknowledged alarms are in the system.

g. Multiple levels of access must be provided for operators and supervisors via user-defined passwords. Provide the following functions for each level:

(1) Operator level access functions:

(a) Display system directory, definable by device.

(b) Display status of an individual device.

(c) Manual command (alarm device with an associated command must use the same system address for both functions).

(d) Report generation, definable by device, output on the VDU[or printer], as desired by the operator.

(e) Activate building notification appliances.

(2) Supervisor level access functions:

(a) Reset time and date.

(b) Enable or disable event initiated programs[, printouts,] and initiators.

(c) Enable or disable individual devices and system components.

h. The above supervisor level functions must not require computer programming skills. Changes to system programs must be [recorded on the printer and]maintained in the control unit as a trouble condition.

]2.7 REMOTE ANNUNCIATOR

[2.7.1 LCD Annunciator

Provide a [semi-recessed][flush] mounted annunciator that includes an LCD display. The display must indicate the device in trouble/alarm or any supervisory device. Display the device name, address[, and actual building location]. The remote annunciator must duplicate functions of the FMCU for message display, fire alarm, supervisory alarm, and trouble conditions, visual and audible notification, and system reset functions. Remote annunciator must require the use of a key for accessing the reset, control and other functions.

A building floor plan must be provided and mounted (behind Plexiglass or similar protective material) at the annunciator location. The floor plan must indicate all rooms by name and number including the locations of stairs and elevators. The floor plan must show all devices and their programmed address to facilitate identification of their physical location from the LCD display information.

][2.7.2 Graphic Annunciator

Graphic annunciator must be of the [interior][weatherproof] type, [flush][surface][pedestal]-mounted. Annunciator must be provided with the [building][room] floor plan, drawn to scale, with alarm lamps mounted to represent the location of [each concealed detector][each initiating device]. Annunciator graphic must also show the locations of the annunciator and control unit, and must have a "you are here" arrow showing its location. Orient building floor plan on graphic to location of person viewing the graphic(i.e., the direction the viewer is facing must be toward the top of the graphic display). Provide a North arrow.[Principal rooms and areas shown must be labeled with room numbers or titles.] Detectors mounted above ceilings, [on ceilings,]and beneath raised floors and different types of initiating devices must have different symbols or lamps of different colors for identification. Lamps must illuminate upon activation of corresponding device and must remain illuminated until the system is reset. Annunciator must have a lamp test switch.

2.7.2.1 Materials

Construct the graphic annunciator face plate of [smoked Plexiglas][non-glare matte finish][anodized bronze][anodized aluminum]. The face plate must be backlit with LEDs. Control equipment and wiring must be housed in a [recessed][semi-recessed][surface mounted] back box. The exposed portions of the back box must be [chrome plated][anodized bronze][anodized aluminum] without knockouts.

2.7.2.2 Programming

Where programming for the operation of the graphic annunciator is accomplished by a separate software program other than the software for the FMCU, the software program must not require reprogramming after loss of power. The software must be reprogrammable in the field.

][2.7.3 Printer

a. Provide a system printer [with no stored memory] to record alarm, supervisory, and trouble conditions without loss of any signal or signals. Printout must be by circuit, device, and function as provided in the FMCU. Printer must operate on a 120 VAC, 60 Hz power supply.

b. The printer must have at least 80 characters per line and have a 96 ASCII character set. The printer must have a microprocessor-controlled, bi-directional, logic seeking head capable of printing 120 characters per second utilizing a 9 by 7 dot matrix print head. Printer must not contain internal software which is essential for proper operation.

c. When the FMCU receives a signal, the alarm, supervisory, and trouble condition must be printed. The printout must include the type of signal, the circuit or device reporting, the date, and the time of the occurrence. The printer must differentiate alarm signals from other printed indications. When the system is reset, this condition must also be printed including the same information concerning device, location, date, and time. Provide a means to automatically print a list of existing alarm, supervisory, and trouble conditions in the system. If a printer is off-line when an alarm is received, the system must have a buffer to retain the data and it must be printed when the printer is restored to service. The printer must have an indicator to alert the operator that the paper has run out.

]2.8 MANUAL STATIONS

Provide metal or plastic, [semi-flush][flush][surface] mounted, [single][double]-action, addressable manual stations, that are not subject to operation by jarring or vibration. Stations must be equipped with screw terminals for each conductor. Stations that require the replacement of any portion of the device after activation are not permitted. Stations must be finished in red with molded raised lettering operating instructions of contrasting color. The use of a key must be required to reset the station.

2.9 SMOKE DETECTORS

2.9.1 Spot Type Detectors

Provide addressable [photoelectric][ionization][laser] smoke detectors as follows:

a. Provide analog/addressable [photoelectric smoke detectors utilizing the photoelectric light scattering principle for operation in accordance with UL 268][smoke detectors that operate on the ionization principle and are actuated by the presence of visible or invisible products of combustion][laser smoke detectors utilizing laser diode and patented smoke sensing chamber, designed to amplify signals from smoke but diminish stray internal reflections and must, on command from the FMCU, send data to the control unit representing the analog level of smoke density]. Smoke detectors must be listed for use with the FMCU.

b. Provide self-restoring type detectors that do not require any readjustment after actuation at the FMCU to restore them to normal operation. The detector must have a visual indicator to show actuation.

c. Vibration must have no effect on the detector's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen must not inhibit the movement of smoke particles into the chamber.

d. Provide twist lock bases [with sounder that produces a minimum of 90 dBA at 10 feet] with screw terminals for each conductor. The detectors must maintain contact with their bases without the use of springs.

e. The detector address must identify the particular unit, its location within the system[, and its sensitivity setting]. Detectors must be of the low voltage type rated for use on a 24 VDC system.

[f. Laser smoke detector must be listed for use with the FMCU. Detector must be able to achieve sensitivities from 0.02 percent-per-foot to 2 percent-per-foot obscuration.

g. Laser smoke detector must provide point identification of the fire location through addressability, must experience no delay in response time due to smoke dilution or smoke transportation time, and must offer complete supervision of wiring and detector.

][2.9.2 Projected Beam Smoke Detector

Detectors must consist of [combined transmitter and receiver unit] [separate transmitter and receiver units]. The transmitter unit must emit an infrared beam to the receiver unit [the use of a supplied reflector is required for the combined unit]. When the signal at the receiver falls below a preset threshold, the detector must initiate an alarm. The receiver must contain an LED status indicator that illuminates when an alarm condition exists. Long-term changes to the received signal caused by environmental variations must be automatically compensated. Detectors must incorporate features to assure that they are operational; a trouble signal must be initiated if the beam is obstructed for more than 3 seconds, the limits of the compensation circuit are reached, or the housing cover is removed. Detectors must have multiple sensitivity settings in order to meet UL listings for the different distances covered by the beam.

]2.9.3 Duct Smoke Detectors

Duct-mounted addressable photoelectric smoke detectors must consist of a smoke detector, as specified in paragraph Spot Type Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry must be mounted in a metallic or plastic enclosure exterior to the duct.[It is not permitted to cut the duct insulation to install the duct detector directly on the duct.] Detectors must be listed for operation over the complete range of air velocities, temperature and humidity expected at the detector when the air-handling system is operating. Detectors must be powered from the FMCU.

a. Sampling tubes must run the full width of the duct. The duct detector package must conform to the requirements of NFPA 90A, UL 268A, and must be listed for use in air-handling systems. The control functions, operation, reset, and bypass must be controlled from the FMCU.

b. Lights to indicate the operation and alarm condition must be visible and accessible with the unit installed and the cover in place. Remote indicators must be provided where required by NFPA 72. Remote indicators as well as the affected fan units must be properly identified in etched plastic placards.

c. Detectors must provide for control of auxiliary contacts that provide control, interlock, and shutdown functions specified in Section 23 09 00 to INSTRUMENTATION AND CONTROL FOR HVAC. Auxiliary contacts provide for this function must be located within 3 feet of the controlled circuit or appliance. The auxiliary contacts must be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

[2.10 AIR SAMPLING SMOKE DETECTION SYSTEM

The [addressable]air sampling smoke system must consist of a detector assembly housing an integral aspiration fan, filter, laser-based detection chamber and control, output and supervision circuitry.[Each sampling point must be capable of being independently addressable.] The system must consist of a piping or tubing distribution network that runs from the detector assembly(s) to the protected area(s) and is supported by air sampling smoke detection system calculations from a computer-based design modeling tool. The system must include configurable alarm and trouble relay outputs for interface to other systems where required.

a. System must be complete in all ways. It must include all engineering, and electrical installation, all detection and control equipment, auxiliary devices and controls, alarm interface, functional checkout and testing, training and all other operations necessary for a functional system.

b. System base detectors and modules must each accommodate up to [40 addressable][_____] microbore sampling tubes where each tube has a sampling point at the end. Additional modules may be used to provide up to [20 addressable][_____] sampling holes per system.

c. Program alarm thresholds to the following values unless the results of the pre-Government system tests indicate a clear need to change them. In the event that such a need is indicated, notify the Contracting Officer and provide complete documentation concerning the need to deviate from these values. Include within the deviation documentation request, information that complies with the paragraph entitled "Sensitivity Verification Test". Ensure initial threshold levels are approved prior to the Government test.

(1) Alarm Level 1: set ALERT at [_____][0.0250] percent obscuration/foot

(2) Alarm Level 2: set PRE-ALARM at [_____][0.0500] percent obscuration/foot

(3) Alarm Level 3: set FIRE 1 at [_____][0.1000] percent obscuration/foot

(4) Alarm Level 4: set FIRE 2 at [_____][0.2000] percent obscuration/foot

d. All air sampling smoke detection devices and associated components must be new, standard products or the manufacturer's latest design and suitable to perform the functions intended.

e. The laser detection chamber must be of the mass light scattering type and capable of detecting a wide range of smoke particle types of varying size. A particle counting method must be employed for the purposes of:

(1) Preventing large particles from affecting the true smoke reading.

(2) Monitoring contamination of the filter (for example, dust and dirt) to automatically notify when maintenance is required. The particle counting method must not be used for the purpose of smoke density measurement.

f. Detector(s) must be self-monitoring for filter contamination and provide indication through system fault when replacement is necessary. Detectors which allow automatic reset of filter status upon removal and re-insertion are not permitted.

g. Detector(s) must contain relays for alarm and fault conditions. The relays must be software programmable to the required functions.

h. Detector(s) must permit configuration by programmers that are either integral to the system, portable or PC based.

i. Detector(s) must allow programming of:

(1) Smoke threshold alarm levels; ALERT, PRE-ALARM, FIRE 1 and FIRE 2.

(2) Time delays. Ensure the display control unit contains individual adjustable alarm time delay features for each of the alarm threshold levels. Provide an adjustment range between 0 and 60 seconds. Program the alarm threshold time delays to 30 seconds for alarm levels 1 and 2, and 15 seconds for alarm levels 3 and 4.

(3) Faults, including airflow, detector, power, filter and network, as well as an indication of the urgency of the fault.

(4) Configuration of relay outputs for remote indication of alarm and fault conditions.

(5) General purpose input functionality.

]2.11 HEAT DETECTORS

2.11.1 Heat Detectors

Heat detectors must be analog/addressable and designed for detection of fire by [fixed temperature][combination fixed temperature and rate-of-rise principle][rate-compensating principle] in accordance with UL 521. The alarm condition must be determined by comparing detector value with the stored values.. Detectors located in areas subject to moisture, exterior atmospheric conditions, or hazardous locations [as defined by NFPA 70][and][as indicated], must be types approved for such locations.

[2.11.1.1 Combination Fixed-Temperature and Rate-of-Rise Detectors

Detectors must be [surface][semi-flush] mounted in the [vertical][horizontal] orientation and supported independently of wiring connections. Detectors must be self-resetting. Detector must operate at

[135][194] degrees F. Detector must feature rate compensation. [Detectors rated to operate at 135 degrees F must not respond to momentary temperature fluctuations less than 30 degrees F per minute between 60 and 100 degrees F].[Detectors rated to operate at 194 degrees F must not respond to momentary temperature fluctuations less than 50 degrees F per minute between 60 and 150 degrees F.][The detector assembly must be [weatherproof][and][explosionproof].]

][2.11.1.2 Rate Compensating Detectors

Detector backbox must be [surface][flush] mounted in the [vertical][horizontal] orientation and supported independently of wiring connections. Detectors must be self-restoring and hermetically sealed.[The detector assembly must be [weatherproof][and][explosionproof].]

][2.11.1.3 Line-Type Fixed Temperature Detectors

Provide [thermostatic][or][thermistor] line-type heat detection cable [with weather-resistant outer covering] where indicated. Cable must be nominally rated for a temperature of [155][190][280] degrees F and must operate on fixed temperature principle only.

][2.11.1.4 Fixed Temperature Detectors

Detectors must be [surface][semi-flush] mounted in the [vertical][horizontal] orientation and supported independently of wiring connections. Detectors must be self-restoring. The detectors must have a specific temperature setting [of [135][_____] degrees F][as shown].[The detector assembly must be [weatherproof][and][explosionproof].]

][2.12 FLAME DETECTORS

Detectors must be sensitive to the micron range best suited for their intended use. Detectors must operate over electrically supervised wiring circuits and the loss of power to the detector must result in a trouble signal. A self-test feature must be provided for each detector to be individually tested.

[2.12.1 Infrared (IR) Single Frequency Flame Detector

The detector must be sensitive in the range of [_____] to [_____] micrometers only.

][2.12.2 Infrared (IR) Multi Frequency Flame Detector

The IR detector must consist of three or more IR sensors, each selected for a different IR frequency. The primary sensor must be sensitive in the range of [_____] to [_____] micrometers only. Secondary sensors are tuned to different IR wavelengths to null out the effect of black body radiation to the primary sensor.

][2.12.3 Ultraviolet (UV) Flame Detectors

UV flame detector must be of the narrow band response type which operates on radiated ultraviolet energy and must be sensitive in the range of [_____] to [_____] micrometers only. The cone of vision must be 80 degrees or greater. Each detector must be completely insensitive to light sources in the visible frequency range.

][2.12.4 Combination UV/IR Flame Detector

The UV/IR detector must provide discrimination against false alarms by requiring both UV and IR flame detection before an alarm is sent. The UV sensor must be sensitive in the range of 0.185 to 0.265 micrometers only. The IR sensor must be sensitive in the range of [_____] to [_____] micrometers only. Detectors must be completely insensitive to light sources in the visible frequency range.

]][2.13 MULTI-CRITERIA DETECTORS

Multi-criteria detectors must contain [fixed temperature [_____] degrees F heat sensor], [rate-of-rise heat sensor], [photoelectric smoke detector], [_____] elements in a single housing.

]2.14 CARBON MONOXIDE DETECTOR

Analog/addressable carbon monoxide (CO) detectors must be listed to UL 2075 and set to respond to the sensitivity limits of UL 2034. Carbon monoxide detectors must be listed for use with fire alarm control units. Detectors must be [surface] [semi-flush] mounted in the [vertical][horizontal] orientation and supported independently of wiring connections. Detectors must be self-restoring. For FMCU with no listed compatible addressable CO detectors, provide listed 4-wire detectors.[Do not provide CO detectors with local alarms.] Detector must be provided with an LED status indicator.

a. Where 4-wire CO detectors are necessary, each 4-wire CO detector must be individually monitored via addressable interface modules for alarm and off normal/trouble conditions (including loss of power to the individual detector). Power circuits for 4-wire CO detectors must be dedicated to powering the CO detectors only. Battery powered and 120 VAC powered detectors are prohibited.

b. Wiring connections must be made by means of screw terminals and detectors must be equipped with trouble relays. Detectors must be able to mount a single-gang electrical box.

c. A trouble condition at an individual CO detector must not affect any other CO detectors. CO detectors must be powered by the FMCU.

d. Detectors must be provided with a means to test CO gas entry into the CO sensing cell.

2.15 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored must be configured as a [Class "A"][Class "B"] initiating device circuits. The module must be listed as compatible with the control unit. The module must provide address setting means compatible with the control unit's SLC supervision and store an internal identifying code. Monitor module must contain an integral LED that flashes each time the monitor module is polled and is visible through the device cover plate. Pull stations with a monitor module in a common backbox are not required to have an LED.[Existing fire alarm system initiating device circuits must be connected to a single module to supervise the circuit.] Modules must be listed for the environmental conditions in which they will be installed.

2.16 ADDRESSABLE CONTROL MODULES

The control module must be capable of operating as a relay (dry contact form C) for interfacing the control unit with other systems, and to control door holders or initiate elevator fire service. The module must be listed as compatible with the control unit. The indicating device or the external load being controlled must be configured as [Class B][Class A] notification appliance circuits. The system must be capable of supervising, audible, visual and dry contact circuits. The control module must have both an input and output address. The supervision must detect a short on the supervised circuit and must prevent power from being applied to the circuit. The control module must provide address setting means compatible with the control unit's SLC supervision and store an internal identifying code. The control module must contain an integral LED that flashes each time the control module is polled and is visible through the device cover plate. Control Modules must be listed for the environmental conditions in which they will be installed.

[2.17 ISOLATION MODULES

a. Provide isolation modules to subdivide each signaling line circuit [into groups of not more than [20 addressable devices][_____]][each floor][in accordance with NFPA 72] between adjacent isolation modules.

b. Isolation modules must provide short circuit isolation for signaling line circuit wiring.

c. Power and communications must be supplied by the SLC and must report faults to the FMCU.

d. After the wiring fault is repaired, the fault isolation modules must test the lines and automatically restore the connection.

]2.18 NOTIFICATION APPLIANCES

2.18.1 Audible Notification Appliances

Audible appliances must conform to the applicable requirements of UL 464. Appliances must be connected into notification appliance circuits. Surface mounted audible appliances must be painted [red][white][_____]. Recessed audible appliances must be installed with a grill that is painted [red][white][_____][with a factory finish to match the surface to which it is mounted].

2.18.1.1 Speakers

a. Speakers must conform to the applicable requirements of UL 1480. Speakers must have six different sound output levels and operate with audio line input levels of 70.7 VRMs and 25 VRMs, by means of selectable tap settings. Interior speaker tap settings must include taps of 1/4, 1/2, 1, and 2 watt, at a minimum. Exterior speakers must also be multi-tapped with no more than 15 watt maximum setting. Speakers must incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 400 Hz to 4,000 Hz, and must have a sealed back construction. Speakers must be capable of installation on standard 4-inch square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single [wall mounted] unit. All inputs must be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FMCU.

b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 16 gage or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes must be ground and finished to provide a smooth and neat appearance for each plate. Each plate must be primed and painted.

c. Speakers must utilize screw terminals for termination of all field wiring.

2.18.2 Visual Notification Appliances

Visual notification appliances must conform to the applicable requirements of UL 1638, UL 1971 and conform to the Architectural Barriers Act (ABA). Visual Notification Appliances must have clear high intensity optic lens, xenon flash tubes, or light emitting diode (LED) and be marked "Alert" in letters of contrasting color. The light pattern must be dispersed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe. Strobe flash rate must be 1 flash per second and a minimum of [15][30][75][_____] candela based on the UL 1971 test. Strobe must be [surface][semi-flush] mounted.

2.18.3 Textual Display Signs

Textual display signs must be [LED][LCD flat panel][LED scrolling] and must not exceed 16 inches long by 6 inches high by 3 inches deep with a height necessary to meet the requirements of NFPA 72. The text display must spell out the word "EVACUATE" or "ANNOUNCEMENT" [and the remainder of the emergency instructions]as appropriate. The design of text display must be such that it cannot be read when not illuminated.

[LCD or LED scrolling text displays must meet the following requirements at a minimum:

a. Two lines of information for high priority messaging.

b. Minimum of 20 characters per line (40 total) displayed.

c. Text must be no less than height requirements and color/contrast requirements of NFPA 72.

d. 32K character memory.

e. Display must be wall or ceiling mounted.

f. Mounting brackets for a convenient wall/cubicle mount.

[g. During non-emergency periods, display date and time.]

h. The system must interface with the textual display sign control panel to activate the proper message.]

2.19 ELECTRIC POWER

2.19.1 Primary Power

Power must be [120][_____] VAC [50][60] Hz service for the FMCU from the AC service to the building in accordance with NFPA 72.

2.20 SECONDARY POWER SUPPLY

Provide for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power must be automatic and must not cause transmission of a false alarm.

2.20.1 Batteries

Provide sealed, maintenance-free, [sealed lead acid][lead-calcium][gel cell] batteries as the source for emergency power to the FMCU. Batteries must contain suspended electrolyte. The battery system must be maintained in a fully charged condition by means of a solid state battery charger. Provide an automatic transfer switch to transfer the load to the batteries in the event of the failure of primary power.

2.20.1.1 Capacity

Battery size must be the greater of the following two capacities. This capacity applies to every control unit associated with this system, including supplemental notification appliance circuit panels, auxiliary power supply panels, fire alarm transmitters, and Base-wide mass notification transceivers. When determining the required capacity under alarm condition, visual notification appliances must include both textual and non-textual type appliances.

a. Sufficient capacity to operate the fire alarm system under supervisory and trouble conditions, including audible trouble signal devices for 48 hours and audible and visual signal devices under alarm conditions for an additional 15 minutes.

b. Sufficient capacity to operate the mass notification for 60 minutes after loss of AC power.

2.20.1.2 Battery Power Calculations

a. Verify that battery capacity exceeds supervisory and alarm power requirements for the criteria noted in the paragraph "Capacity" above.

   (1) Substantiate the battery calculations for alarm and supervisory power requirements. Include ampere-hour requirements for each system component and each control unit component, and compliance with UL 864.

   (2) Provide complete battery calculations for both the alarm and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.

   (3) Provide voltage drop calculations to indicate that sufficient voltage is available for proper operation of the system and all components. Calculations must be performed using the minimum rated voltage of each component.

b. For battery calculations assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Using 20.4 VDC as starting voltage, perform a voltage drop calculation for circuits containing device and/or appliances remote from the power sources.

2.20.2 Battery Chargers

Provide a solid state, fully automatic, variable charging rate battery charger. The charger must be capable of providing 120 percent of the connected system load and must maintain the batteries at full charge. In the event the batteries are fully discharged (20.4 Volts dc), the charger must recharge the batteries back to 95 percent of full charge within 48 hours after a single discharge cycle as described in paragraph CAPACITY above. Provide pilot light to indicate when batteries are manually placed on a high rate of charge as part of the unit assembly if a high rate switch is provided.

2.21 SURGE PROTECTIVE DEVICES

Surge protective devices must be provided to suppress all voltage transients which might damage fire alarm control unit components. Systems having circuits located outdoors, communications equipment must be protected against surges induced on any signaling line circuit. Cables and conductors, that serve as communications links, must have surge protection circuits installed at each end. The surge protective device must wire in series to the power supply of the protected equipment with screw terminations. Line voltage surge arrestor must be installed directly adjacent to the power panel where the FMCU breaker is located.

a. Surge protective devices for nominal 120 VAC must be UL 1449 listed with a maximum 500 volt suppression level and have a maximum response time of 5 nanoseconds. The surge protective device must also meet IEEE C62.41.1 and IEEE C62.41.2 category B tests for surge capacity. The surge protective device must feature multi-stage construction and be provided with a long-life indicator lamp (either light emitting diode or neon) which extinguishes upon failure of protected components. Any unit fusing must be externally accessible.

b. Surge protective devices for nominal 24 VAC, fire alarm telephone dialer, or ethernet connection must be UL 497B listed, meet IEEE C62.41.1 and have a maximum response time of 1-nanosecond. The surge protective device must feature multi-stage construction and be self-resetting. The surge protective device must be a base and plug style. The base assembly must have screw terminals for fire alarm wiring. The base assembly must accept "plug-in" surge protective module.

c. All surge protective devices (SPD) must be the standard product of a single manufacturer and be equal or better than the following:

(1) For 120 VAC nominal line voltage: UL 1449 and UL 1283 listed, series connected 120 VAC, 20A rated, surge protective device in a NEMA 4x enclosure. Minimum 50,000 amp surge current rating with EMI/RFI filtering and a dry contact circuit for remote monitoring of surge protection status.

(2) For 24-volt nominal line voltage: UL 497B listed, series connected low voltage, 24-volt, 5A rated, loop circuit protector, base and replaceable module.

(3) For alarm telephone dialers: UL 497A listed, series connected, 130-volt, 150 mA rated with self-resetting fuse, dialer circuit protector with modular plug and play.

(4) For IP-DACTS: UL 497B listed, series connected, 6.4-volt, 1.5A rated with 20 kA/pair surge current, data network protector with modular plug and play.

2.22 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein.

2.22.1 Alarm Wiring

IDC and SLC wiring must be [fiber optic][or][solid copper] cable in accordance with the manufacturers requirements. Copper signaling line circuits and initiating device circuit field wiring must be No. [14][16][18][_____] AWG size conductors at a minimum. Visual notification appliance circuit conductors, that contain audible alarm appliances, must be copper No. 14 AWG size conductors at a minimum. Speaker circuits must be copper No. [16][_____] AWG size twisted and shielded conductors at a minimum.[Wiring for textual notification appliance circuits must be in accordance with manufacturer's requirements but must be supervised by the FMCU.] Wire size must be sufficient to prevent voltage drop problems. Circuits operating at 24 VDC must not operate at less than the listed voltages for the detectors and/or appliances. Power wiring, operating at 120 VAC minimum, must be a minimum No. 12 AWG solid copper having similar insulation. Acceptable power-limited cables are FPL, FPLR or FPLP as appropriate with red colored covering. Nonpower-limited cables must comply with NFPA 70.

2.23 INTERFACE TO THE BASE-WIDE MASS NOTIFICATION NETWORK

[2.23.1 Fiber Optic

The fiber optic transceiver must be fully compatible with EIA standards for RS-232, RS-422 and RS-485 at data rates from 0 (DC) to 2.1 mbps (200 kbps for RS-232) in the low speed mode or from 10 kbps to 10 mbps in the high-speed mode. The fiber optic transceiver must be capable of simplex or full duplex asynchronous transmissions in both point-to-point systems and drop-and-repeat data networks. The fiber optic transceiver must be user configurable for the protocol, speed and mode of operation required. The fiber optic transceiver must be installed as a [stand-alone][card-cage] unit. The fiber optic transceiver must operate on [Multi-mode][Single-mode] fiber optic cable. The fiber optic transceiver must be supplied with [ST][or][FCPC] type optical connectors. Cabling: as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

][2.23.2 Radio

The mass notification transceiver must be bi-direction and meet all the requirements of paragraph, RADIO TRANSMITTER AND INTERFACE PANELS as specified in this specification section. The transceiver utilized in the mass notification system must be capable of the following:

a. Communication with the central control/monitoring system to provide supervision of communication link and status changes are reported by automatic and manual poll/reply/acknowledge routines.

b. All monitored points/status changes are transmitted immediately and at programmed intervals until acknowledged by the central control/monitoring system.

c. Each transceiver must transmits a unique identity code as part of all messages; the code is set by the user at the transceiver.

][2.23.3 Telephone

A modem must be provided for communication with the central control/monitoring system. The modem must be 56k, compatible with data mode V.90, utilizing Hayes compatible command codes. The modem must be capable of auto dialing a preset number based on preprogrammed events. The modem must auto answer and provide a secure password protection system. Cabling: as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

][2.23.4 Secure Radio System

2.23.4.1 Communications Network

The communications network provides two-way signals between central control units and autonomous control units (in individual building systems), and should include redundant (primary and backup) communication links. The system must incorporate technology to prevent easy interruption of the radio traffic for MNS alerting.

2.23.4.2 Radio Frequency Communications

Use of radio frequency-type communications systems must comply with National Telecommunications and Information Administration (NTIA) requirements. The systems must be designed to minimize the potential for interference, jamming, eavesdropping, and spoofing.

2.23.4.3 Licensed Radio Frequency Systems

An approved DD Form 1494 for the system is required prior to operation.

]2.24 AUTOMATIC FIRE ALARM TRANSMITTERS

[2.24.1 Radio Transmitter and Interface Panels

Transmitters must be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter must be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters must be provided in accordance with applicable portions of NFPA 72, Federal Communications Commission (FCC) 47 CFR 90 and Federal Communications Commission (FCC) 47 CFR 15. Transmitter electronics module must be contained within the physical housing as an integral, removable assembly. The proprietary supervising station receiving equipment is [_____] and the transmitter must be fully compatible with this equipment. At the contractors option, and if listed, the transmitter may be housed in the same control unit as the FMCU. The transmitter must be narrowband radio, with FCC certification for narrowband operation and meets the requirements of the NTIA (National Telecommunications and Information Administration) Manual of Regulations and Procedures for Federal Frequency Management.

2.24.1.1 Operation

Operate each transmitter from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter must automatically switch to battery operation. Switchover must be accomplished with no interruption of protective service, and must automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply must also be automatic.

2.24.1.2 Battery Power

Transmitter standby battery capacity must provide sufficient power to operate the transmitter in a normal standby status for a minimum of 72 hours and be capable of transmitting alarms during that period.

2.24.1.3 Transmitter Housing

Use NEMA Type 1 for housing. The housing must contain a lock that is keyed [identical to the fire alarm system for the building][identical to radio alarm transmitter housings on the Installation]. Radio alarm transmitter housing must be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

2.24.1.4 Antenna

Antenna must be [omnidirectional, coaxial, halfwave dipole antennas][_____] for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts must be corrosion resistant and designed to withstand wind velocities of 100 mph. Do not mount antennas to any portion of the building roofing system. Protect the antenna from physical damage.

][2.24.2 Digital Alarm Communicator Transmitter (DACT)

Provide DACT that is compatible with the existing supervising station fire alarm system. Transmitter must have a means to transmit alarm, supervisory, and trouble conditions via a single transmitter. Transmitter must have a source of power for operation that conforms to NFPA 72. Transmitter must be capable of initiating a test signal daily at any selected time. Transmitter must be arranged to seize telephone circuits in accordance with NFPA 72.

]2.24.3 Signals to Be Transmitted to the Base Receiving Station

The following signals must be sent to the base receiving station:

[a. Sprinkler waterflow

][b. Manual pull stations

][c. Smoke detectors

][d. Duct smoke detectors

][e. Sleeping room smoke detectors

][f. Carbon monoxide detectors

][g. Heat detectors

][h. Fire extinguishing system

][i. Sprinkler valve supervision

][j. Fire pump running

][k. Fire pump supervision

][l. Water supply level and temperature

][m. Combustion engine drive fire pump running

(1) Selector switch in position than automatic

(2) Engine over-speed

(3) Low fuel

(4) Low battery

(5) Engine trouble (for example, low oil, over temp)

]2.25 SYSTEM MONITORING

2.25.1 Valves

Each valve affecting the proper operation of a fire protection system, including automatic sprinkler control valves,[standpipe control valves,] sprinkler service entrance valve,[valves at fire pumps,] isolating valves for pressure type waterflow or supervision switches, and valves at backflow preventers, whether supplied under this contract or existing, must be electrically monitored to ensure its proper position. Provide each tamper switch with a separate address[, unless they are within the same room, then a maximum of five can use the same address].

[2.25.2 High/Low [Air][Nitrogen] Supervisory Switches

Provide monitoring of high and low supervisory [air][nitrogen] for [dry pipe][and][preaction] systems. Each air supervisory switch must have a separate address. Switches must be listed extinguishing system attachments. The device must contain double pole, double throw contacts. Operation of the switch must cause a supervisory signal to be transmitted to the FMCU when [air][nitrogen] pressure in the system monitored sprinkler system increases more than 5 psi above the normal system pressure or drops halfway from the normal pressure to the tripping point.

][2.25.3 Room Low Temperature Supervisory Switch

Provide [monitoring of the]listed supervisory air temperature switch for the [fire pump][sprinkler riser] room[s]. Switch must cause a supervisory signal to be transmitted to the FMCU whenever the temperature in the room drops to below 40 degrees F. Device must reset when temperature rises above 40 degrees F.

][2.25.4 Electromagnetic Door Holders

Electromagnetic holding devices must operate on [120 VAC][24 VDC], and require not more than [3][_____] watts of power to develop 25 psi of holding force. Under normal conditions, the magnets must attract and hold the doors open. Operation must be fail safe with no moving parts. Electromagnetic door hold-open devices must not be required to be held open during building power failure. The device must be listed based on UL 228 tests.

]2.26 ENVIRONMENTAL ENCLOSURES OR GUARDS

Environmental enclosures must be provided to permit fire alarm/mass notification components to be used in areas that exceed the environmental limits of the listing. The enclosure must be listed for the device or appliance as either a manufactured part number or as a listed compatible accessory for the component is currently listed. Guards required to deter mechanical damage must be either a listed manufactured part or a listed accessory for the category of the initiating device or notification appliance.

[2.27 FIREFIGHTER TELEPHONE COMMUNICATION SYSTEM

2.27.1 General

Provide a firefighter telephone communication system with complete, common talk, closed circuits. The system must include, but not be limited to, a master control station mounted in the fire alarm control unit, a power supply and standby battery system, and remote telephone stations.

2.27.2 Features

The system must include the following features:

a. A master control station which must provide power, supervision, and control for wiring, components, and circuits. The act of lifting any remote telephone hand set from its cradle must cause both a visual and audible signal to annunciate at the master control station. Removing the hand set at the master control station and depressing a button at the remote telephone hand set must cause the automatic silencing of the audible signal.

b. Communication between the master control station hand set and any/or all remote hand sets must require the depressing of a push-to-talk switch located on any/all remote hand sets. During the time that the master control hand set is removed from its cradle it must be possible to communicate between five remote hand sets and the master control station.

c. Hand sets must be able to monitor any conversation in progress and join the conversation by pressing the push-to-talk button. It must not be possible to communicate between two or more remote hand sets with the master control station hand set in its cradle.

d. The master control station hand set must be red in color and equipped with a 5-foot long strain-relieved coiled cord.

e. The master control station must monitor wire and connections for any opens, shorts, or grounds which would render the system inoperable or unintelligible.

f. The master control station must be equipped with a silencing switch and ring-back feature such that any audible trouble signal can be silenced and must be so indicated by the lighting of an amber LED. Once any trouble condition has been corrected, the amber LED must be extinguished.

g. The master control station must be equipped with a separate, LED annunciated switch for each telephone circuit. In addition, LEDs must provide for the annunciation of operating and supervisory power.

h. The loss of operating or supervisory power must cause an audible and visual indication at the master control station and must also cause the fire alarm trouble signal to sound on the FMCU.

i. Switches, LEDs, and controls must be fully labeled.

2.27.3 Handsets

Handsets must have the following features:

a. Provide [surface][flush] mounted remote telephone stations.

b. Each station must be equipped with a hinged door that is magnetically locked.

c. Each hand set must be permanently wired in place with a coiled cord.

d. Each hand set must be red high-impact cycolac and must be equipped with a push-to-talk switch which, when operated, must signal the master control station and a switch-equipped, storage cradle.

e. Provide operating and supervising power from the same supply circuit(s) utilized for the FMCU.

]PART 3 EXECUTION

3.1 VERIFYING ACTUAL FIELD CONDITIONS

Before commencing work, examine all adjoining work on which the contractor's work is in any way dependent for perfect workmanship according to the intent of this specification section, and report to the Contracting Officer's Representative any condition which prevents performance of first class work. No "waiver of responsibility" for incomplete, inadequate or defective adjoining work will be considered unless notice has been filed before submittal of a proposal.

3.2 INSTALLATION

3.2.1 Fire Alarm and Mass Notification Control Unit (FMCU)

Locate the FMCU [where indicated on the drawings][_____]. [Recess][Semi-recess][Surface mount] the enclosure with the top of the cabinet 6 feet above the finished floor or center the cabinet at [5][_____] feet, whichever is lower. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the FMCU. Locate the document storage cabinet adjacent to the FMCU unless the Contracting Officer directs otherwise.

3.2.2 Battery Cabinets

When batteries will not fit in the FMCU, locate battery cabinets below or adjacent to the FMCU. Battery cabinets must be installed at an accessible location when standing at floor level. Battery cabinets must not be installed lower than 12 inches above finished floor, measured to the bottom of the cabinet, nor higher than 36 inches above the floor, measured to the top of the cabinet. Installing batteries above drop ceilings or in inaccessible locations is prohibited. Battery cabinets must be large enough to accommodate batteries and also to allow ample gutter space for interconnection of control units as well as field wiring. The cabinet must be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions.The cabinet must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must indicate the control unit(s) the batteries power and must not be less than 1-inch high.

3.2.3 Manual Stations

Locate manual stations as required by NFPA 72[and as indicated on the drawings]. Mount stations so they are located no farther than [5][_____] feet from the exit door they serve, measured horizontally. Manual stations must be mounted at [42][44][_____] inches measured to the operating handle.

3.2.4 Notification Appliances

a. Locate notification appliance devices[as required by NFPA 72][where indicated][and to meet the intelligibility requirements]. Where two or more visual notification appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices must use screw terminals for all field wiring.[Audible and visual notification appliances mounted in acoustical ceiling tiles must be centered in the tiles plus or minus 2 inches.]

b. Audible and visual notification appliances mounted on the exterior of the building, within unconditioned spaces, or in the vicinity of showers must be listed weatherproof appliances installed on weatherproof backboxes.

c. Speakers must not be located in close proximity to the FMCU or LOC so as to cause feedback when the microphone is in use.

3.2.5 Smoke and Heat Detectors

Locate detectors[as required by NFPA 72 and their listing][as indicated on the drawings] on a 4-inch mounting box. Install heat detectors not less than 4 inches from a side wall to the near edge. Heat detectors located on the wall must have the top of the detector at least 4 inches below the ceiling, but not more than 12 inches below the ceiling. Smoke detectors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling.[In raised floor spaces, install the smoke detectors to protect[225 square feet per detector][_____].] Install smoke detectors no closer than 3 feet from air handling supply diffusers. Detectors installed in acoustical ceiling tiles must be centered in the tiles plus or minus 2 inches.

3.2.6 Carbon Monoxide Detectors

Locate detectors[as required by NFPA 72 and their listings][as indicated on the drawings] on a 4-inch mounting box.[Carbon monoxide detectors must be installed separate from smoke and/or heat detectors.]

[3.2.7 Air Sampling Smoke Detector

Locate air sampling smoke detectors in accordance with the manufacturer's instructions. Air sampling smoke detectors must be installed as follows:

a. Air Sampling Smoke Detector Assembly:

(1) Detector assembly must be mounted to a wall at a height between 48 to 60 inches to top of detector measured above the finished floor.

(2) Mounting must be in a fully accessible and visible location.

(3) Mounting or attachment to site equipment, cable trays, movable walls, other equipment or equipment supports is not permitted.

(4) Piping network insertion into the detector inlet must not be glued.

(5) Air sampling smoke detector assembly must be installed in accordance with this specification section and the manufacturer's installation and instruction manuals.

(6) Flexible tubing for termination of the sampling pipe network into detector inlet is not permitted unless allowed by its listing.

(7) Provide red background with white lettering labels that are plastic or phenolic type with a minimum of 0.25-inch block lettering to indicate detector and zone. For example: "AIR SAMPLING SOME DETECTOR No. 1-1 No. 5".

(8) Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a conspicuous location observable from the ASD panel. The card must show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions must be approved by the Contracting Officer before being posted.

b. Pipe and Sampling Tube Mounting:

(1) The pipe and sampling tubing detection network must be mounted as per the design and manufacturer's specification. The hardware used for mounting will depend upon the design and site requirements.

(2) To minimize flexing, pipes must be secured every 5 feet.

(3) Pipes must be suspended between 1 and 4 inches below the ceiling. In areas with a suspended ceiling, the pipe network must be installed above the ceiling utilizing the manufacturer's capillary sample port supported by the ceiling.

(4) The sampling tubes must be of the same length or use the manufacturer's guidelines to run tubes of the required lengths.

(5) When installing a pipe network in areas subject to high temperature fluctuations allow for the contraction and expansion of pipes.

(6) Where expansion or contraction of pipes is likely either after installation or on a continuous basis, do not place pipe clips adjacent to couplings and socket unions as these may interfere with the movement of the pipe.

(7) No bends are permitted within the first 18 inches from the detector inlet.

(8) The routing of the piping and sample tube network must be coordinated with potential obstructions, including cable trays, grounding bars, and HVAC ductwork.

(9) All changes in direction must be made with standard elbows or tees.

(10) All joints must be air-tight and made by using solvent cement, except at the entry to the detector assembly. Refer to ASTM F402.

(11) All pipes must be supported by mechanical hangers attached to the structure of the building. Not more than 1-foot of pipe must extend beyond the last hanger of each sampling pipe. The final installation must result in no noticeable deflection in the piping network.

(12) Attachment of air sampling pipes to cable trays, "gray iron", and telecommunications equipment is prohibited.

(13) Clearly label pipe network to distinguish the pipe from other facility pipe work or protective cabling enclosures. For example: "SMOKE DETECTION SAMPLING TUBE - DO NOT DISTURB". In open rooms and exposed areas, provide labels at no greater than 20-foot intervals. Provide labels every 10 feet where piping is installed above suspended ceilings and every 2 feet, centered in the floor panels, where piping is installed within the raised floor cavity.

(14) Placement of the sampling tube must take into consideration appropriate sampling point locations and spacing.

c. Air Sampling Points:

(1) Open area ceiling sampling points must be oriented downward and must be within 1 to 4 inches below the underside of the ceiling above where the ceiling is smooth.

(2) Label all air sampling points with a round red label, each with a center hole to match the diameter of the drilled sampling point. For example: "AIR SAMPLING POINT DIA 0.125 INCHES". Indicate fractional dimensions in decimal format with a minimum of three decimal places.

][3.2.8 Graphic Annunciator

Locate the graphic annunciator as shown on the drawings. Mount the annunciator, with the top 6 feet above the finished floor or center the annunciator at [5][_____] feet, whichever is lower.

]3.2.9 LCD REMOTE Annunciator

Locate the LCD annunciator as shown on the drawings. Mount the annunciator, with the top 6 feet above the finished floor or center the annunciator at [5][_____] feet, whichever is lower.

[3.2.10 Electromagnetic Door Holder Release

Doors must be held open at a minimum of 90 degrees so as not to impede egress from the space. Mount the armature portion on the door and have an adjusting screw for seating the angle of the contact plate. Wall-mount the electromagnetic release, with a total horizontal projection not exceeding 4 inches. Ensure all doors release to close upon first stage (pre-discharge) alarm. Electrical supervision of wiring external of control unit for magnetic door holding circuits is not required.

][3.2.11 Firefighter Telephones

Mount telephone[hand sets][jacks] on the wall in each stair at each floor landing, in each emergency generator room, in each fire pump room, in each elevator machine room, in each elevator lobby, and in each elevator cab 4 feet above the finished floor.

]3.2.12 Local Operating Console (LOC)

Locate the LOC(s) as required by NFPA 72 and as indicated. Mount the console so that the top message button and microphone is no higher than 4 feet above the floor and the bottom (lowest) message button and microphone is at least 3 feet above the finished floor.

3.2.13 Ceiling Bridges

Provide ceiling bridges for ceiling-mounted appliances. Ceiling bridges must be as recommended/required by the manufacturer of the ceiling-mounted notification appliance.

3.3 SYSTEM FIELD WIRING

3.3.1 Wiring within Cabinets, Enclosures, and Boxes

Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet. Conductors that are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting, or junction box must be connected to screw-type terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. The use of wire nuts or similar devices is prohibited. Wiring to conform with NFPA 70.

Indicate the following in the wiring diagrams:

a. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FMCU and remote fire alarm/mass notification control units, initiating circuits, switches, relays and terminals.

b. Complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Include a color code schedule for the wiring. Include floor plans showing the locations of devices and equipment.

3.3.2 Terminal Cabinets

Provide a terminal cabinet at the base of any circuit riser, on each floor at each riser, and where indicated on the drawings. Terminal size must be appropriate for the size of the wiring to be connected. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the terminal cabinet. Minimum size is 8 inches by 8 inches. Only screw-type terminals are permitted. Provide an identification label, that displays "FIRE ALARM TERMINAL CABINET" with 2-inch lettering, on the front of the terminal cabinet.

3.3.3 Alarm Wiring

a. Voltages must not be mixed in any junction box, housing or device, except those containing power supplies and control relays.

b. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, in or adjacent to the FMCU.

c. [Pigtail or T-tap connections to signal line circuits, initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited.][T-tapping using screw terminal blocks is allowed for Class "B" signaling line circuits.]

d. Color coding is required for circuits and must be maintained throughout the circuit. Conductors used for the same functions must be similarly color coded. Conform wiring to NFPA 70.

e. Pull all conductors splice free. The use of wire nuts, crimped connectors, or twisting of conductors is prohibited. Where splices are unavoidable, the location of the junction box or pull box where they occur must be identified on the as-built drawings. The number and location of splices must be subject to approval by the [_____] Designated Fire Protection Engineer (DFPE).

3.3.4 Back Boxes and Conduit

In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide all wiring in rigid metal conduit or intermediate metal conduit unless specifically indicated otherwise. Minimum conduit size must be 3/4-inch in diameter. Do not use electrical non-metallic tubing (ENT) or flexible non-metallic tubing and associated fittings.

a. Galvanized rigid steel (GRS) conduit must be utilized where exposed to weather, where subject to physical damage, and where exposed on exterior of buildings. Intermediate metal conduit (IMC) may be used in lieu of GRS as allowed by NFPA 70.

b. Electrical metallic tubing (EMT) is permitted above suspended ceilings or exposed where not subject to physical damage. Do not use EMT underground, encased in concrete, mortar, or grout, in hazardous locations, where exposed to physical damage, outdoors or in fire pump rooms. Use die-cast compression connectors.

c. For rigid metallic conduit (RMC), only threaded type fitting are permitted for wet or damp locations.

d. Flexible metal conduit is permitted for initiating device circuits 6 feet in length or less. Flexible metal conduit is prohibited for notification appliance circuits and signaling line circuits. Use liquid tight flexible metal conduit in damp and wet locations.

e. Schedule 40 (minimum) polyvinyl chloride (PVC) is permitted where conduit is routed underground or underground below floor slabs. Convert non-metallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before turning up through floor slab.

f. Exterior wall penetrations must be weathertight. Conduit must be sealed to prevent the infiltration of moisture.

[g. For Class "A" or "X" circuits with conductor lengths of 10 feet or less, the conductors must be permitted to be installed in the same raceway in accordance with NFPA 72.

]3.3.5 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCU[, and remote FMCU] and the LOC must be provided at each conductor connection. Each conductor or cable must have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCU, and remote FMCU must contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing must be neat, using 12 point lettering minimum size, and mounted within each cabinet, control unit, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

[3.4 DISCONNECTION AND REMOVAL OF EXISTING SYSTEM

Maintain existing fire alarm/mass notification equipment fully operational until the new equipment has been tested and accepted by the Contracting Officer. As new equipment is installed, label it "NOT IN SERVICE" until the new equipment is accepted. Once the new system is completed, tested, and accepted by the Government, it must be placed in service and connected to the supervising station. Remove tags from new equipment and tag the existing equipment "NOT IN SERVICE" until removed from the building.

a. After acceptance of the new system by the Contracting Officer, remove existing equipment not connected to the new system, remove unused exposed conduit, and restore damaged surfaces. Remove the material from the site and dispose.

b. Disconnect and remove the existing fire alarm/mass notification and smoke detection systems where indicated and elsewhere in the specification.

c. Control units and fire alarm devices and appliances disconnected and removed must be turned over to the Contracting Officer.

d. Properly dispose of fire alarm outlet and junction boxes, wiring, conduit, supports, and other such items.

3.5 CONNECTION OF NEW SYSTEM

The following new system connections must be made during the last phase of construction, at the beginning of the pre-Government tests. New system connections must include:

a. Connection of new relays to existing magnetic door hold-open devices.

b. Connection of new elevator recall relays to existing wiring and conduit.

c. Connection of new system transmitter to existing installation fire reporting system.

Once these connections are made, system must be left energized. Report immediately to the Contracting Officer, coordination and field problems resulting from the connection of the above components.

]3.6 FIRESTOPPING

Provide firestopping for holes at conduit penetrations through floor slabs, fire-rated walls, partitions with fire-rated doors, corridor walls, and vertical service shafts in accordance with Section 07 84 00 FIRESTOPPING.

3.7 PAINTING

a. In unfinished areas (including areas above drop ceilings), paint all exposed electrical conduit (serving fire alarm equipment), fire alarm conduit, surface metal raceway, junction boxes and covers red. In lieu of painting conduit, the contractor may utilize red conduit with a factory applied finish.

b. In finished areas, paint exposed electrical conduit (serving fire alarm equipment), fire alarm conduit, surface metal raceways, junction boxes, and electrical boxes to match adjacent finishes. The inside cover of the junction box must be identified as "Fire Alarm" and the conduit must have painted red bands 3/4-inch wide at 10-foot centers and at each side of a floor, wall, or ceiling penetration.

c. Painting must comply with Section 09 90 00 PAINTS AND COATINGS.

3.8 FIELD QUALITY CONTROL

3.8.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level [III][or][IV] Fire Alarm Technician, and the representative of the installing company, [and reviewed by the QFPE] [60][_____] days prior to performing system tests. Detailed test procedures must list all components of the installed system such as initiating devices and circuits, notification appliances and circuits, signaling line devices and circuits, control devices/equipment, batteries, transmitting and receiving equipment, power sources/supply, annunciators, special hazard equipment, emergency communication equipment, interface equipment, and surge protective devices. Test procedures must include sequence of testing, time estimate for each test, and sample test data forms. The test data forms must be in a check-off format (pass/fail with space to add applicable test data; similar to the forms in NFPA 72 and NFPA 4.) The test procedures and accompanying test data forms must be used for the pre-Government testing and the Government testing. The test data forms must record the test results and must:

a. Identify the NFPA Class of all Initiating Device Circuits (IDC), and Notification Appliance Circuits (NAC), Voice Notification System Circuits (NAC Audio), and Signaling Line Circuits (SLC).

b. Identify each test required by NFPA 72 Test Methods and required test herein to be performed on each component, and describe how these tests must be performed.

c. Identify each component and circuit as to type, location within the facility, and unique identity within the installed system. Provide necessary floor plan sheets showing each component location, test location, and alphanumeric identity.

d. Identify all test equipment and personnel required to perform each test (including equipment necessary for smoke detector testing. The use of magnets is not permitted.

e. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.8.2 Pre-Government Testing

3.8.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that devices and circuits are functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" as required by NFPA 72. The contractor and an authorized representative from each supplier of equipment must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 72 including all referenced annex sections and the test reports noted below.

a. NFPA 72 Record of Completion.

b. NFPA 72 Record of Inspection and Testing.

c. Fire Alarm and Emergency Communication System Inspection and Testing Form.

d. Audibility test results with marked-up test floor plans.

e. Intelligibility test results with marked-up floor plans.

f. Documentation that all tests identified in the paragraph "Minimum System Tests" are complete.

3.8.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the [_____][Designated Fire Protection Engineer (DFPE)][Contracting Officer's Representative (COR)]. Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Government final testing will not be performed until after the connections to the installation-wide fire reporting system[and the installation-wide mass notification system have] been completed and tested to confirm communications are fully functional. Submit request for test at least [15][_____] calendar days prior to the requested test date.

3.8.3 Correction of Deficiencies

If equipment was found to be defective or non-compliant with contract requirements, perform corrective actions and repeat the tests. Tests must be conducted and repeated if necessary until the system has been demonstrated to comply with all contract requirements.

3.8.4 Government Final Tests

The tests must be performed in accordance with the approved test procedures in the presence of the DFPE. Furnish instruments and personnel required for the tests. The following must be provided at the job site for Government Final Testing:

a. The manufacturer's technical representative.

[b. The contractor's Qualified Fire Protection Engineer (QFPE).

] c. Marked-up red line drawings of the system as actually installed.

d. Loop resistance test results.

e. Complete program printout including input/output addresses.

f. Copy of pre-Government Test Certificate, test procedures and completed test data forms.

g. Audibility test results with marked-up floor plans.

h. Intelligibility test results with marked-up floor plans.

Government Final Tests will be witnessed by the [_____], [Designated Fire Protection Engineer][Contracting Officer's Representative (COR)][, Qualified Fire Protection Engineer (QFPE)]. At this time, any and all required tests noted in the paragraph "Minimum System Tests" must be repeated at their discretion.

3.9 MINIMUM SYSTEM TESTS

3.9.1 System Tests

Test the system in accordance with the procedures outlined in NFPA 72. The required tests are as follows:

a. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests must be witnessed by the Contracting Officer and test results recorded for use at the final Government test.

b. Verify the absence of unwanted voltages between circuit conductors and ground. The tests must be accomplished at the pre-Government test with results available at the final system test.

c. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.

d. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke detectors must be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors must comply with the requirements of NFPA 72 except disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision must be tested at each device.

e. Carbon Monoxide Detector Tests: Carbon monoxide detectors must be tested in accordance with NFPA 72 and the manufacturer's recommended calibrated test method.

f. Test the system for specified functions in accordance with the contract drawings and specifications and the manufacturer's O&M manual.

g. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the time period and in the manner specified.

h. Determine that the system is operable under trouble conditions as specified.

i. Visually inspect wiring.

j. Test the battery charger and batteries.

k. Verify that software control and data files have been entered or programmed into the FMCU. Hard copy records of the software must be provided to the Contracting Officer.

l. Verify that red-line drawings are accurate.

m. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.

n. Measure voltage readings for circuits to ensure that voltage drop is not excessive.

o. Disconnect the verification feature for smoke detectors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke detectors must be conducted using real smoke or the use of canned smoke which is permitted.

p. Measure the voltage drop at the most remote appliance (based on wire length) on each notification appliance circuit.

q. Verify the documentation cabinet is installed and contains all as-built shop drawings, product data sheets, design calculations, site-specific software data package, and all documentation required by paragraph titled "Test Reports".

3.9.2 Audibility Tests

Sound pressure levels from audible notification appliances must be a minimum of 15 dBa over ambient with a maximum of 110 dBa in any occupiable area. The provisions for audible notification (audibility and intelligibility) must be met with doors, fire shutters, movable partitions, and similar devices closed.

3.9.3 Intelligibility Tests

Intelligibility testing of the System must be accomplished in accordance with NFPA 72 for Voice Evacuation Systems, and ASA S3.2. Following are the specific requirements for intelligibility tests:

a. Intelligibility Requirements: Verify intelligibility by measurement after installation.

b. Ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically could be found. The minimum required value for CIS is [.7][.8]. Rounding of values is permitted.

c. Areas of the building provided with hard wall and ceiling surfaces (such as metal or concrete) that are found to cause excessive sound reflections may be permitted to have a CIS score less than the minimum required value if approved by the DFPE, and if building occupants in these areas can determine that a voice signal is being broadcast and they must walk no more than 33 feet to find a location with at least the minimum required CIS value within the same area.

d. Areas of the building where occupants are not expected to be normally present are permitted to have a CIS score less than the minimum required value if personnel can determine that a voice signal is being broadcast and they must walk no more than 50 feet to a location with at least the minimum required CIS value within the same area.

e. Take measurements near the head level applicable for most personnel in the space under normal conditions (e.g., standing, sitting, sleeping, as appropriate).

f. The distance the occupant must walk to the location meeting the minimum required CIS value must be measured on the floor or other walking surface as follows:

   (1) Along the centerline of the natural path of travel, starting from any point subject to occupancy with less than the minimum required CIS value.

   (2) Curving around any corners or obstructions, with a 12 inches clearance there from.

   (3) Terminating directly below the location where the minimum required CIS value has been obtained.

Use commercially available test instrumentation to measure intelligibility as specified by NFPA 72 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

3.10 SYSTEM ACCEPTANCE

Following acceptance of the system, as-built drawings and O&M manuals must be delivered to the Contracting Officer for review and acceptance. The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of as-built (marked-up) drawings must be provided at the time of, or prior to the Final Government Test.

a.[The drawings must be prepared electronically and sized no less than the contract drawings.][Furnish one set of CDs or DVDs containing software back-up and CAD based drawings in latest version of [MicroStation] [AutoCAD,]DXF and portable document formats of as-built drawings and schematics.]

b. Include complete wiring diagrams showing connections between devices and equipment, both factory and field wired.

c. Include a riser diagram and drawings showing the as-built location of devices and equipment.

d. Provide Operation and Maintenance (O&M) Instructions.

[In existing buildings, the transfer of devices from the existing system to the new system and the permission to begin demolition of the old fire alarm system will not be permitted until the as-built drawings and O&M manuals are received.]

3.11 INSTRUCTION OF GOVERNMENT EMPLOYEES

3.11.1 Instructor

Provide the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the operation, inspection, testing, and maintenance of the system provided. The instructor must train the Government employees designated by the Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm system. The instructor must be thoroughly familiar with all parts of this installation. The instructor must be trained in operating theory as well as in practical O&M work. Submit the instructors information and qualifications including the training history.

3.11.2 Required Instruction Time

Provide [8][16][_____] hours of instruction after final acceptance of the system. The instruction must be given during regular working hours on such dates and times selected by the Contracting Officer. The instruction may be divided into two or more periods at the discretion of the Contracting Officer. The training must allow for rescheduling for unforeseen maintenance and/or fire department responses.

[3.11.2.1 Technical Training

Equipment manufacturer or a factory representative must provide [1][3][_____] days of on site[and 5 days of technical training to the Government at the manufacturing facility]. Training must allow for classroom instruction as well as individual hands on programming, troubleshooting and diagnostics exercises.[Factory training must occur within [6][12][_____] months of system acceptance.]

]3.11.3 Technical Training Manual

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training must familiarize designated government personnel with proper operation of the installed system. The maintenance training course must provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

3.12 EXTRA MATERIALS

3.12.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system must be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During the warranty period, the service technician must be on-site within 24 hours after notification. All repairs must be completed within 24 hours of arrival on-site.

During the warranty period, the installing fire alarm contractor is responsible for conducting all required testing and maintenance in accordance with the requirements and recommended practices of NFPA 72 and the system manufacturer[s]. Installing fire alarm contractor is NOT responsible for any damage resulting from abuse, misuse, or neglect of equipment by the end user.

3.12.2 Spare Parts

Spare parts furnished must be directly interchangeable with the corresponding components of the installed system[s]. Spare parts must be suitably packaged and identified by nameplate, tagging, or stamping. Spare parts must be delivered to the Contracting Officer at the time of the Government testing and must be accompanied by an inventory list.

3.12.3 Document Storage Cabinet

Upon completion of the project, but prior to project close-out, place in the document storage cabinet copies of the following record documentation:

a. As-built shop drawings

b. Product data sheets

c. Design calculations

d. Site-specific software data package

e. All documentation required by SD-06.

-- End of Section --

SECTION 31 00 00

EARTHWORK
08/08, CHG 2: 02/21

PART 1 GENERAL

1.1 MEASUREMENT PROCEDURES

1.1.1 Excavation

The unit of measurement for excavation and borrow will be the cubic yard, computed by the average end area method from cross sections taken before and after the excavation and borrow operations, including the excavation for ditches, gutters, and channel changes, when the material is acceptably utilized or disposed of as herein specified. The measurements will include authorized excavation of rock (except for piping trenches that is covered below), authorized excavation of unsatisfactory subgrade soil, and the volume of loose, scattered rocks and boulders collected within the limits of the work; allowance will be made on the same basis for selected backfill ordered as replacement. The measurement will not include the volume of subgrade material or other material that is scarified or plowed and reused in-place, and will not include the volume excavated without authorization or the volume of any material used for purposes other than directed. The volume of overburden stripped from borrow pits and the volume of excavation for ditches to drain borrow pits, unless used as borrow material, will not be measured for payment. The measurement will not include the volume of any excavation performed prior to the taking of elevations and measurements of the undisturbed grade.

1.1.2 Piping Trench Excavation

Measure trench excavation by the number of linear feet along the centerline of the trench and excavate to the depths and widths specified for the particular size of pipe. Replace unstable trench bottoms with a selected granular material. Include the additional width at manholes and similar structures, the furnishing, placing and removal of sheeting and bracing, pumping and bailing, and all incidentals necessary to complete the work required by this section.

1.1.3 Rock Excavation for Trenches

Measure and pay for rock excavation by the number of cubic yards of acceptably excavated rock material. Measure the material in place, but base volume on a maximum 30 inches width for pipes 12 inches in diameter or less, and a maximum width of 16 inches greater than the outside diameter of the pipe for pipes over 12 inches in diameter. Provide the measurement to include all authorized overdepth rock excavation as determined by the Contracting Officer. For manholes and other appurtenances, compute volumes of rock excavation on the basis of 1 foot outside of the wall lines of the structures.

1.1.4 Topsoil Requirements

Separate excavation, hauling, and spreading or piling of topsoil and related miscellaneous operations will be considered subsidiary obligations of the Contractor, covered under the contract unit price for excavation.

1.1.5 Overhaul Requirements

Allow the unit of measurement for overhaul to be the station-yard. The overhaul distance will be the distance in stations between the center of volume of the overhaul material in its original position and the center of volume after placing, minus the free-haul distance in stations. The haul distance will be measured along the shortest route determined by the Contracting Officer as feasible and satisfactory. Do no measure or waste unsatisfactory materials for overhaul where the length of haul for borrow is within the free-haul limits.

1.1.6 Select Granular Material

Measure select granular material in place as the actual cubic yards replacing wet or unstable material in trench bottoms in authorized overdepth areas. Provide unit prices which include furnishing and placing the granular material, excavation and disposal of unsatisfactory material, and additional requirements for sheeting and bracing, pumping, bailing, cleaning, and other incidentals necessary to complete the work.

1.2 PAYMENT PROCEDURES

Payment will constitute full compensation for all labor, equipment, tools, supplies, and incidentals necessary to complete the work.

1.2.1 Classified Excavation

Classified excavation will be paid for at the contract unit prices per cubic yard for common or rock excavation.

1.2.2 Piping Trench Excavation

Payment for trench excavation will constitute full payment for excavation and backfilling, including specified overdepth except in rock or unstable trench bottoms.

1.2.3 Rock Excavation for Trenches

Payment for rock excavation will be made in addition to the price bid for the trench excavation, and will include all necessary drilling and blasting and all incidentals necessary to excavate and dispose of the rock. Select granular material, used as backfill replacing rock excavation, will not be paid for separately, but will be included in the unit price for rock excavation.

1.2.4 Unclassified Excavation

Unclassified excavation will be paid for at the contract unit price per cubic yard for unclassified excavation.

1.2.5 Classified Borrow

Classified borrow will be paid for at the contract unit prices per cubic yard for common or rock borrow.

1.2.6 Unclassified Borrow

Unclassified borrow will be paid for at the contract unit price per cubic yard for unclassified borrow.

1.2.7 Authorized Overhaul

The number of station-yards of overhaul to be paid for will be the product of number of cubic yards of overhaul material measured in the original position, multiplied by the overhaul distance measured in stations of 100 feet and will be paid for at the contract unit price per station-yard for overhaul in excess of the free-haul limit as designated in paragraph DEFINITIONS.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180 (2017) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600 (2017) Installation of Ductile-Iron Mains and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding Code - Steel

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA P5 (2015) Standard for Waterborne Preservatives

ASTM INTERNATIONAL (ASTM)

ASTM A139/A139M (2016) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)

ASTM A252 (2010) Standard Specification for Welded and Seamless Steel Pipe Piles

ASTM C33/C33M (2018) Standard Specification for Concrete Aggregates

ASTM C136/C136M (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM D698 (2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1883	(2016) Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2937	(2017; E 2017; E 2018) Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718/D4718M	(2015) Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes
EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-203 (Rev C; Notice 3) Paper, Kraft, Untreated

1.4 DEFINITIONS

1.4.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, CL, ML, CL-ML, CH, MH. Satisfactory materials for grading comprise stones less than 8 inches, except for fill material for pavements and railroads which comprise stones less than 3 inches in any dimension.

1.4.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.4.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C136/C136M and ASTM D1140.

1.4.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with AASHTO T 180 and corrected with ASTM D4718/D4718M. To maintain the same percentage of coarse material, use the "remove and replace" procedure as described in NOTE 8 of Paragraph 7.2 in AASHTO T 180.

1.4.5 Overhaul

Overhaul is the authorized transportation of satisfactory excavation or borrow materials in excess of the free-haul limit of 2,000 stations. Overhaul is the product of the quantity of materials hauled beyond the free-haul limit, and the distance such materials are hauled beyond the free-haul limit, expressed in station yards.

1.4.6 Topsoil

Material suitable for topsoils obtained from offsite areas excavations and areas indicated on the drawings is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

1.4.7 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3 inch in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.4.8 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.4.9 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.4.10 Select Granular Material

1.4.10.1 General Requirements

Select granular material consist of materials classified as GW, GP, SW, SP, or by ASTM D2487 where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D1140. Provide a minimum coefficient of permeability of 0.002 feet per minute when tested in accordance with ASTM D2434.

1.4.10.2 California Bearing Ratio Values

Bearing Ratio: At 0.1 inch penetration, provide a bearing ratio as specified in the soils investigation at 95 percent ASTM D1557 maximum density as determined in accordance with ASTM D1883 for a laboratory soaking period of not less than 4 days. Maximum expansion shall be as specified in soils investigation. Conform the combined material to the following sieve analysis:

Sieve Size	Percent Passing by Weight
2-1/2 inches	100

Sieve Size	Percent Passing by Weight
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60
No. 200	5 - 25

1.4.11 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 3 inches or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, free the initial backfill material of stones larger than 12 inches in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

1.4.12 Expansive Soils

Expansive soils are defined as soils that have a plasticity index equal to or greater than 10 when tested in accordance with ASTM D4318.

1.4.13 Nonfrost Susceptible (NFS) Material

Nonfrost susceptible material are a uniformly graded washed sand with a maximum particle size of 1 inch and less than 5 percent passing the No. 200 size sieve, and with not more than 3 percent by weight finer than 0.02 mm grain size.

1.4.14 Pile Supported Structure

As used herein, a structure where both the foundation and floor slab are pile supported.

1.5 SYSTEM DESCRIPTION

Subsurface soil boring logs are as defined in the Geotechnical Investigation Report. The subsoil investigation report and samples of materials taken from subsurface investigations may be examined by the contracting officer. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.5.1 Classification of Excavation

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation. Finish the specified excavation on a classified basis, in accordance with the following designations and classifications.

1.5.1.1 Common Excavation

Include common excavation with the satisfactory removal and disposal of all materials not classified as rock excavation.

1.5.1.2 Rock Excavation

Submit notification of encountering rock in the project. Include rock excavation with blasting, excavating, grading, disposing of material classified as rock, and the satisfactory removal and disposal of boulders 1/2 cubic yard or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting; and hard materials (see Definitions). Include the removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic yard in volume that may be encountered in the work in this classification. If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock excavation, uncover such material and notify the Contracting Officer. Do not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, and allow ample time for classification and cross sectioning of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contracting Officer for the areas of work in which such deposits occur.

1.5.2 Blasting

Blasting will not be permitted.

1.5.3 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring; G

Dewatering Work Plan; G

SD-03 Product Data

Utilization of Excavated Materials; G

Rock Excavation

Opening of any Excavation or Borrow Pit

Shoulder Construction

SD-06 Test Reports

Testing

Borrow Site Testing

Within 24 hours of conclusion of physical tests, submit 6 copies of test results, including calibration curves and results of calibration tests.

SD-07 Certificates

Testing

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR OFFSITE SOILS

Test offsite soils brought in for use as backfill for Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and full Toxicity Characteristic Leaching Procedure (TCLP) including ignitability, corrosivity and reactivity. Provide backfill containing a maximum of 100 parts per million (ppm) of total petroleum hydrocarbons (TPH) and a maximum of 10 ppm of the sum of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and passing the TCPL test. Determine TPH concentrations by using EPA 600/4-79/020 Method 418.1. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5030/8020. Perform TCLP in accordance with EPA SW-846.3-3 Method 1311. Provide Borrow Site Testing for TPH, BTEX and TCLP from a composite sample of material from the borrow site, with at least one test from each borrow site. Do not bring material onsite until tests have been approved by the Contracting Officer.

2.2 BURIED WARNING AND IDENTIFICATION TAPE

Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes	
Red	Electric
Yellow	Gas, Oil; Dangerous Materials
Orange	Telephone and Other Communications
Blue	Water Systems
Green	Sewer Systems
White	Steam Systems
Gray	Compressed Air

2.2.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.2.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.3 DETECTION WIRE FOR NON-METALLIC PIPING

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.4 MATERIAL FOR RIP-RAP

Provide Bedding material Grout Filter fabric and rock conforming to these requirements for construction indicated.

2.4.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well graded, with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index less than six.

2.4.2 Grout

Provide durable grout composed of cement, water, an air-entraining admixture, and sand mixed in proportions of one part portland cement to two parts of sand, sufficient water to produce a workable mixture, and an amount of admixture which will entrain sufficient air, as determined by the Contracting Officer. Mix grout in a concrete mixer. Allow a sufficient mixing time to produce a mixture having a consistency permitting gravity flow into the interstices of the rip-rap with limited spading and brooming.

2.4.3 Rock

Provide rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Use rock fragments free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. Provide fragments sized so that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Provide rock with a minimum specific gravity of 2.50 . Do not permit the inclusion of more than trace quantities of dirt, sand, clay, and rock fines.

2.5 CAPILLARY WATER BARRIER

Provide capillary water barrier of clean, poorly graded crushed rock, crushed gravel, or uncrushed gravel placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below. Conform to ASTM C33/C33M for fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve, or coarse aggregate Size 57, 67, or 77.

2.6 PIPE CASING

2.6.1 Casing Pipe

ASTM A139/A139M, Grade B, or ASTM A252, Grade 2, smooth wall pipe. Match casing size to the outside diameter and wall thickness as indicated. Protective coating is not required on casing pipe.

2.6.2 Wood Supports

Provide wood with nonleaching water-borne pressure preservative (ACA or CCA) and treatment conforming to AWPA P5. Secure wood supports to carrier pipe with stainless steel or zinc-coated steel bands.

PART 3 EXECUTION

3.1 STRIPPING OF TOPSOIL

Where indicated or directed, strip topsoil to a depth of 4 inches. Spread topsoil on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations. Remove from the site any surplus of topsoil from excavations and gradings.

3.2 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill and unsatisfactory excavated material as specified in paragraph DISPOSITION OF SURPLUS MATERIAL. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from the borrow areas indicated or from other approved areas selected by the Contractor as specified.

3.2.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown. Do not excavate ditches and gutters below grades shown. Backfill the excessive open ditch or gutter excavation with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed, except in no case allow material be deposited a maximum 4 feet from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.2.2 Drainage Structures

Make excavations to the lines, grades, and elevations shown, or as directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level until just before the concrete or masonry is to be placed. Where pile foundations are to be used, stop the excavation of each pit at an elevation 1 foot above the base of the footing, as specified, before piles are driven. After the pile driving has been completed, remove loose and displaced material and complete excavation, leaving a smooth, solid, undisturbed surface to receive the concrete or masonry.

3.2.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity [and] [or] provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.2.4 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Do not permit French drains, sumps, ditches or trenches within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Take control measures by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, maintain the water level continuously, below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system. Relieve hydrostatic head in previous zones below subgrade elevation in layered soils to prevent uplift.

3.2.5 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended in the manufacturer's printed installation manual. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving ground or cave in, as determined by the Contractor's Safety Engineer or other competent person; refer to USACE publication EM 385-1-1. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 24 inches plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter, and do not exceed 36 inches plus pipe outside diameter for sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.2.5.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 3 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.2.5.2 Removal of Unyielding Material

Where overdepth is not indicated and unyielding material is encountered in the bottom of the trench, remove such material 6 inch below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.2.5.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.2.5.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members. Clean rock or loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.5.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Contracting Officer, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.2.6 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by utility company. Excavation made with power-driven equipment is not permitted within 3 feet of known Government-owned utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.2.7 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Contracting Officer prior to concrete placement. Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Contracting Officer. Backfill and compact over excavations and changes in grade due to pile driving operations to 95 percent of ASTM D698 maximum density.

3.3 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Obtain borrow material from the borrow areas or from approved private sources. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval. Consider necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon related operations to the borrow excavation.

3.4 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS

Notify the Contracting Officer sufficiently in advance of the opening of any excavation or borrow pit or borrow areas to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, excavate borrow pits and other excavation areas providing adequate drainage. Transport overburden and other spoil material to designated spoil areas or otherwise dispose of as directed. Provide neatly trimmed and drained borrow pits after the excavation is completed. Ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.5 SHORING

3.5.1 General Requirements

Submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.5.2 Geotechnical Engineer

Hire a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer is responsible for updating the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and submit an updated plan if necessary. Submit a monthly written report, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Contracting Officer is responsible for arranging meetings with the Geotechnical Engineer at any time throughout the contract duration.

3.6 GRADING AREAS

Where indicated, divide work into grading areas within which satisfactory excavated material will be placed in embankments, fills, and required backfills. Do not haul satisfactory material excavated in one grading area to another grading area except when so directed in writing. Place and grade stockpiles of satisfactory and unsatisfactory as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.7 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. For pile foundations, stop the excavation at an elevation of from 6 to 12 inches above the bottom of the footing before driving piles. After pile driving has been completed, complete the remainder of the excavation to the elevations shown. Only use excavation methods that will leave the foundation rock in a solid and unshattered condition. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect shales from slaking and all surfaces from erosion resulting from ponding or water flow.

3.8 GROUND SURFACE PREPARATION

3.8.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Contracting Officer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 6 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inches, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.8.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.9 UTILIZATION OF EXCAVATED MATERIALS

Use satisfactory material removed from excavations, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. Submit procedure and location for disposal of unused satisfactory material. Dispose surplus satisfactory excavated material not required for fill and unsatisfactory excavated material as specified in paragraph DISPOSITION OF SURPLUS MATERIAL. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

3.10 BURIED TAPE AND DETECTION WIRE

3.10.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.10.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.11 FILLING, BACKFILLING AND COMPACTION

Place fill and backfill beneath and adjacent to any and all type of structures, in successive horizontal layers of loose material not more than 8 inches in depth, or in loose layers not more than 5 inches in depth when using hand-operated compaction equipment. Compact to at least 90 percent of laboratory maximum density for cohesive materials or 95 percent of laboratory maximum density for cohesionless materials, except as otherwise specified. Perform compaction in such a manner as to prevent wedging action or eccentric loading upon or against the structure. Moisture condition fill and backfill material to a moisture content that will readily facilitate obtaining the specified compaction.

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs GROUND SURFACE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.11.1 Trench Backfill

Backfill trenches to the grade shown.

3.11.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.11.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6 inches loose thickness.

3.11.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D698 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

3.11.1.3.1 Class I

Angular, 0.25 to 1.5 inch, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

3.11.1.3.2 Class II

Coarse sands and gravels with maximum particle size of 1.5 inch, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

3.11.1.3.3 Sand

Clean, coarse-grained sand classified in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL, [SW or SP by ASTM D2487 for bedding and backfill as indicated].

3.11.1.3.4 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof having a classification of GW GP in accordance with ASTM D2487 for bedding and backfill as indicated. Do not exceed maximum particle size of 3 inches.

3.11.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, railroads and airfields, with satisfactory material. Place backfill material and compact as follows:

3.11.1.4.1 Roadways, Railroads, and Airfields

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

3.11.1.4.2 Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Do not permit compaction by water flooding or jetting. Apply this requirement to all other areas not specifically designated above.

3.11.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 3 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.12 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.12.1 Gas Distribution

Excavate trenches to a depth that will provide a minimum 18 inches of cover in rock excavation and a minimum 24 inch of cover in other excavation.

3.12.2 Water Lines

Excavate trenches to a depth that provides a minimum cover of 5 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.12.3 Heat Distribution System

Free initial backfill material of stones larger than 1/4 inch in any dimension.

3.12.4 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.12.5 Sewage Absorption Trenches or Pits

3.12.5.1 Porous Fill

Provide backfill material consisting of clean crushed rock or gravel having a gradation such that 100 percent passes the 2 inch sieve and zero percent passes the 1/2 inch sieve. conforming to the requirements of gradation No. 4 for coarse aggregate in ASTM C33/C33M.

3.12.5.2 Cover

Filter fabric Concrete Kraft paper conforming to CID A-A-203, Grade B, No. 2, 50 pound weight or a layer of straw at least 2 inches thick as indicated.

3.12.6 Pipeline Casing

Provide new smooth wall steel pipeline casing under new and existing by the boring and jacking method of installation. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated. Install pipeline casing by dry boring and jacking method as follows:

3.12.6.1 Bore Holes

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other fluids in connection with the boring operation.

3.12.6.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.12.6.3 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight segmented elastomeric end seals.

3.12.7 Rip-Rap Construction

Construct rip-rap on bedding material and on filter fabric with grout in the areas indicated. Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.12.7.1 Bedding Placement

Spread filter fabric bedding material uniformly to a thickness of at least 3 inches on prepared subgrade as indicated. Compaction of bedding is not required. Finish bedding to present even surface free from mounds and windrows.

3.12.7.2 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above. For grouted rip-rap, hand-place surface rock with open joints to facilitate grouting and do not fill smaller spaces between surface rock with finer material. Provide at least one "weep hole" through grouted rip-rap for every 50 square feet of finished surface. Provide weep holes with columns of bedding material, 4 inches in diameter, extending up to the rip-rap surface without grout.

3.12.7.3 Grouting

Prior to grouting, wet rip-rap surfaces. Grout rip-rap in successive longitudinal strips, approximately 10 feet in width, commencing at the lowest strip and working up the slope. Distribute grout to place of final deposit and work into place between stones with brooms, spades, trowels, or vibrating equipment. Take precautions to prevent grout from penetrating bedding layer. Protect and cure surface for a minimum of 7 days.

3.13 EMBANKMENTS

3.13.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 3 inches. Place the material in successive horizontal layers of loose material not more than 8 inches in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise break up each layer; moisten or aerate as necessary; thoroughly mix; and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Backfill and fill material must be to a moisture content that will readily facilitate obtaining the specified compaction.

Compaction requirements for the upper portion of earth embankments forming subgrade for pavements are identical with those requirements specified in paragraph SUBGRADE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.13.2 Rock Embankments

Construct rock embankments from material classified as rock excavation, as defined above, placed in successive horizontal layers of loose material not more than 8 inch in depth. Do not use pieces of rock larger than 3 inch in the greatest dimension. Spread each layer of material uniformly, completely saturate, and compact to a minimum density of 90 pcf. Adequately bond each successive layer of material to the material on which it is placed. Finish compaction with vibratory compactors, heavy rubber-tired rollers or steel-wheeled rollers. Do not use rock excavation as fill material for the construction of pavements. In embankments on which pavements are to be constructed, do not use rock above a point 24 inch below the surface of the pavement.

3.14 SUBGRADE PREPARATION

3.14.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade of the with six passes of a dump truck loaded with 4 cubic yards of soil Operate the truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2-1/2 to 3-1/2 mph. When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Contracting Officer. Undercut rutting or pumping of material as directed by the Contracting Officer to a depth of 6 inch and replace with select material.

3.14.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inches below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, do not show deviations for the surface of the subgrade for roadways greater than 1/2 inch when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area. After rolling, do not show deviations for the surface of the subgrade for airfields greater than 3/16 inch when tested with a 10 foot straightedge applied both parallel and at right angles to the centerline of the area. Do not vary the elevation of the finish subgrade more than 0.05 foot from the established grade and cross section.

3.14.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas and railroads, compact each layer of the embankment to at least 90 percent of laboratory maximum density.

3.14.3.1 Subgrade for Railroads

Compact subgrade for railroads to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials.

3.14.3.2 Subgrade for Pavements

Compact subgrade for pavements to at least 95 percentage laboratory maximum density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact the top 8 inch of subgrade.

3.14.3.3 Subgrade for Shoulders

Compact subgrade for shoulders to at least 90 percentage laboratory maximum density for the full depth of the shoulder.

3.14.3.4 Subgrade for Airfield Pavements

Compact top 24 inches below finished pavement or top 12 inches of subgrades, whichever is greater, to 100 percent of ASTM D1557; compact fill and backfill material to 100 percent of ASTM D1557.

3.15 SHOULDER CONSTRUCTION

Construct shoulders of satisfactory excavated or borrow material or as otherwise shown or specified.. Submit advanced notice on shoulder construction for rigid pavements. Construct shoulders immediately after adjacent paving is complete. In the case of rigid pavements, do not construct shoulders until permission of the Contracting Officer has been obtained. Compact the entire shoulder area to at least the percentage of maximum density as specified in paragraph SUBGRADE PREPARATION above, for specific ranges of depth below the surface of the shoulder. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Finish shoulder construction in proper sequence in such a manner that adjacent ditches will be drained effectively and that no damage of any kind is done to the adjacent completed pavement. Align the completed shoulders true to grade and shaped to drain in conformity with the cross section shown.

3.16 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.16.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.16.2 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.16.3 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.17 PLACING TOPSOIL

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 6 inch and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas or areas indicated.

3.18 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. Submit qualifications of the Corps validated commercial testing laboratory or the Contractor's validated testing facilities. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Contracting Officer.

a. Determine field in-place density in accordance with ASTM D1556/D1556M ASTM D2167 and ASTM D6938. When ASTM D6938 is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556/D1556M. ASTM D6938 results in a wet unit weight of soil in determining the moisture content of the soil when using this method.

b. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938; check the calibration of both the density and moisture gauges at the beginning of a job on each different type of material encountered and at intervals as directed by the Contracting Officer. ASTM D2937, use the Drive Cylinder Method only for soft, fine-grained, cohesive soils. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements.

c. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. TState that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.18.1 Fill and Backfill Material Gradation

One test per 200 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with

ASTM C136/C136M .

3.18.2 In-Place Densities

a. One test per 20,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

b. One test per 20,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

c. One test per 500 linear feet, or fraction thereof, of each lift of embankment or backfill for roads or airfields.

d. One test per 500 linear feet, or fraction thereof, of each lift of embankment or backfill for railroads.

3.18.3 Check Tests on In-Place Densities

If ASTM D6938 is used, check in-place densities by ASTM D1556/D1556M as follows:

a. One check test per lift for each 10,000 square feet, or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines.

b. One check test per lift for each 10,000 square feet, of fill or backfill areas compacted by hand-operated machines.

c. One check test per lift for each 500 linear feet, or fraction thereof, of embankment or backfill for roads or airfields.

d. One check test per lift for each 500 linear feet, or fraction thereof, of embankment or backfill for railroads.

3.18.4 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Contracting Officer.

3.18.5 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 500 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

3.18.6 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.18.7 Displacement of Sewers

After other required tests have been performed and the trench backfill compacted to 2, feet above the top of the pipe , inspect the pipe to determine whether significant displacement has occurred. Conduct this inspection in the presence of the Contracting Officer. Inspect pipe sizes larger than 36 inches, while inspecting smaller diameter pipe by shining a light or laser between manholes or manhole locations, or by the use of television cameras passed through the pipe. If, in the judgment of the Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the defects as directed at no additional cost to the Government.

3.19 DISPOSITION OF SURPLUS MATERIAL

Remove surplus material and excavated unsatisfactory material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber from Government property and properly disposed of in accordance with all applicable laws and regulations.

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SECTION 31 05 19.13

GEOTEXTILES FOR EARTHWORK
02/21

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Payment

Payment will be made at the contract unit price and will constitute full compensation to the Contractor for providing all plant, labor, material, and equipment and performing all operations necessary for the complete and satisfactory installation of the geotextile. The following items are included in the contract unit price for Geotextiles and will not be counted a second time in the process of determining the extent of geotextile placed: Material and associated equipment and operation used in laps, seams, or extra length; securing pins and associated material, equipment, and operations; and material and associated equipment and operations used to provide cushioning layer of sand or gravel or both to permit increase in allowable drop height of stone. No payment will be made for geotextiles replaced because of waste, contamination, damage, repair, or due to Contractor fault or negligence.

1.1.2 Measurement

Installed geotextiles will be measured for payment in place to the nearest square feet of protected area as delineated in the drawings.

1.1.3 Unit of Measure

Unit of measure: square feet.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D123	(2015b; R 2017) Standard Terminology Relating to Textiles
ASTM D4354	(2012; R 2020) Sampling of Geosynthetics for Testing
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles

ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D4884/D4884M	(2014a) Strength of Sewn or Thermally Bonded Seams of Geotextiles
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1601	(1991; 1994 Change 1) Engineering and Design -- Hydraulic Design of Flood Control Channels

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Geotextiles

Minimum of 60 days prior to the beginning of installation of the same textile

SD-06 Test Reports

Geotextiles
Site Verification

SD-07 Certificates

Geotextiles
Needle Punched Geotextile

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver only approved geotextile to the project site. Label, ship, store, and handle all geotextile in accordance with ASTM D4873/D4873M. Do not use hooks, tongs, or other sharp instruments for handling geotextile.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide geotextile that is a woven or non-woven pervious sheet of plastic yarn as defined by ASTM D123 matching or exceeding the minimum average roll values listed in TABLE 1. Strength values indicated in the table are for the weaker principal direction.

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	lb	160	ASTM D4632/D4632M
SEAM STRENGTH	lb	150	ASTM D4632/D4632M
PUNCTURE	lb	55	ASTM D6241
TRAPEZOID TEAR	lb	55	ASTM D4533/D4533M
APPARENT OPENING SIZE	U.S. SIEVE	30	ASTM D4751
PERMITTIVITY	sec -1	0.02	ASTM D4491/D4491M
ULTRAVIOLET DEGRADATION	Percent	50 at 500 Hrs	ASTM D4355/D4355M

2.1.2 Geotextile Fiber

Use fibers consisting of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polyamides. Add stabilizers and/or inhibitors to the base polymer, if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Do not add reclaimed or recycled fibers or polymer to the formulation. Form geotextile into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Finish the edges of the geotextile to prevent the outer fiber from pulling away from the geotextile.

2.1.3 Seams

Sew the seams of the geotextile with thread of a material meeting the chemical requirements given above for geotextile yarn or bond the seams by cementing or by heat. Attach the sheets of geotextile at the factory or another approved location. Test seams in accordance with method ASTM D4884/D4884M. Seam strength less than 90 percent of the required grab tensile strength of the unaged geotextile in any principal direction is not permitted.

2.1.4 Securing Pins

Secure the geotextile to the embankment or foundation soil by pins to prevent movement prior to placement of revetment materials. Other appropriate means to prevent movement such as staples, sand bags, and stone could also be used. Insert securing pins through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Remove securing pins as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes. Maximum spacing between securing pins depends on the steepness of the embankment slope. Provide maximum pins spacing equal to or less than the values listed in TABLE 2. When windy conditions prevail at the construction site, increase the number of pins upon the demand of the Contracting Officer. Anchor terminal ends of the geotextile with key trench or apron at crest, toe of the slope and upstream and downstream limits of installation.

TABLE 2
MAXIMUM SPACING FOR SECURING PINS

EMBANKMENT	SPACING, feet
STEEPER THAN 1V ON 3H	2
1V ON 3H TO 1V ON 4H	3
FLATTER THAN 1V ON 4H	5

2.2 INSPECTIONS, VERIFICATIONS, AND TESTING

2.2.1 Manufacturing and Sampling

Provide geotextiles and factory seams meeting the requirements specified in TABLE 1.

2.2.1.1 Conformance Testing

Perform conformance testing in accordance with the manufacturers approved quality control manual. Submit manufacturer's quality control conformance test results.

2.2.1.2 Factory Sampling

Randomly sample geotextiles in accordance with ASTM D4354 (Procedure Method A). Sample factory seams at the frequency specified in ASTM D4884/D4884M. Provide all samples from the same production lot as will be supplied for the contract, of the full manufactured width of the geotextile by at least 10 feet long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least 5 feet. Identify samples submitted for testing by manufacturers lot designation.

2.2.1.3 Needle Punched Geotextile

For needle punched geotextile, provide manufacturer certification that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

2.2.1.4 Manufacturer Certification

All brands of geotextile and all seams to be used will be accepted on the basis of mill certificates or affidavits. Submit duplicate copies of the mill certificate or affidavit signed by a legally authorized official from the company manufacturing the geotextile. Attest that the geotextile meets the chemical, physical and manufacturing requirements stated in this specification.

2.2.2 Site Verification and Testing

Collect samples at approved locations upon delivery to the site at the request of the Contracting Officer. Test samples to verify that the geotextile meets the requirements specified in TABLE 1. Identify samples by manufacturers name, type of geotextile, lot number, roll number, and machine direction. Perform testing at an approved laboratory. Submit test results from the lot under review for approval prior to deployment of that lot of geotextile. Immediately rewrap rolls which are sampled in their protective covering.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Prepare surface, on which the geotextile will be placed, to a relatively smooth surface condition in accordance with the applicable portion of this specification and must be free from obstruction, debris, depressions, erosion feature, or vegetation. Remove any irregularities so as to ensure continuous, intimate contact of the geotextile with all the surface. Remove loose material, soft or low density pockets of material; grade erosion features such as rills and gullies out of the surface before geotextile placement.

3.2 INSTALLATION OF THE GEOTEXTILE

3.2.1 General

Place the geotextile in the manner and at the locations shown. At the time of installation, reject the geotextile if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

3.2.2 Placement

Place the geotextile with the long dimension parallel to the trench and laid smooth and free of tension, stress, folds, wrinkles, or creases. Place the strips to provide a minimum width of 12 inches of overlap for each joint. The placement procedure requires that the length of the geotextile be approximately [_____] percent greater than the slope length. Adjust the actual length of the geotextile used based on initial installation experience. Temporary pinning of the geotextile to help hold it in place until the [bedding layer][riprap] is placed will be allowed. Remove the temporary pins as the [bedding][granular material][riprap] is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Design protection of riprap in compliance with EM 1110-2-1601. Perform trimming in such a manner that the geotextile is not damaged in any way.

3.3 PROTECTION

Protect the geotextile at all times during construction from contamination by surface runoff; remove any geotextile so contaminated and replaced with uncontaminated geotextile. Replace any geotextile damaged during its installation or during placement of granular filter materials, bedding materials or riprap at no cost to the Government. Schedule the work so that the covering of the geotextile with a layer of the specified material is accomplished within 7 calendar days after placement of the geotextile. Failure to comply will require replacement of geotextile. Protect the geotextile from damage prior to and during the placement of riprap or other materials. This may be accomplished by limiting the height of drop to less than 1 foot, by placing a cushioning layer of sand or gravel on top of the geotextile before placing the material, or other methods deemed necessary. Care should be taken to ensure that the utilized cushioning materials will not impede the flow of water. Before placement of riprap or other materials, demonstrate that the placement technique will not cause damage to the geotextile. Do not allow equipment on the unprotected geotextile.

3.4 PLACEMENT OF CUSHIONING MATERIAL

Perform placing of cushioning material in a manner to ensure intimate contact of the geotextile with the prepared surface and with the cushioning material. Do not damage the geotextile, including tear, puncture, or abrasion, during placement. On sloping surfaces place the cushioning material from the bottom of the slopes upward. During placement, the height of the drop of riprap material greater than 12 inches is not permitted. Uncover any geotextile damaged beneath the cushioning material, as necessary, and replaced at no cost to the Government.

3.5 OVERLAPPING AND SEAMING

3.5.1 Overlapping

The overlap of geotextile must be 12 inches. Appropriate measures will be taken to ensure required overlap exists after cushion placement.

3.5.2 Sewn Seams

High strength thread should be used so that seam test conforms to ASTM D4884/D4884M. Provide thread meeting the chemical, ultraviolet, and physical requirements of the geotextile, and provide color different from that of the geotextile. Provide seam strength equal to the strength required for the geotextile in the direction across the seam. Overlapping J-type seams are preferable over prayer-type seams as the overlapping geotextile reduces the chance of openings to occur at the seam. Use double sewing, specially for field seams, to provide a safety factor against undetected missed stitches.

-- End of Section --

SECTION 31 10 00

SITE CLEARING
02/21

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Clearing (Timber and Structure)

1.1.1.1 Payment

Payment will be made for costs associated with furnishing plant, labor, materials and equipments, and performing all operations necessary for clearing (timber and structures) as specified.

1.1.1.2 Unit of Measure

Unit of measure: lump sum.

1.2 DEFINITIONS

1.2.1 Trees

The line of demarcation between brush and trees, for the purpose of distinguishing clearing requirements, is that trees, as used, will be considered as that woody growth not falling within the limits of brush as defined below.

1.2.2 Brush

Brush is that growth which is less than 2 inches in diameter measured6 inches from the ground on the uphill side and is less than 6 feet in height measured from the ground on the uphill side.

1.2.3 Structures

The term "structures" includes buildings or portions thereof, walls, silos, storm or root cellars, cisterns, wells, windmills, pit silos, water towers, etc. Remove or fill structures to the ground surface.

1.3 PROJECT/SITE CONDITIONS

1.3.1 Aesthetics and Pollution Control

1.3.1.1 Ground Areas

All ground areas in the zone of normal pool level fluctuations which are disturbed by clearing operations and which would become subject to erosion will be protected or restored.

1.3.1.2 Construction Roads

All construction roads proposed for use by the Contractor for removing salvaged timber or for access to the work area must be approved, as to location and alignment, prior to construction. Where such roads are determined to be of no value to project operation or will not serve recreational access needs after project construction, the areas occupied by these roads will be restored as nearly as possible to pre-construction conditions by reasonable grading and seeding of a native cover crop along with the planting of seedling trees if in a tree cover area.

1.3.2 Existing Conditions

1.3.2.1 Boundaries

The area to be cleared under this section/contract may have general limits as indicated on the drawings and maps and aerial photographs, which form a part of this contract.

1.3.2.2 Cemeteries

Cemeteries are in the area to be cleared. Do not disturb or destroy any grave marker, or allow any vehicle to pass over a grave, or otherwise disturb the surface of the ground over any grave. Adequately mark the graves to insure that equipment does not work over the areas. Graves and headstones or markers will be relocated by others.

1.3.2.3 Structures

Burn combustible materials obtained from removal of structures in accordance with paragraph DISPOSAL OF MATERIAL or dispose of them off the reservoir area. Where filling of structures is required, fill to within 18 inches of the ground surface and made with noncombustible materials such as masonry rubble, and other debris. When all available debris has been used in filling, all remaining unfilled portions, together with the above 18 inches, completely fill to the ground surface with earth, borrowed as directed by the Contracting Officer. The top surfaces of fills must be neat in appearance and smooth enough not to constitute a hazard to persons or livestock.

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

3.1 CLEARING REQUIREMENTS

3.1.1 Brush

The cutting of brush in either zone is not required.

3.1.2 Zone 1

Remove all trees and stumps, not defined as brush, shall be removed.

3.1.3 Equipment

A tree crushing machine may be used at the option of the Contractor in all clearing operations.

3.2 DISPOSAL OF MATERIAL

3.2.1 General

Completely remove material cleared from the areas by transporting from the Government property unless otherwise approved by the Contracting Officer. All timber from which saw logs, posts, ties or cordwood can be produced will become the property of the Contractor and in the interest of conservation it is required that the Contractor make a reasonable effort to dispose of material for these purposes. The Contractor may cut timber into convenient lengths at the site but approval must be secured prior to the operation of saw mills within the Government lands. Do not throw or leave cleared material in the creeks or river. Remove all felled timber. However, it is intended that all existing down timber will remain in place except dispose solid, floatable material that is larger than 4 inches in diameter (regardless of length) and/or over 8 feet in length (regardless of diameter) in the manner prescribed for cleared material. Clean up floatable debris. The cutting of branches and debris remaining after clean-up, to reduce their length in order to avoid removal, will not be permitted.

3.2.2 Burning

a. The material cleared will not be burned on Moody Air Force Base.

3.2.3 Burial

In certain cases, such as along drainage channels in remote areas, cleared material may be disposed of by burial in areas designated for disposal of excess excavation or spoil. When this option is used, care will be taken to insure that all such cleared material will be buried under not less than 18 inches of earth. Approval will be obtained for each area selected for debris disposal for burial prior to beginning such operations. Areas to be used for permanent roadways, levees or embankments will not be used for disposal of material from clearing operations. Areas for disposal of cleared materials by burial will not be located within 300 feet of public road crossings or of project areas to be regularly visited by the public.

3.2.4 Removal from Site

Except as otherwise provided, the Contractor will be permitted to remove felled and trimmed timber from the site of the work. The Contractor will not be allowed to stockpile salvaged timber. The Government will assume no responsibility for the protection and safekeeping of such material. All timber must be removed from Government lands before final acceptance of the work will be made.

3.3 DEBRIS

Combustible debris will not be burned on Moody Air Force Base. Debris includes trash of all kinds.

3.4 MARKETABLE MATERIALS

Any of the cleared materials which the Contractor considers marketable becomes its property and remove from the reservoir area.

3.5 LOCATIONS

The locations of structures and debris to be cleared as indicated.

-- End of Section --

SECTION 31 11 00

CLEARING AND GRUBBING
11/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07	(2019) DOD Pest Management Program

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Herbicide Application Plan

SD-03 Product Data

Tree Wound Paint

Herbicides; G

SD-07 Certificates

Qualifications; G

SD-11 Closeout Submittals

Pest Management Report

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

Comply with DODI 4150.07 for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent. These forms may be obtained from the main web site: https://www.acq.osd.mil/eie/afpmb/docs/standardlists/dd1532-1.xlsm.

1.3.2 Qualifications

For the application of herbicides, use the services of an applicator who is commercially certified in the state where the work is to be performed as required by DODI 4150.07. Submit a copy of the pesticide applicator certificates.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

1.4.1 Storage

Storage of herbicides on the installation will not be permitted unless it is written into the contract.

1.4.2 Handling

Handle herbicides in accordance with the manufacturer's label and Safety Data Sheet (SDS), preventing contamination by dirt, water, and organic material. Protect herbicides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on herbicide control vehicles. Mixing of herbicides on the installation will not be permited unless it is written into the contract.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Tree Wound Paint

Use bituminous based paint from standard manufacture specially formulated for tree wounds.

2.1.2 Herbicide

Provide herbicides currently registered by the EPA or approved for such use by the appropriate agency of the host county and approved by the Contracting Officer. Select a herbicide that is suitable for the climatic conditions at the project site. Submit manufacturer's label and SDS for herbicides proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Herbicide Application Plan

Prior to commencing application of herbicide, submit a herbicide application plan with proposed sequence of treatment work including dates and times of application. Include the herbicide trade name, EPA registration number, chemical composition, formulation, application rate of active ingredients, method of application, area or volume treated, and amount applied. Include a copy of the pesticide applicator certificates.

3.1.2 Protection

3.1.2.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.2.2 Trees, Shrubs, and Existing Facilities

Provide protection in accordance with Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS. Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.2.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Contracting Officer immediately of damage to or an encounter with an unknown existing utility line. The Contractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contracting Officer in ample time to minimize interruption of the service. Refer to Section 01 30 00 ADMINISTRATIVE REQUIREMENTS and Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS for additional utility protection.

3.2 APPLICATION

3.2.1 Herbicide Application

Adhere to safety precautions as recommended by the manufacturer concerning handling and application of the herbicide.

3.2.1.1 Clean Up, Disposal, And Protection

Once application has been completed, proceed with clean up and protection of the site without delay. Clean the site of all material associated with the treatment measures, according to label instructions, and as indicated. Remove and dispose of excess and waste material off Government property.

3.2.1.1.1 Disposal of Herbicide

Dispose of residual herbicides and containers off Government property, and in accordance with the approved disposal plan, label instructions and EPA requirements.

3.3 CLEARING

Clearing consists of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Clearing also includes the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work. Cut off flush with or below the original ground surface trees, stumps, roots, brush, and other vegetation in areas to be cleared, except such trees and vegetation as may be indicated or directed to be left standing. Trim dead branches 1-1/2 inches or more in diameter on trees designated to be left standing within the cleared areas and trim all branches to the heights indicated or directed. Neatly cut close to the bole of the tree or main branches, limbs and branches to be trimmed. Paint, with an approved tree-wound paint, cuts more than 1-1/2 inches in diameter. Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.

3.3.1 Tree Removal

Where indicated or directed, remove trees and stumps that are designated as trees from areas outside those areas designated for clearing and grubbing. This work includes the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Dispose of trees as specified in paragraph DISPOSAL OF MATERIALS.

3.3.2 Pruning

Prune/Trim trees designated to be left standing within the cleared areas of dead branches 1-1/2 inches or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 1-1/4 inches in diameter with an approved tree wound paint.

3.3.3 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.4 DISPOSAL OF MATERIALS

Dispose of excess materials in accordance with the approved solid waste management permit and include those materials in the solid waste management report.

All wood or wood like materials, except for salable timber, remaining from clearing, prunning or grubbing such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials is the property of the Contractor and dispose of as specified. All non-saleable timber and wood or wood like materials remaining from timber harvesting such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials is the property of the Contractor and dispose of as specified.

3.4.1 Saleable Timber

Consider felled timber from which saw logs, pulpwood, posts, poles, ties, or fuelwood can be produced as saleable timber. Trim limbs and tops, and saw into saleable lengths for saw logs, for pulpwood, for poles, for ties, and for fuelwood, and stockpile adjacent to the site. The stockpile timber will remain the property of the Government.

The Government will, by separate contract, harvest all saleable timber from the project site.

All timber removed from the project site is the property of the Contractor . Reimburse the Government for the fair market value of the timber which the Government as appraised by the Contracting Officer. Submit payment to the Contracting Officer by cashier's or certified check in the amount of the appraised value, made payable to the U.S. Treasury for deposit into the appropriate U.S. Government account.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Herbicides

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the type of operation, brand name and manufacturer of herbicide, formulation, concentration or rate of application used.

-- End of Section --

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SECTION 31 23 00.00 20

EXCAVATION AND FILL
02/11, CHG 2: 08/15

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C2	(2003) Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes
AWPA P5	(2015) Standard for Waterborne Preservatives

ASTM INTERNATIONAL (ASTM)

ASTM A139/A139M	(2016) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A252	(2010) Standard Specification for Welded and Seamless Steel Pipe Piles
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by

	Washing
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1883	(2016) Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3786/D3786M	(2018) Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011; R 2018) Standard Practice for Determining the Specification Conformance of Geosynthetics
ASTM D4833/D4833M	(2007; R 2020) Standard Test Method forIndex Puncture Resistance of

	Geomembranes and Related Products
ASTM D5084	(2016a) Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

1.2 DEFINITIONS

1.2.1 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below a slab.

1.2.2 Degree of Compaction

Degree of compaction is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557, for general soil types, abbreviated as percent laboratory maximum density.

1.2.3 Hard Materials

Weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" but which usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.4 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 - 1 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.5 Pile Supported Structure

As used herein, a structure where both the foundation and floor slab are pile supported.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring and Sheeting Plan

Dewatering work plan

Submit 15 days prior to starting work.

SD-06 Test Reports

Borrow Site Testing; G

Fill and backfill test

Select material test

Porous fill test for capillary water barrier

Density tests

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

1.4 DELIVERY, STORAGE, AND HANDLING

Perform in a manner to prevent contamination or segregation of materials.

1.5 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.

d. Material character is indicated by the boring logs.

e. Hard materials and rock will be encountered in the excavations as indicated by the boring log.

f. Borrow material, Suitable backfill and bedding material in the quantities required is not available at the project site on Government property

g. Blasting will not be permitted. Remove material in an approved manner.

1.6 REQUIREMENTS FOR OFF SITE SOIL

Soils brought in from off site for use as backfill shall be tested for petroleum hydrocarbons, BTEX, PCBs and HW characteristics (including toxicity, ignitability, corrosivity, and reactivity). Backfill shall not contain concentrations of these analytes above the appropriate State and/or EPA criteria, and shall pass the tests for HW characteristics. Determine petroleum hydrocarbon concentrations by using appropriate State protocols. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5035/8260B. Perform complete TCLP in accordance with EPA SW-846.3-3 Method 1311. Perform HW characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide borrow site testing for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory evidence), with at least one test from each borrow site. For each borrow site, provide borrow site testing for HW characteristics from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring material onsite until tests results have been received and approved by the Contracting Officer.

1.7 QUALITY ASSURANCE

1.7.1 Shoring and Sheeting Plan

Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Drawings shall include material sizes and types, arrangement of members, and the sequence and method of installation and removal. Calculations shall include data and references used.

The Contractor is required to hire a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer shall be responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer shall update the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and shall submit an updated plan if necessary. A written report shall be submitted, at least monthly, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Geotechnical Engineer shall be available to meet with the Contracting Officer at any time throughout the contract duration.

1.7.2 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.7.3 Utilities

Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by utility company. Excavation made with power-driven equipment is not permitted within three feet of known Government-owned utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Common Fill

Approved, unclassified soil material with the characteristics required to compact to the soil density specified for the intended location.

2.1.2 Backfill and Fill Material

ASTM D2487, classification GW, GP, GM, GC, SW, SP, SM, SC with a maximum ASTM D4318 liquid limit of 35, maximum ASTM D4318 plasticity index of 12, and a maximum of 25 percent by weight passing ASTM D1140, No. 200 sieve.

2.1.3 Select Material

Provide materials classified as GW, GP, SW, SP, or by ASTM D2487 where indicated. The liquid limit of such material shall not exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index shall not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight shall be finer than No. 200 sieve when tested in accordance with ASTM D1140. Coefficient of permeability shall be a minimum of 0.002 feet per minute when tested in accordance with ASTM D5084.

Bearing Ratio: At 0.1 inch penetration, the bearing ratio shall be as specified in soils investigation report at 95 percent ASTM D1557 maximum density as determined in accordance with ASTM D1883 for a laboratory soaking period of not less than 4 days. Maximum expansion shall be as specified in soils investigation. The combined material shall conform to the following sieve analysis:

Sieve Size	Percent Passing by Weight
2 1/2 inches	100
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60

Sieve Size	Percent Passing by Weight
No. 200	5 - 25

2.1.4 Topsoil

Provide as specified in Section 32 92 19SEEDING.

Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

2.2 POROUS FILL FOR CAPILLARY WATER BARRIER

ASTM C33/C33M fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve, or coarse aggregate Size 57, 67, or 77 and conforming to the general soil material requirements specified in paragraph entitled "Satisfactory Materials."

2.3 UTILITY BEDDING MATERIAL

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Backfill to top of pipe shall be compacted to 95 percent of ASTM D698 maximum density. Plastic piping shall have bedding to spring line of pipe. Provide ASTM D2321 materials as follows:

a. Class I: Angular, 0.25 to 1.5 inches, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

b. Class II: Coarse sands and gravels with maximum particle size of 1.5 inches, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

2.3.1 Sand

Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding and backfill.

2.4 BORROW

Obtain borrow materials required in excess of those furnished from excavations from sources outside of Government property.

2.5 BACKFILL FOR UNDERDRAINAGE SYSTEMS

Clean sand, crushed rock, or gravel meeting the following requirements:

a. Perforated or Slotted-Wall Pipe: Backfill meeting requirements of Type I material as specified in Table 1.

b. Open Joint Pipe: backfill consisting of both Type I and Type II materials as specified in Table 1.

c. Blind or French Drains: Backfill consisting of Type II material as specified in Table 1.

d. Any Type Drain Used With Filter Fabric: Clean gravel or crushed stone or gravel conforming to ASTM C33/C33M coarse aggregate grading size 57, 67, or 7 fill consisting of Type I or Type II material as specified in Table 1.

TABLE 1

	Type I Gradation E 11 ASTM C33/C33M	Type II Gradation 57 ASTM C33/C33M
ASTM D422 Sieve Size	Percent Passing	Percent Passing
1.5 inches	--	100
1 inch	--	90 - 100
3/8 inch	100	25 - 60
No. 4	95 - 100	5 - 40
No. 8	--	0 - 20
No. 16	45 - 80	--
No. 50	10 - 30	--
No. 100	0 - 10	--

2.6 FILTER FABRIC

Provide a pervious sheet of polyester, nylon, glass or polypropylene , ultraviolet resistant filaments woven, spun bonded, fused, or otherwise manufactured into a nonraveling fabric with uniform thickness and strength. Fabric shall have the following manufacturer certified minimum average roll properties as determined by ASTM D4759:

	Class A	Class B
a. Grab tensile strength (ASTM D4632/D4632M) machine and transversed direction	min. 180	80 lbs.
b. Grab elongation (ASTM D4632/D4632M) machine and transverse direction	min. 15	15 percent
c. Puncture resistance (ASTM D4833/D4833M)	min. 80	25 lbs.
d. Mullen burst strength (ASTM D3786/D3786M)	min. 290	130 psi
e. Trapezoidal Tear (ASTM D4533/D4533M)	min. 50	25 lbs.
f. Apparent Opening Size (ASTM D4751)	See Criteria Below	
(1) Soil with 50 percent or less particles by weight passing US No. 200 Sieve, AOS less than 0.6 mm (greater than #30 US Std. Sieve)		
(2) Soil with more than 50 percent particles by weight passing US No. 200 Sieve, AOS less than 0.297 mm (greater than #50 US Std.Sieve)		
g. Permeability (ASTM D4491/D4491M)	k fabric greater than k Soil	
h. Ultraviolet Degradation (ASTM D4355/D4355M)	70 percent Strength retained at 150 hours	

2.7 MATERIAL FOR PIPE CASING

2.7.1 Casing Pipe

ASTM A139/A139M, Grade B, or ASTM A252, Grade 2, smooth wall pipe. Casing size shall be of the outside diameter and wall thickness as indicated. Protective coating is not required on casing pipe.

2.7.2 Wood Supports

Treated Yellow Pine or Douglas Fir, rough, structural grade. Provide wood with nonleaching water-borne pressure preservative (ACA or CCA) and treatment conforming to AWPA P5 and AWPA C2, respectively. Secure wood supports to carrier pipe with stainless steel or zinc-coated steel bands.

2.8 MATERIAL FOR RIP-RAP

Bedding material Grout Filter fabric and rock conforming to these requirements DOT State Standard for construction indicated.

2.8.1 Bedding Material

Consisting of sand, gravel, or crushed rock, well graded, or poorly graded with a maximum particle size of 2 inches. Material shall be composed of tough, durable particles. Fines passing the No. 200 standard sieve shall have a plasticity index less than six.

2.8.2 Grout

Composed of cement, water, an air-entraining admixture, and sand mixed in proportions of one part portland cement to two parts of sand, sufficient water to produce a workable mixture, and an amount of admixture which will entrain sufficient air to produce durable grout, as determined by the Contracting Officer. Mix grout in a concrete mixer. Mixing time shall be sufficient to produce a mixture having a consistency permitting gravity flow into the interstices of the rip-rap with limited spading and brooming.

2.8.3 Rock

Rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Rock fragments shall be free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. The size of the fragments shall be such that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Specific gravity of the rock shall be a minimum of 2.50 . The inclusion of more than trace 1 percent quantities of dirt, sand, clay, and rock fines will not be permitted.

2.9 BURIED WARNING AND IDENTIFICATION TAPE

Polyethylene plastic and metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inch minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Color and printing shall be permanent, unaffected by moisture or soil.

Warning Tape Color Codes	
Red:	Electric
Yellow:	Gas, Oil; Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air

2.9.1 Warning Tape for Metallic Piping

Acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of tape shall be 0.003 inch. Tape shall have a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.9.2 Detectable Warning Tape for Non-Metallic Piping

Polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of the tape shall be 0.004 inch. Tape shall have a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Tape shall be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.10 DETECTION WIRE FOR NON-METALLIC PIPING

Detection wire shall be insulated single strand, solid copper with a minimum of 12 AWG.

PART 3 EXECUTION

3.1 PROTECTION

3.1.1 Shoring and Sheeting

Provide shoring bracing cribbing trench boxes underpinning and sheeting where indicated. In addition to Section 25 A and B of EM 385-1-1 and other requirements set forth in this contract, include provisions in the shoring and sheeting plan that will accomplish the following:

a. Prevent undermining of pavements, foundations and slabs.

b. Prevent slippage or movement in banks or slopes adjacent to the excavation.

c. Allow for the abandonment of shoring and sheeting materials in place in critical areas as the work is completed. In these areas, backfill the excavation to the elevation indicated or within 3 feet of the finished grade and remove the remaining exposed portion of the shoring before completing the backfill.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

So that construction operations progress successfully, completely drain construction site during periods of construction to keep soil materials sufficiently dry. The Contractor shall establish/construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, dikes, swales, and other drainage features and equipment as required to maintain dry soils, prevent erosion and undermining of foundations. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site, the area immediately surrounding the site, and the area affecting operations at the site shall be continually and effectively drained.

3.1.2.2 Dewatering

Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least below the working level.

Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system. Relieve hydrostatic head in previous zones below subgrade elevation in layered soils to prevent uplift.

3.1.3 Underground Utilities

Location of the existing utilities indicated is approximate. The Contractor shall physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor shall contact the Public Works Department for assistance in locating existing utilities.

3.1.4 Machinery and Equipment

Movement of construction machinery and equipment over pipes during construction shall be at the Contractor's risk. Repair, or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Unless indicated otherwise, remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations within the clearing limits or within lines 5 feet outside of each building and structure line. Remove stumps entirely. Grub out matted roots and roots over 2 inches in diameter to at least 18 inches below existing surface.

3.2.2 Stripping

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Material unsuitable for use as topsoil shall be stockpiled and used for backfilling. Locate topsoil so that the material can be used readily for the finished grading. Where sufficient existing topsoil conforming to the material requirements is not available on site, provide borrow materials suitable for use as topsoil. Protect topsoil and keep in segregated piles until needed.

3.2.3 Unsuitable Material

Remove vegetation, debris, decayed vegetable matter, sod, mulch, and rubbish underneath paved areas or concrete slabs.

3.3 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Reuse excavated materials that meet the specified requirements for the material type required at the intended location. Keep excavations free from water. Excavate soil disturbed or weakened by Contractor's operations, soils softened or made unsuitable for subsequent construction due to exposure to weather. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory material encountered below the grades shown shall be removed as directed. Refill with backfill and fill material satisfactory material select material porous fill and compact to 95 percent of ASTM D1557 maximum density. Unless specified otherwise, refill excavations cut below indicated depth with backfill and fill material satisfactory material select material porous fill and compact to 95 percent of ASTM D1557 maximum density. Satisfactory material removed below the depths indicated, without specific direction of the Contracting Officer, shall be replaced with satisfactory materials to the indicated excavation grade; except as specified for spread footings. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Contracting Officer.

3.3.1 Structures With Spread Footings

Ensure that footing subgrades have been inspected and approved by the Contracting Officer prior to concrete placement. Fill over excavations with concrete during foundation placement.

3.3.2 Pile Cap Excavation and Backfilling

Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Contracting Officer. Backfill and compact overexcavations and changes in grade due to pile driving operations to 95 percent of ASTM D698 maximum density.

3.3.3 Pipe Trenches

Excavate to the dimension indicated. Grade bottom of trenches to provide uniform support for each section of pipe after pipe bedding placement. Tamp if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least 6 inches below the bottom of the pipe.

3.3.4 Hard Material and Rock Excavation

Remove hard material and rock to elevations indicated in a manner that will leave foundation material in an unshattered and solid condition. Roughen level surfaces and cut sloped surfaces into benches for bond with concrete. Protect shale from conditions causing decomposition along joints or cleavage planes and other types of erosion. Removal of hard material and rock beyond lines and grades indicated will not be grounds for a claim for additional payment unless previously authorized by the Contracting Officer. Excavation of the material claimed as rock shall not be performed until the material has been cross sectioned by the Contractor and approved by the Contracting Officer. Common excavation shall consist of all excavation not classified as rock excavation.

3.3.5 Excavated Materials

Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory material shall be disposed of as specified in Paragraph "DISPOSITION OF SURPLUS MATERIAL."

3.3.6 Final Grade of Surfaces to Support Concrete

Excavation to final grade shall not be made until just before concrete is to be placed. For pile foundations, the excavation shall be stopped at an elevation 6 to 12 inches above the bottom of the footing before driving piles. After pile driving has been completed, the remainder of the excavation shall be completed to the elevations shown. Only excavation methods that will leave the foundation rock in a solid and unshattered condition shall be used. Approximately level surfaces shall be roughened, and sloped surfaces shall be cut as indicated into rough steps or benches to provide a satisfactory bond. Shales shall be protected from slaking and all surfaces shall be protected from erosion resulting from ponding or flow of water.

3.4 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials as directed by the Contracting Officer. The surface shall be scarified to a depth of 6 inches before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 6 inches, pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 12 inches and compacted as specified for the adjacent fill. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted.

3.4.1 Proof Rolling

Proof rolling shall be done on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade of the with six passes of a dump truck loaded with 212 cubic feet of soil Operate the roller truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2 1/2 to 3 1/2 miles per hour. When proof rolling under buildings, the building subgrade shall be considered to extend 5 feet beyond the building lines, and one-half of the passes made with the roller shall be in a direction perpendicular to the other passes. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Proof rolling shall be performed in the presence of the Contracting Officer. Rutting or pumping of material shall be undercut to a depth of 6 inches and replaced with fill and backfill select material.

3.5 SUBGRADE FILTER FABRIC

Place synthetic fiber filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inches diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.6 FILLING AND BACKFILLING

Fill and backfill to contours, elevations, and dimensions indicated. Compact each lift before placing overlaying lift.

3.6.1 Common Fill Placement

Provide for general site and under porous fill of pile-supported structures. Use satisfactory materials. Place in 6 inch lifts. Compact areas not accessible to rollers or compactors with mechanical hand tampers. Aerate material excessively moistened by rain to a satisfactory moisture content. Finish to a smooth surface by blading, rolling with a smooth roller, or both.

3.6.2 Backfill and Fill Material Placement

Provide for paved areas and under concrete slabs, except where select material is provided. Place in 6 inch lifts. Do not place over wet or frozen areas. Place backfill material adjacent to structures as the structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against the structure.

3.6.3 Select Material Placement

Provide under porous fill of structures not pile supported. Place in 6 inch lifts. Do not place over wet or frozen areas. Backfill adjacent to structures shall be placed as structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against structure.

3.6.4 Backfill and Fill Material Placement Over Pipes and at Walls

Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Backfill shall be brought to indicated finish grade and shall include backfill for outside grease interceptors and underground fuel tanks. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 2 feet above sewer lines and 1 foot above other utility lines shall be free from stones larger than 1 inch in any dimension. Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Backfill shall not be placed against foundation walls prior to 7 days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall.

3.6.5 Porous Fill Placement

Provide under floor and area-way slabs on a compacted subgrade. Place in 4 inch lifts with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.6.6 Trench Backfilling

Backfill as rapidly as construction, testing, and acceptance of work permits. Place and compact backfill under structures and paved areas in 6 inch lifts to top of trench and in 6 inch lifts to one foot over pipe outside structures and paved areas.

3.7 BORROW

Where satisfactory materials are not available in sufficient quantity from required excavations, approved borrow materials shall be obtained as specified herein.

3.8 BURIED WARNING AND IDENTIFICATION TAPE

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.9 BURIED DETECTION WIRE

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. The wire shall extend continuously and unbroken, from manhole to manhole. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. The wire shall remain insulated over it's entire length. The wire shall enter manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, the wire shall terminate in the valve pit at the pump station end of the pipe.

3.10 COMPACTION

Determine in-place density of existing subgrade; if required density exists, no compaction of existing subgrade will be required. Density requirements specified herein are for cohesionless materials. When cohesive materials are encountered or used, density requirements may be reduced by 5 percent.

3.10.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 90 percent of ASTM D1557.

3.10.2 Structures, Spread Footings, and Concrete Slabs

Compact top 12 inches of subgrades to 95 percent of ASTM D1557. Compact common fill fill and backfill material select material to 95 percent of ASTM D1557.

3.10.3 Adjacent Area

Compact areas within 5 feet of structures to 95 percent of ASTM D1557.

3.10.4 Paved Areas

Compact top 12 inches of subgrades to 95 percent of ASTM D1557. Compact fill and backfill materials to 95 percent of ASTM D1557.

3.10.5 Airfield Pavements

Compact top 24 inches below finished pavement or top 12 inches of subgrades, whichever is greater, to 100 percent of ASTM D1557; compact fill and backfill material to 100 percent of ASTM D1557.

3.11 PIPELINE CASING UNDER RAILROAD AND PAVEMENT

Provide new smooth wall steel pipeline casing under new existing railroad and pavement in a trench by the boring and jacking method of installation. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated.

3.11.1 Earthwork for Pipeline Casings

Provide excavation, sheet piling, shoring, dewatering, and backfilling for pipeline casings under this section.

3.11.2 Steel Cased Pipelines

Excavate and place bedding and backfill as indicated. Install pipeline casing by dry boring and jacking method as follows:

3.11.2.1 Hole for Pipeline Casing

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other fluids in connection with the boring operation.

3.11.2.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.11.2.3 Piped Utilities

Provide in casing using wood supports adjusted to obtained grades and elevations indicated.

3.11.2.4 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight end seals as indicated. segmented elastomeric end seals.

3.12 SPECIAL EARTHWORK REQUIREMENTS FOR SUBSURFACE DRAINS

Excavate to dimensions indicated. Provide a bedding surface of no more than one inch of sand and gravel Type I subdrain backfill material and place on compacted native soil impermeable material as indicated. Backfill blind or french drains around and over the pipes after pipe installation has been approved. Place special granular filter material in 6 inch lifts and compact with mechanical, vibrating plate tampers or rammers until no further consolidation can be achieved. Compact backfill overlying the special granular filter material as specified for adjacent or overlying work.

3.12.1 Granular Backfill Without Filter Fabric

3.12.1.1 Perforated or Slotted Wall Pipe

Place granular material as pipe is laid and extend fit for a minimum of one pipe diameter on each side of and 18 inches above the top of the pipe. Place a layer of kraft paper on top of granular filter before continuing with the backfill.

3.12.1.2 Open-Joint Pipe

Place both types of granular material specified as pipe is laid forming an aggregate filter around the pipe. Provide Type II material to envelope the pipe a minimum of one-half the pipe diameter or twice the maximum aggregate size, whichever is larger, on each side and on top of the pipe. Place Type I material next to and on top of the Type II material to provide a total fill extending at least one pipe diameter on each side of and 18 inches above the top of the pipe. Place a layer of kraft paper on top of the granular filter before continuing with the backfill.

3.12.2 Granular Backfill Using Filter Fabric

3.12.2.1 Perforated or Slotted Wall Pipes

Wrap one layer of filter fabric around pipe in such a manner that longitudinal overlaps are in unperforated or unslotted quadrants of the pipe. Overlap fabric a minimum of 2 inches. Secure fabric to pipe so that backfill material does not infiltrate through overlaps. Place granular material and extend it for one pipe diameter, minimum of 6 inches on each side of and 18 inches above top of pipe. Place a layer of filter fabric on top of granular filter before continuing with backfill.

3.12.2.2 Open-Joint Pipe

Wrap one layer of filter fabric around pipe joints overlapping a minimum of 2 inches in the longitudinal direction and extending at least 6 inches on both sides of the joint. Secure fabric to pipe so that backfill material does not infiltrate through overlaps. Place granular material specified and extend it for a minimum of one pipe diameter on each side of and 18 inches above top of pipe. Place a layer of filter fabric on top of granular filter before continuing with backfill.

3.12.2.3 Blind or French Drains

Install filter cloth in trenches with smoothly graded sides and bottom, free of cavities or projecting rocks. Lay the cloth flat but not stretched and secure with anchor pins. Place filter cloth so that drain water must pass through the cloth into the specified granular filter material. Overlap ends at least of 12 inches. Place backfill on filter cloth in the direction of overlaps. Where fabric is damaged, place a new piece of filter cloth over damaged area and overlap at least of 12 inches in every direction.

3.13 EARTHWORK REQUIREMENTS FOR SEWAGE ABSORPTION TRENCHES PITS

Provide sewage absorption trench pit as indicated. Grade trenches uniformly downward to ends of laterals. Place pre-cast concrete base ring or concrete footing for pit sections at the elevation indicated. Assemble succeeding sections as indicated and as recommended by manufacturer. Place porous fill around and over pipe around absorption pit as indicated. Take special care to prevent displacement of or damage to pipe pit walls. Cover porous fill with kraft paper, filter fabric or a concrete cover as indicated before continuing with backfill for adjacent or overlying work.

3.14 RIP-RAP CONSTRUCTION

Construct rip-rap on bedding material or on filter fabric with grout in the areas indicated.

3.14.1 Preparation

Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.14.2 Bedding Placement

Spread filter fabric bedding material uniformly to a thickness of at least 3 inches on prepared subgrade as indicated. Compaction of bedding is not required. Finish bedding to present even surface free from mounds and windrows.

3.14.3 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above. For grouted rip-rap, hand-place surface rock with open joints to facilitate grouting and do not fill smaller spaces between surface rock with finer material. Provide at least one "weep hole" through grouted rip-rap for every 50 square feet of finished surface. Weep holes shall consist of columns of bedding material, 4 inches in diameter, extending up to the rip-rap surface without grout.

3.14.4 Grouting

Prior to grouting, wet rip-rap surfaces. Grout rip-rap in successive longitudinal strips, approximately 10 feet in width, commencing at the lowest strip and working up the slope. Distribute grout to place of final deposit and work into place between stones with brooms, spades, trowels, or vibrating equipment. Take precautions to prevent grout from penetrating bedding layer. Protect and cure surface for a minimum of 7 days.

3.15 FINISH OPERATIONS

3.15.1 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.15.2 Topsoil and Seed

Provide as specified in Section 32 92 19 SEEDING.

Scarify existing subgrade. Provide 4 inches of topsoil for newly graded finish earth surfaces and areas disturbed by the Contractor. Topsoil shall not be placed when the subgrade is frozen, excessively wet, extremely dry, or in a condition otherwise detrimental to seeding, planting, or proper grading. Additional topsoil will not be required if work is performed in compliance with stripping and stockpiling requirements. If there is insufficient on-site topsoil meeting specified requirements for topsoil, provide topsoil required in excess of that available. Seed shall match existing vegetation. Provide seed at 5 pounds per 1000 square feet. Provide granular controlled release fertilizer.

Provide mulch and water to establish an acceptable stand of grass.

3.15.3 Protection of Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.16 DISPOSITION OF SURPLUS MATERIAL

Remove from Government property surplus or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber.

3.17 FIELD QUALITY CONTROL

3.17.1 Sampling

Take the number and size of samples required to perform the following tests.

3.17.2 Testing

Perform one of each of the following tests for each material used. Provide additional tests for each source change.

3.17.2.1 Fill and Backfill Material Testing

Test fill and backfill material in accordance with ASTM C136/C136M for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D4318 for liquid limit and for plastic limit; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

3.17.2.2 Select Material Testing

Test select material in accordance with ASTM C136/C136M for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

3.17.2.3 Porous Fill Testing

Test porous fill in accordance with ASTM C136/C136M for conformance to gradation specified in ASTM C33/C33M.

3.17.2.4 Density Tests

Test density in accordance with ASTM D1556/D1556M, or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556/D1556M density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556/D1556M density test at the start of the job, and for every 10 ASTM D6938 density tests thereafter. Test each lift at randomly selected locations every 2000 square feet of existing grade in fills for structures and concrete slabs, and every 2500 square feet for other fill areas and every 2000 square feet of subgrade in cut. Include density test results in daily report.

Bedding and backfill in trenches: One test per 50 linear feet in each lift.

3.17.2.5 Moisture Content Tests

In the stockpile, excavation or borrow areas, a minimum of two tests per day per type of material or source of materials being placed is required during stable weather conditions. During unstable weather, tests shall be made as dictated by local conditions and approved moisture content shall be tested in accordance with ASTM D2216. Include moisture content test results in daily report.

-- End of Section --

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SECTION 31 31 16.13

CHEMICAL TERMITE CONTROL
08/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07	(2019) DOD Pest Management Program

1.2 ADMINISTRATIVE REQUIREMENTS

Coordinate work related to final grades, landscape plantings, foundations, or any other alterations to the finished construction which might alter the condition of treated soils.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Termiticide Application Plan; G

SD-03 Product Data

Termiticides

SD-05 Design Data

Mixing Formulation

SD-06 Test Reports

Soil Moisture

Calibration Test

SD-07 Certificates

Qualifications; G

Foundation Exterior

Utilities and Vents

Crawl and Plenum Air Spaces

List of Equipment

SD-08 Manufacturer's Instructions

Termiticides

SD-11 Closeout Submittals

Verification of Measurement

Warranty

Pest Management Report

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

Comply with DODI 4150.07 for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent, and submit copies of records when requested by the Contracting Officer. These forms may be obtained from the main web site: https://www.esd.whs.mil/Directives/forms/fmo_poc/

1.4.2 Qualifications

For the application of pesticides, use the services of an applicator whose principal business is pest control. The applicator must be commercially certified in the state where the work is to be performed as required by DODI 4150.07. No contractor personnel may work under the supervision of a certified person even where this is permitted practice in those States or host nations in which the DOD property is located. Termiticide applicators must also be certified in the U.S. Environmental Protection Agency (EPA) pesticide applicator category which includes structural pest control. Submit a copy of the pest control business license and pesticide applicator certificates to the Contracting Officer prior to any applications.

1.4.3 Safety Requirements

Formulate, apply, and dispose of termiticides and their containers in accordance with label directions. Draw water for formulating only from sites designated by the Contracting Officer, and fit the filling hose with a backflow preventer meeting local plumbing codes or standards. Maintain an air gap between the filling hose and tank. Perform filling operations under the direct and continuous observation of a contractor's representative to prevent overflow. Secure pesticides and related materials under lock and key when unattended. Ensure that proper protective clothing and equipment are worn and used during all phases of termiticide application. Dispose of used pesticide containers off Government property.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver termiticide material to the site in the original unopened containers bearing legible labels indicating the EPA registration number, manufacturer's registered uses and in new or otherwise good condition as supplied by the manufacturer or formulator.

1.5.2 Inspection

Inspect termiticides upon arrival at the job site for conformity to type and quality in accordance with paragraph TERMITICIDES. Each label must bear evidence of registration under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended or under appropriate regulations of the host county. Inspect other materials for conformance with specified requirements. Remove unacceptable materials from the job site.

1.5.3 Storage

Storage of pesticides on the installation will not be permitted unless it is written into the contract.

1.5.4 Handling

Handle and mix termiticides in accordance with the manufacturer's label and SDS, preventing contamination by dirt, water, and organic material. Protect termiticides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on pest control vehicles and must be available at the mixing site. Conduct termiticide mixing in an area that has been approved by the Integrated Pest Management Coordinator (IPMC) or Contracting Officer, and with adequate spill containment that can contain at least 110 percent of the volume of the tank.

1.6 SITE CONDITIONS

The following site conditions determine the acceptable time of application.

1.6.1 Soil Moisture

Test soils to be treated immediately before application. Test soil moisture content to a minimum depth of 3 inches. The soil moisture must be as recommended by the termiticide manufacturer. Application of the termiticide is not permitted when soil moisture content exceeds manufacturer's recommendations.

1.6.2 Runoff and Wind Drift

Application of termiticide will not be permitted during or immediately following heavy rains, when conditions may allow runoff, when it may create an environmental hazard or when average wind speed exceeds 10 miles per hour. Termiticide is not permitted to enter water systems, aquifers, or endanger humans or animals.

1.7 WARRANTY

Provide a 5 year written warranty against infestations or reinfestations by subterranean termites of the buildings or building additions constructed under this contract. Include in the warranty annual inspections of the buildings or building additions during the warranty period. If live subterranean termite infestation or subterranean termite damage is discovered during the warranty period, and the soil and building conditions have not been altered in the interim:

a. Re-treat the site and perform other treatment as may be necessary for elimination of subterranean termite infestation;

b. Repair damage caused by termite infestation; and

c. Reinspect the building approximately 180 days after the re-treatment.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Chemical termite control uses liquid termiticide treatments applied to the soil to form a continuous chemical barrier in the soil around both sides of the foundation. The application can be surface applied or rodded and trenched. This barrier prevents foraging termites from reaching the foundation and piers. Only the soil adjacent to these foundation elements is treated. For slab construction (including foundations, patios and garages), the entire soil (or gravel) surface is treated before the vapor barrier is installed and the slab poured over it. Soil treatment is coordinated with all building activities from foundation construction through final grading of the soil around the building's exterior. In order for the treatment to be effective, the final phase of the application must be done after final grading and sometimes after landscaping is completed so that the treated soil is not disturbed.

2.2 MATERIALS

2.2.1 Termiticides

Provide termiticides currently registered by the EPA or approved for such use by the appropriate agency of the host county and as approved by the Contracting Officer. Select non-repellent termiticides (active ingredient: chlorantraniliprole, chlorfenapyr, fipronil, or imidacloprid) for maximum effectiveness and duration after application. Select a termiticide that is suitable for the soil and climatic conditions at the project site and apply at the highest labeled rate. Submit manufacturer's label and Safety Data Sheet (SDS) for termiticides proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

Before termiticide application begins, remove all cellulose containing materials from the site such as wood debris from clearing and grubbing and post construction wood scraps, such as ground stakes, form boards, cardboard paper, and scrap lumber from the site.

3.1.1 Verification

Before work starts, verify that final grades are as indicated and smooth grading has been completed in accordance with Section 31 00 00 EARTHWORK. Finely grade soil and remove particles larger than 1 inch. Compact soil particles to eliminate soil movement.

3.1.2 Foundation Exterior

If the exterior perimeter treatment is applied before major construction is completed it will be damaged or removed. The exterior foundation perimeter treatment will have to occur in phases during completion of any pads, porches, aprons, sidewalks, final grading, or landscape plantings adjacent to the building foundation. These treatment areas should be coordinated after all major construction but before any pads, porches, or other items requiring special consideration are poured adjacent to the foundation walls. Submit written verification that final grading, landscape planting, and other items adjacent to the foundation will not disturb treatment of the soil on the exterior sides of foundation walls, grade beams, and similar structures.

3.1.3 Utilities and Vents

Turn off and block HVAC ducts and vents located in the treatment area prior to application to protect people and animals from termiticide. Submit written verification that the HVAC ducts and vents, water and sewer lines, and plumbing have been turned off or blocked prior to applying termiticide.

3.1.4 Crawl and Plenum Air Spaces

Submit written verification that crawl and plenum air spaces have been located and identified prior to applying termiticide.

3.1.5 Application Plan

Prior to commencing application of termiticide, submit a Termiticide Application Plan addressing the following items:

a. proposed sequence of treatment work including dates and times of application

b. termiticide trade name

c. EPA registration number

d. chemical composition

e. concentration of original and diluted material

f. formulation

g. manufacturer's recommended application rates

h. regional requirements

i. application rate of active ingredients

j. method of application

k. area or volume to be treated

l. amount to be applied

m. copy of the pest control business license

n. copy of the pesticide applicator certificates

3.2 APPLICATION

For areas to be treated, establish complete and unbroken vertical and horizontal soil chemical barriers between the soil and all portions of the intended structure which may allow termite access to wood and wood related products. Make applications to crawl spaces in accordance with label directions. Applications to crawl space areas that are used as plenum air spaces will not be permitted.

3.2.1 Equipment Calibration and Tank Measurement

Submit a list of equipment to be used. Conduct calibration test on the application equipment to be used immediately prior to commencement of termiticide application. Measure the volume and contents of the application tank. Testing must confirm that the application equipment is operating within the manufacturer's specifications and meets the specified requirements. Submit written certification of the equipment calibration test results within one week of testing. Where results from the equipment calibration and tank measurements tests are unsatisfactory, re-treatment will be required.

3.2.2 Mixing and Application

Perform all work related to formulating, mixing, and application in the presence of the Contracting Officer's representative, a DOD certified pesticide applicator, Pest Management Quality Assurance Evaluator (QAE)/Performance Assessment Representative (PAR), or IPMC. Applications must be made at the highest rate or concentration allowed by the label. Submit mixing formulation:

a. Quantity of pesticide used.

b. Rate of dispersion.

c. Percent of use.

d. Total amount used.

A closed system is recommended as it prevents the termiticide from coming into contact with the applicator or other persons. Only use water from designated locations. Fit filling hoses with a backflow preventer meeting local plumbing codes or standards. Maintain an air gap between filling hoses and tanks. Prevent overflow during the filling operation. Spill kits must be maintained on pest control vehicles and must be available at the mixing site. Termiticide mixing must be conducted in an area that has been designated by the IPMC or Contracting Officer and that has adequate spill containment. Inspect the application equipment prior to each day of use for leaks, clogging, wear, or damage. Immediately perform repairs on the application equipment to prevent or eliminate leaks and clogging.

3.2.2.1 Application Method

3.2.2.1.1 Surface Application

Use surface applications for establishing horizontal barriers. Apply termiticide as a coarse spray and provide uniform distribution over the soil surface. Termiticide must penetrate a minimum of 1 inch into the soil, or as recommended by the manufacturer. If soils are treated to a depth less than specified or approved, repeat work performed to the depth specified at no additional cost to the Government.

3.2.2.1.2 Rodding and Trenching

Use rodding and trenching for establishing vertical soil barriers. Trenching must be to the depth of the foundation footing. Width of trench must be as recommended by the manufacturer, or as indicated. Rodding or other approved method may be implemented for saturating the base of the trench with termiticide. Backfill the trench immediately after termiticide has reached maximum penetration as recommended by the manufacturer. If maximum penetration is not achieved, as recommended by the manufacturer, repeat work performed to maximum penetration as recommended by the manufacturer at no additional cost to the Government. Backfill in 6 inch rises or layers. Treat each rise or layer with termiticide.

3.2.3 Sampling

The Contracting Officer may draw samples for analysis, at any time and without prior notice, from stocks at the job site to determine if the amount of active ingredient specified on the label is being applied. When analysis, performed by the Government, indicates samples contain less than the amount of active ingredient specified on the label, repeat work performed with pesticides conforming to this specification at no additional cost to the Government.

3.2.4 Vapor Barriers and Waterproof Membranes

Apply termiticide prior to placement of a vapor barrier or waterproof membrane.

3.2.5 Placement of Concrete

Place concrete covering treated soils after the termiticide has reached maximum penetration into the soil as recommended by the manufacturer. Cover treated areas with plastic if slab is not to be poured immediately following termiticide application.

3.2.6 Clean Up, Disposal, and Protection

Once application has been completed, proceed with clean up and protection of the site without delay.

3.2.6.1 Clean Up

Clean the site of all material associated with the treatment according to label instructions, and as indicated. Remove and dispose of excess and waste material off Government property.

3.2.6.2 Disposal of Termiticide

Dispose of residual termiticides and containers off Government property, and in accordance with label instructions and EPA criteria.

3.3 FIELD QUALITY CONTROL

3.3.1 Verification of Measurement

Once termiticide application has been completed, measure tank contents to determine the remaining volume. The total volume measurement of used contents for the application must equal the application rate established in the application plan. Submit written verification that the volume of termiticide used meets the application rate established in the application plan.

3.3.2 Inspection

3.3.2.1 Technical Representative

Provide a technical representative who is a DOD certified pesticide applicator, Pest Management QAE/PAR, or IPMC. The technical representative must be present at all meetings concerning treatment measures for subterranean termites and during treatment application. Contact the Integrated Pest Management Coordinator prior to starting work.

3.4 CLOSEOUT ACTIVITIES

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the target pest, type of operation, brand name and manufacturer of pesticide, formulation, concentration or rate of application used.

3.5 PROTECTION

3.5.1 Protection of Treated Area

Immediately after the application, protect the area from other use by erecting barricades as required or directed. Provide signage in accordance with Section 10 14 00.10 EXTERIOR SIGNAGE. Place signage inside the entrances to crawl spaces and identify the space as treated with termiticide and not safe for children or animals.

3.5.2 Disturbance of Treated Soils

Re-treat soil and fill material disturbed after treatment before placement of slabs or other covering structures.

-- End of Section --

SECTION 31 31 16.19

TERMITE CONTROL BARRIERS
08/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A478	(1997; R 2019) Standard Specification for Chromium-Nickel Stainless Steel Weaving and Knitting Wire
ASTM A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM C128	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Pre-Installation Meetings

Convene a pre-installation meeting at least one week prior to beginning installation to review conditions of preparation, storage and handling, installation procedures, sequencing, protection, and coordination with other related work. The project superintendent, installer, installer's crew leader, and representatives of the trades affected by this work are required to attend. Notify the Contracting Officer at least 10 calendar days before the meeting.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Steel Mesh Shop Drawings; G

Basaltic Sand Shop Drawings; G

SD-03 Product Data

Steel Mesh Materials

Accessories

Steel Mesh System

Written Warranty

SD-04 Samples

Steel Mesh Materials; G

SD-06 Test Reports

Basaltic Sand; G

SD-07 Certificates

System Installers

Steel Mesh Materials

Written Verification

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instruction Manual

Manufacturer's Guidance

Manufacturer's Installation Instructions

SD-09 Manufacturer's Field Reports

Site Conditions

SD-11 Closeout Submittals

Written Warranty

1.4 QUALITY CONTROL

1.4.1 Qualifications

1.4.1.1 Steel Mesh Barrier System

a. Only employee system installers trained in the behavior of termites and installation techniques of the mesh barrier, and accredited by the system's manufacturer. Submit certification that system installers meet the requirements specified and for the effective time period of accreditation.

b. Only employ workers trained and accredited at the appropriate level by the system's manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site in original, unbroken packaging and containers, with original labels in place, to include any U.S. Environmental Protection Agency (EPA) designation. Store materials in conformance with system manufacturer's recommendations.

Store and handle the material so as to prevent contamination by dirt, water, and organic material.

1.6 SITE CONDITIONS

1.6.1 Environmental Requirements

In addition to the manufacturer's installation instructions and before placing material, ensure project site is free from standing water.

1.7 WARRANTY

Furnish a 5-year written warranty against infestations or reinfestation by subterranean termites of the buildings or building additions constructed under this contract. Written warranty must be jointly signed by an officer of the Contractor and the supplier. Perform annual inspections of the buildings or building additions. If live subterranean termite infestation or subterranean termite damage is discovered during the warranty period, and building conditions have not been altered in the interim, take the following actions:

a. Correct defective steel mesh basaltic sand installation and perform other treatment as may be necessary to eliminate subterranean termite infestation.

b. Repair damage caused by termite infestation.

c. Reinspect the building approximately 180 calendar days after the repair.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Steel Mesh System Description

A complete termite control barrier system encompasses a fine steel mesh placed across all termite entry points to the building. Principal entry points include all cracks, joints, penetrations, and other termite entry points within the concrete slabs and cavities in walls. The steel mesh and fastening system physically prevents the termites from entering the building. The mesh is too fine for the termites to pass through, too hard to chew through, and highly corrosion resistant against future break down.

2.1.2 Basaltic Sand System Description

A complete termite control barrier system composed of a graded basaltic sand as a physical barrier below the concrete slab or foundation of a structure to prevent the entry of Formosan ground termites into wood components of the structure, similar to laying down a chemical barrier of soil termiticide. The use of this preventive measure does not preclude the use of other preventive measures such as chemical treatment, steel mesh barrier system, and pressure treated lumber to provide maximum protection to the structure. It is recommended that this material be used in conjunction with chemical treatments of vulnerable areas such as around electrical conduits, plumbing pipes that penetrate the slab, and the shoulder portions of the barrier and with pressure treated lumber to provide maximum protection to the structure.

2.2 MATERIALS

2.2.1 Asbestos Prohibition

No asbestos containing materials or equipment are permitted at the job site. Ensure materials proposed for the project are asbestos free.

2.2.2 Steel Mesh Materials

Provide stainless steel mesh that conform to ASTM A478 and ASTM A580/A580M, Type A1AA marine grade 316 stainless steel mesh of 0.007 inches diameter wire with mesh openings of 0.026 by 0.018 inches.

2.2.2.1 Steel Mesh Material Submittals

Submit statements signed by responsible officials of the manufacturer of material attesting that material meets specification requirements. These statements must be dated after award of the project contract and clearly name the project.

Submit samples of steel mesh materials. Provide 4 by 4 inch samples of steel mesh to be used in this work.

2.2.3 Accessories

Provide parging adhesives, bonding cement, high grade stainless steel clamps, ties, and other accessories as recommended by system's manufacturer.

2.2.4 Basaltic Sand

Provide clean, dry sand material manufactured from crushed basalt rock that meets the following requirements.

a. Material gradation, ASTM C136/C136M.

Sieve Size	Percent Passing
No. 4	100
No. 8	95-100
No. 10	75-95
No. 12	35-50
No. 16	1-10

b. Specific gravity, ASTM C128, 2.80.

c. Silica (S102) content, 45 percent.

d. Abrasion loss, after 500 revolutions, 20 percent, when tested in accordance with ASTM C131/C131M.

PART 3 EXECUTION

3.1 EXAMINATION

Examine the substrates and conditions under which work of this section will be performed. Coordinate with this specification all work related to final grades, landscape plantings, foundations, or any other alternations to finished construction that might alter the condition of the site. Do not proceed until any unsatisfactory conditions detrimental to timely and proper completion of the work have been corrected. Submit written verification that site conditions are as required and other site work will not disturb the installation.

3.2 PREPARATION

In addition to the manufacturer's requirements and before placing material, remove any visible plant roots, construction wood scraps such as ground stakes, form boards, scrap lumber, and standing water from the excavated area. Inspect the utility trenches to ensure they are sufficiently wide to permit adequate cover under, around, and over pipes and conduit that will be encapsulated with the basaltic sand materials. In addition, inspect the foundation perimeter to ensure there is sufficient room between the sides of the excavations and the edges of the foundations to provide the required barrier depth and width.

Provide finished or temporary site grading to remove standing water from the project site (i.e., excavated areas or adjacent areas). Grading must provide positive drainage towards temporary, new or existing drainage features. Grading must not result in low spots that hold water or direct water towards new or existing facilities.

3.2.1 Surface Preparation

Perform work related to final grades, landscape plantings, foundations, or any other operations that might alter the condition of the site, in accordance with this specification. Before installing the steel mesh, ensure that the following have been completed:

a. Eliminate termite food sources by removing wood debris, such as ground stakes, form boards, scrap lumber, and any cellulose containing material from the work area.

b. The work area has been filled with finely graded soil consisting of particle sizes no larger than 1 inch and compacted to eliminate soil movement. Ensure the site conditions meet the manufacturer's recommendations for installing the steel mesh.

c. Footings, foundations, and outer forms are in place.

d. Penetrating pipes for communications, electrical, and plumbing are in place.

e. Submit site conditions certificate documenting that the site conditions are acceptable for the steel mesh barrier system.

3.3 INSTALLATION

Install a basaltic sand system in accordance with the manufacturer's installation instructions.

Submit basaltic sand shop drawings of the basaltic sand installation at all interior and perimeter foundations, joints, and penetration conditions to the Contracting Officer for approval before installation.

3.3.1 Steel Mesh Instructions

Strictly follow the manufacturer's instructions published in Manufacturer's Installation Instruction Manual. In addition to the system manufacturer's instructions, place the stainless steel mesh across all openings, joints, penetrations, and other termite entry points to the building (including all shrinkage cracks in concrete slabs and built penetrations in slabs and walls that termites may use for access points)and in accordance with manufacturer's recommendations. Clamp, parge adhere, bond, or embed the steel mesh to the material surrounding the opening in accordance with the manufacturer's recommendations. Install with no gaps, penetrations, or damage to the mesh system. Submit steel mesh shop drawings of the termite steel mesh installation at all perimeter foundations, joints, and penetration conditions to the Contracting Officer for approval before installation.

To avoid an electrolytic reaction, do not place dissimilar metals in contact with the steel mesh.

3.3.1.1 Installation Sequence

a. Install the steel mesh barrier in accordance with the manufacturer's recommendations. Fit and clamp the mesh around all pipe penetrations, and terminate the mesh at the perimeters, as appropriate for the building construction and as described in the manufacturer's installation manual. Lap joint the mesh 0.39 to 0.59 inches and the joint may be strengthened by using bonding cement for a minimum distance of 20 inches along the joint.

b. Install special fittings that are appropriate to the construction, as described in manufacturer's installation manual.

c. Following installation of mesh and vapor barrier, install reinforcing steel and concrete, as specified under other sections. Seal penetrations and shrinkage cracks through concrete slabs in accordance with manufacturer's recommendations.

d. To maintain resistance to termites, complete the system and do not disturb, penetrate, or damage during the remaining contract time period.

3.3.1.2 Steel Mesh Integration

Where required, integrate mesh into subsequent construction, as described in manufacturer's installation manual.

3.3.2 Placement

Place the basaltic sand barrier under slabs, in utility trenches, along edges of concrete pavement, in concrete masonry unit (CMU) cells, along retaining walls, and other areas that termites may use for access points and in accordance with manufacturer's recommendations.

Place material in one lift for thicknesses of 6 inches or less and in successive lifts of 4 to 6 inches where the indicated thickness is greater than 6 inches. Compact each lift prior to placing successive lifts. Use power driven, vibrating-plate type tampers for large areas and rod-and-plate type hand tampers for small areas such as utility trenches and foundation and walk edges.

3.3.2.1 Slab on Grade

Provide a barrier of the depth indicated. Rake smooth and machine tamp, making at least three passes over the entire area. Hand tamp around pipe and conduit risers.

3.3.2.1.1 Utility Trenches

Place the required depth of material for bedding in the trenches prior to placing pipes and conduits and hand tamp the material. For pipes 3 inches and larger in diameter: after placing the pipe, bring material up to the top of the pipe and carefully hand tamp the material. Then, bring the material up to the top of the trench and tamp. For pipes smaller than 3 inches in diameter and for conduit: bring material up to the top of the trench and tamp.

3.3.2.1.2 Edges

After concrete is placed and the form is removed, remove any dirt, loose concrete, and other debris and hand place and tamp additional material to the existing grade

3.3.2.2 CMU Block Walls

Place the material in non-grouted cells at a height of at least one course above grade of the wall.

3.3.2.3 Fence Posts and Utility Poles

Line the designated hole with a geotextile or similar material before proceeding with the work.

Once the geotextile is in place, put a 4 to 6 inch layer of the basaltic sand at the bottom of the hole. Hand tamp the material. After positioning the fence post or utility pole in the middle of the hole, fill around the sides, compacting the material after successive lifts of 6 to 12 inches until the hole is completely filled. Ensure that a 4 to 6 inch basaltic sand barrier exists around the perimeter of the post or pole.

3.3.2.4 Retaining Walls

Place the required amount of material below the footing and up to the grade level of the wall. Place lifts of 4 to 6 inches with compaction of each lift prior to placing successive lifts.

3.4 FIELD QUALITY CONTROL

3.4.1 Inspection

Provide Manufacturer's Guidance for performing a visual inspection of the installed mesh to ensure the steel mesh provides the designed termite physical barrier.

3.4.2 Manufacturer Field Services

Before installing the steel mesh, verify that final grades are as indicated and smooth grading has been completed. Provide written verification that the site conditions under the proposed slabs are proper for the installation of the termite barrier system in accordance with the manufacturer's recommendations.

3.5 PROTECTION

Protect the installed steel mesh system, attachments, and accessories before, during, and after the work of all trades, as required by the system manufacturer or as directed by the Contracting Officer.

In the event that subsequent trades on the site move or damage the mesh, clamps, or parging mix, immediately contact the mesh installer for a recommendation of the necessary repairs.

-- End of Section --

SECTION 31 32 19.16

GEOTEXTILE SOIL STABILIZATION
02/21

PART 1 GENERAL

1.1 MEASUREMENT

Measure the as-built surface area, covered by geotextile, in square yards. Allowance will be made for geotextile in anchor and/or drainage trenches but no allowance will be made for waste, overlaps, damaged materials, repairs, or materials used for the convenience of the Contractor.

1.2 PAYMENT

Geotextile installed and accepted will be paid for at the respective contract unit price in the bidding schedule. This unit price will include the cost of materials, equipment, installation, testing, and other costs associated with placement of the geotextile.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D4354	(2012; R 2020) Sampling of Geosynthetics for Testing
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011; R 2018) Standard Practice for Determining the Specification Conformance of Geosynthetics
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D6241	(2014) Standard Test Method for the Static

Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Thread
Manufacturing Quality Control Sampling and Testing

SD-04 Samples

Quality Assurance Samples and Tests

SD-07 Certificates

Geotextile

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver, store, and handle geotextile in accordance with ASTM D4873/D4873M.

1.5.1 Delivery

Notify the Contracting Officer a minimum of 24 hours prior to delivery and unloading of geotextile rolls packaged in an opaque, waterproof, protective plastic wrapping. Do not remove the plastic wrapping until deployment. If quality assurance samples are collected, immediately rewrap rolls with the plastic wrapping. Repair or replace as directed, geotextile or plastic wrapping damaged during storage or handling. Label each roll with the manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured.

1.5.2 Storage

Protect rolls of geotextile from construction equipment, chemicals, sparks and flames, temperatures in excess of 160 degrees F, or any other environmental condition that may damage the physical properties of the geotextile. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate.

1.5.3 Handling

Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Do not drag rolls along the ground, lift by one end, or drop to the ground.

PART 2 PRODUCTS

2.1 RAW MATERIALS

A minimum of [7] [_____] days prior to scheduled use, submit manufacturer's certificate of compliance stating that the geotextile meets the requirements of this section. For needle punched geotextiles, certify that the geotextile has been continuously inspected using permanent on-line full-width metal detectors and does not contain any needles which could damage other geosynthetic layers. Provide the certificate of compliance attested to by a person having legal authority to bind the geotextile manufacturer.

2.1.1 Geotextile

Provide geotextile that is a [woven] [nonwoven] pervious sheet of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. The use of woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Add stabilizers and/or inhibitors to the base polymer, as needed, to make the filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure. Regrind material, which consists of edge trimmings and other scraps that have never reached the consumer, may be used to produce the geotextile. Post-consumer recycled material [may also] [must not] be used. Form geotextile into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Meet the requirements specified in Table 1. Where applicable, Table 1 property values represent minimum average roll values (MARV) in the weakest principal direction. Values for AOS represent maximum average roll values.

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	LBS	[160] [_____]	ASTM D4632/D4632M
SEAM STRENGTH	LBS	[_____]	ASTM D4632/D4632M
PUNCTURE	LBS	[55] [_____]	ASTM D6241
TRAPEZOID TEAR	LBS	[55] [_____]	ASTM D4533/D4533M
APPARENT OPENING SIZE	U.S. SIEVE	[_____]	ASTM D4751
PERMITTIVITY	SEC -1	[_____]	ASTM D4491/D4491M
ULTRAVIOLET DEGRADATION	PERCENT	50 AT 500 HRS	ASTM D4355/D4355M

2.1.2 Thread

A minimum of [7] [_____] days prior to scheduled use, submit proposed thread type for sewn seams along with data sheets showing the physical properties of the thread. Construct sewn seams with high-strength polyester, nylon, or other approved thread type. Provide thread with ultraviolet light stability equivalent to the geotextile and color that contrasts with the geotextile.

2.2 MANUFACTURING QUALITY CONTROL SAMPLING AND TESTING

The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. A minimum of [7] [_____] days prior to scheduled use, submit manufacturer's quality control manual. Provide documentation describing the quality control program upon request. Perform manufacturing quality control sampling and testing in accordance with the manufacturer's approved quality control manual. As a minimum, randomly sample geotextiles for testing in accordance with ASTM D4354, Procedure A. Acceptance of geotextile must be in accordance with ASTM D4759. Tests not meeting the specified requirements will result in the rejection of applicable rolls.

PART 3 EXECUTION

3.1 QUALITY ASSURANCE SAMPLES AND TESTS

3.1.1 Quality Assurance Samples

Provide assistance to the Contracting Officer in the collection of quality assurance samples for quality assurance testing; assign [7] [_____] days in the schedule to allow for testing. Collect samples upon delivery to the site [at the request of the Contracting Officer.] [in accordance with ASTM D4354, Procedure B. Consider the lot size for quality assurance sampling to be the shipment quantity of the product or a truckload of the product, whichever is smaller. The unit size is considered one roll of geotextile.] [at a frequency of one per 100,000 square feet]. Identify samples with a waterproof marker by manufacturer's name, product identification, lot number, roll number, and machine direction. Note the date and a unique sample number on the sample. Discard the outer layer of the geotextile roll prior to sampling a roll. Collect samples by cutting the full-width of the geotextile sheet a minimum of 3 feet long in the machine direction. Immediately reseal rolls which are sampled in their protective covering.

3.1.2 Quality Assurance Tests

[Provide] [The Contracting Officer will provide] quality assurance samples to an Independent Laboratory. Samples will be tested to verify that geotextile meets the requirements specified in Table 1. Do not perform test method ASTM D4355/D4355M on the collected samples. Base geotextile product acceptance on ASTM D4759. Tests not meeting the specified requirements will result in the rejection of applicable rolls.

3.2 INSTALLATION

3.2.1 Subgrade Preparation

The surface underlying the geotextile must be smooth and free of ruts or protrusions which could damage the geotextile. Provide subgrade materials and compaction requirements in accordance with Section [_____].

3.2.2 Placement

Notify the Contracting Officer a minimum of 24 hours prior to installation of geotextile. Repair or replace geotextile rolls which are damaged or contain imperfections as directed. Lay the geotextile flat and smooth so that it is in direct contact with the subgrade. The geotextile must also be free of tensile stresses, folds, and wrinkles. On slopes steeper than 10 horizontal on 1 vertical, lay the geotextile with the machine direction of the fabric parallel to the slope direction.

3.3 SEAMS

3.3.1 Overlap Seams

Continuously overlap geotextile panels a minimum of [12] [_____] inches at all longitudinal and transverse joints. Where seams must be oriented across the slope, lap the upper panel over the lower panel. If approved, sewn seams may be used instead of overlapped seams.

3.3.2 Sewn Seams

Sew factory and field seams [on all slopes steeper than 1 vertical on [4][_____] horizontal] [at the locations shown on the drawings.] Use a 401 locking chain stitch or a stitch recommended by the manufacturer. [For field and factory seams which are sewn, provide at least a 2-meter sample of sewn seam before the geotextile is installed. For seams that are field sewn, sew the seams using the same equipment and procedures as will be used for the production seams. If seams are sewn in both the machine and cross machine direction, provide samples of seams from both directions.] [Provide Quality Assurance seam samples to the Government at the request of the Contracting Officer]. Provide seam strength meeting the minimum requirements specified in Table 1. Tie off the thread at the end of each seam run to prevent unraveling. Sew skipped stitches or discontinuities with an extra line of stitching with a minimum of 18 inches of overlap.

3.4 PROTECTION

Protect the geotextile during installation from clogging, tears, and other damage. Repair or replace damaged geotextile as directed. Use adequate ballast (e.g. sand bags) to prevent uplift by wind. Do not leave the geotextile uncovered for more than [14] [_____] days after installation.

3.5 REPAIRS

Repair torn or damaged geotextile. Remove clogged areas of geotextile. Perform repairs by placing a patch of the same type of geotextile over the damaged area. Extend the patch a minimum of 12 inches beyond the edge of the damaged area. Continuously fasten patches using approved methods. Align the machine direction of the patch with the machine direction of the geotextile being repaired. Remove and replace geotextile rolls which cannot be repaired. Perform repairs at no additional cost to the Government

3.6 PENETRATIONS

Construct engineered penetrations of the geotextile [as shown on the drawings] [by methods recommended by the geotextile manufacturer].

3.7 COVERING

Do not cover geotextile prior to inspection and approval by the Contracting Officer. Place cover soil in a manner that prevents soil from entering the geotextile overlap zone, prevents tensile stress from being mobilized in the geotextile, and prevents wrinkles from folding over onto themselves. On side slopes, place soil backfill from the bottom of the slope upward. Do not drop cover soil onto the geotextile from a height greater than 3 feet. Do not operate equipment directly on top of the geotextile without approval of the Contracting Officer. Use equipment with ground pressures less than 7 psi to place the first lift over the geotextile. Maintain a minimum of [12][_____] inches of soil between full-scale construction equipment and the geotextile. Cover soil material type, compaction, and testing requirements are described in Section 31 00 00 EARTHWORK. Do not use equipment for placing cover soil that stops abruptly, makes sharp turns, spins their wheels, or travels at speeds exceeding [5] [_____] mph.

-- End of Section --

SECTION 32 01 11.51

RUBBER AND PAINT REMOVAL FROM AIRFIELD PAVEMENTS
05/16, CHG 2: 08/17

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

Rubber and paint removal is measured by the number of square feet of rubber and paint to be removed.

1.1.2 Payment

Rubber and paint removal is paid for at the contract unit price per square feet of rubber and paint to be removed.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

1.3 ADMINISTRATIVE REQUIREMENTS

Submit a schedule of work to the Contracting Officer. Describe the work to be accomplished; noting the location of work, distances from the ends of runways, taxiways, buildings, and other structures; and indicating dates and hours during which the work will be accomplished. Schedule the work to conform to aircraft operating schedules. The Government will try to schedule aircraft operations so as to permit the maximum amount of time for the Contractor's work. However, in the event of any emergency, intense operational demands, adverse wind conditions, and other unforseen difficulties, discontinue all work at locations in the aircraft operational area. Keep the approved schedule of work current and notify the Contracting Officer of any changes prior to beginning each day's work.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Schedule of work; G,

Rubber and Paint Removal Process Plan; G

Waste Collection, Identification and Disposal Plan; G

SD-03 Product Data

Mechanical rubber and paint removal equipment

Chemical rubber and paint removal equipment

Rubber and Paint Removal Detergents or Chemicals; G

SD-06 Test Reports

Test Section Results

1.5 MECHANICAL REMOVAL EQUIPMENT

Submit product data for mechanical rubber and paint removal equipment including area of coverage per pass, range of water pressures, and water tank capacity.

Mechanical removal equipment includes waterblasting, grinding or scarifying, or other approved non-chemical systems. Control the equipment used on asphalt or tar concrete to remove rubber and paint accumulations while minimizing disturbances to asphalt or tar mixtures. Control the equipment used on portland cement concretes to remove rubber and paint accumulations and prevent removal of hardened paste from the concrete. Basic hand tools and the following major types of mechanical equipment are considered acceptable for this project:

a. Waterblasting Equipment.

b. Grinding or Scarifying Equipment.

1.5.1 Waterblasting Equipment

Provide mobile waterblasting equipment capable of producing a pressurized stream of water that effectively removes rubber and paint from the pavement surface without significantly damaging the pavement. Provide equipment, tools, and machinery which are safe and and in good working order at all times. Provide equipment interlocks to prohibit high pressure water discharge when the vehicle or cleaning head is stationary (not moving forward or side to side).

1.5.2 Grinding or Scarifying Equipment

Provide equipment capable of removing surface contaminates, paint build-up, or extraneous markings from the pavement surface without leaving any residue. If a weed torch is used to remove paint, the surface must be cleaned by hydro blast afterwards to remove surface contaminates and ash.

1.6 CHEMICAL REMOVAL EQUIPMENT

Submit product data for chemical rubber and paint removal equipment. Use chemical equipment capable of applying and removing chemicals from the pavement surface while leaving only non-toxic biodegradable residue.

1.7 TEST SECTION

Prior to the start of work, remove rubber and paint on designated test areas not less than 50 feet in length. Use procedures, water pressures, nozzle height, nozzle spacings, nozzle angle, and equipment movement rate to achieve the required degree of rubber and paint removal in accordance with Paragraph RUBBER AND PAINT REMOVAL. Methods included in paragraph COMPLIANCE TESTING will be used to detemine if the rubber and paint was successfully removed from the test section. The test will examine seven random locations within the test section. Submit the test section results before conducting any further removal work. Provide photos of seven random locations within the test area taken before and after the removal. Provide photos of four random locations at joint seals within the test area taken before and after removal.

1.8 DELIVERY, STORAGE, AND HANDLING

Deliver required materials in original manufacturer's containers labeled with appropriate EPA, OSHA, or other agency warnings, if applicable, and Safety Data Sheets. Protect materials from degrading until their use is required during execution of the work.

1.9 PROJECT/SITE CONDITIONS

1.9.1 Environmental Requirements

Ensure pavement surface is free of snow, ice or slush. Ensure surface temperature is at least 40 degrees F and rising at the beginning of operations. Cease operation during thunder and lightning storms. Cease operation during rainfall except for waterblasting and removal of previously applied chemicals. Cease waterblasting where surface water accumulation alters the effectiveness of material removal.

1.9.2 Airfield Traffic Control

Coordinate performance of all work in the controlled zones of the airfield with the Contracting Officer and with the Flight Operations Officer or Airfield Manager . Neither equipment nor personnel can use any portion of the airfield without permission of these officers unless the runway is closed.

1.9.3 Radio Communication

No personnel or equipment will be allowed in the controlled zones of the airfield until radio contact has been made with the control tower and permission is granted by the control tower. A radio for this purpose will be provided by the Government. The Contractor is responsible for the radio and must reinburse the Government for repair or replacement of the radio if it is lost, damaged, or destroyed . Maintain contact with the control tower at all times during work in vicinity of the airfield. Notify the control tower when work is completed and all personnel, equipment and materials have been removed from all aircraft operating surfaces.

1.9.4 Emergency Landing and Takeoff

Emergencies take precedence over all operations. Upon notification from the Control Tower of an emergency landing or imminent takeoff, stop all operations immediately and evacuate all personnel and equipment to an area not utilized for aircraft traffic which is at least 250 feet measured perpendicular to and away from the near edge of the runway unless otherwise authorized by the Contracting Officer or the Contracting Officer's Representative. Equipment and chemicals or detergents as well as excess water must be able to clear the work area within 3 minutes.

1.9.5 Airfield Lighting

When night operations are necessary, provide all necessary lighting and equipment. Direct or shade lighting to prevent interference with aircraft, the air traffic control tower, and other base operations. Provide lighting and related equipment capable of being removed from the runway within 15 minutes of notification of an emergency. Night work must be coordinated with the Flight Operations Manager or Airfield Manager and approved in advance by the Contracting Officer or authorized representative.

1.9.6 Water

Water to be used for high-pressure water equipment will be made available from Government hydrant at no cost to the Contractor . Furnish equipment and labor for delivery of water from the hydrant to the job site. Notify the Contracting Officer on location of fire hydrants to be used and the respective times of use. The Contracting Officer will notify the Fire Department of fire hydrants to be used and designated times of use. Connections to a fire hydrant will be subject to the Contracting Officer's inspection and approval. The Contractor must provide and use a backflow prevention device for filling water tanks. The Contractor is responsible for testing, treating, and filtering the water to ensure it will not interfere with the rubber removal or damage or clog the rubber removal equipment.

1.10 SAFETY

Comply with OSHA 29 CFR 1910.

PART 2 PRODUCTS

2.1 RUBBER AND PAINT REMOVAL DETERGENTS OR CHEMICALS

The use of environmentally acceptable detergents or chemical agents must be considered on a case-by-case basis. Submit the Safety Data Sheet (SDS) for detergents or chemicals in the rubber and paint removal process. Use of any detergents or chemicals in the rubber and paint removal process must be approved in advance by the Contracting Officer. The Government specifically reserves the right to reject the use of any process which the Contracting Officer determines may pose unnecessary risks to human health, the environment, the pavement, aircraft or NAVAIDS due to corrosion or foreign object damage (FOD) potential as a result of its use, storage, or disposal.

PART 3 EXECUTION

3.1 RUBBER AND PAINT REMOVAL

Prior to any work being completed, submit a Rubber and Paint Removal Process Plan for approval by the Contracting Officer.

a. The pavement surface type is as indicated.

b. Remove 90 percent of all visible rubber on portland cement concrete pavements and 85 percent of all visible rubber on asphaltic concrete pavements.

c. Chemical methods used must be compatible with pavement materials, the environment and working personnel.

d. Exercise close control of water pressure and blasting time/duration to prevent damage to joints, existing markings that are not intended for removal, or the wearing surface.

e. Demonstrate the ability to remove rubber at a touchdown area of the runway selected by the Contracting Officer; at least one site per runway will be chosen. Rubber removal must not damage the pavement surface. The surface texture of the cleaned demonstration area will be compared to that of non-rubber traffic areas to determine satisfactory completion of the removal operation.

f. After approval of the Contractor's operations by the Contracting Officer, the cleaned sample area will become the standard for rubber removal and final surface texture for the remainder of work.

g. Compliance testing for the amount of rubber and paint to be removed must conform to the requirements in paragraph COMPLIANCE TESTING.

3.2 RATE OF REMOVAL

Remove rubber at a minimum rate of 10,000 square feet per hour. Remove paint at a minimum rate of 1,000 square feet per hour. Do not permit high-pressure water application to remove the existing pavement surface, joint seals or crack seals.

3.3 WATER PRESSURE

Provide water pressure impact upon the indicated pavement areas sufficient to remove the designated rubber and paint to the required degree of removal without damaging the existing pavement, joint sealant, or other airfield appurtenances. The Contractor is responsible for repairing any damage caused by the removal work.

3.4 CLEANUP AND WASTE DISPOSAL

Keep the worksite clean of by-products, debris and waste from rubber and paint removal operations. Perform cleanup operations continuously. Remove all residue from the pavement. Obtain the approval of residue removal and disposal method from the Contracting Officer prior to beginning work. Submit a Waste Collection, Identification and Disposal Plan describing proposed actions regarding waste collection, control, identification, and disposal to the Contracting Officer's Representative for approval prior to the start of work. The plan will address disposal methods and requirements for hazardous and non-hazardous wastes.

3.5 COMPLIANCE TESTING

a. Compliance with the rubber and paint removal requirements must be determined by direct testing within the designated work area.

b. Use a one square foot section of transparent material inscribed with a grid of 100 equal squares as a tool for quantitative measure of the percent removal. Place the grid pattern on the pavement surface at random locations. Then count the squares which contain rubber and/or paint deposits. The number of squares containing rubber and/or paint deposits must not exceed the allowed percentage in each of the randomly selected locations.

c. Divide each work area designated for rubber and paint removal into at least four equal zones for the purpose of compliance testing. The layout of each zone must be approved by the Contracting Officer. Within each zone, a minimum of seven random locations must be evaluated. The amount of rubber and paint removed at each of the randomly selected test locations within each zone must meet the requirement described in paragraph RUBBER AND PAINT REMOVAL. Evaluate each zone independently. A zone not meeting the required percentage must be recleaned by the Contractor at the Contractor's expense.

d. Deposits of rubber or rubber buildup and paint are defined as any surface deposit that can be removed by scratching the deposit with a flat sharp object (such as a pocket knife) without damaging the pavement surface. Stains are defined as materials in the pavement surface microtexture that cannot be removed without damaging the pavement surface. Stain is generally embedded in the surface of the pavement below the horizontal plane of the surface texture. The Contractor is not responsible for stain removal.

3.6 DAMAGE REPAIR

Repair any damage to the pavement surface, joint, joint and crack seals, or other Government property caused during the performance of the work at the Contractor's expense. Submit a repair plan to include methods and material to the Contracting Officer's Representative for approval prior to performance of the repairs. Complete the repairs within the performance period of the Contract.

-- End of Section --

SECTION 32 01 13.62

ASPHALT SURFACE TREATMENT

05/18

PART 1 GENERAL

1.1 UNIT PRICES

The bituminous material and aggregate to be paid for will be the measured quantities used in the accepted work.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D946/D946M	(2020) Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D977	(2019a; E 2019) Standard Specification for Emulsified Asphalt
ASTM D1139/D1139M	(2015) Aggregate for Single or Multiple Bituminous Surface Treatments
ASTM D2028/D2028M	(2015) Cutback Asphalt (Rapid-Curing Type)
ASTM D2397/D2397M	(2019a) Standard Specification for Cationic Emulsified Asphalt
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors

ASTM D3625/D3625M	(2012) Standard Practice for Effect of Water on Bituminous-Coated Aggregate Using Boiling Water
ASTM D6373	(2016) Standard Specification for Performance Graded Asphalt Binder

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Waybills and Delivery Tickets
Cutback Asphalt
Emulsified Asphalt
Asphalt Cement

SD-06 Test Reports

Tests

1.4 QUALITY CONTROL

1.4.1 Safety Precautions

Smoking or open flames will not be permitted within 25 feet of heating, distributing, or transferring operations of bituminous materials other than bituminous emulsions.

1.4.2 Sampling and Testing

Sampling and testing is the responsibility of the Contractor. Perform sampling and testing using an approved commercial testing laboratory, or by the Contractor, subject to approval. Sampling must be in accordance with ASTM D75/D75M for aggregates and ASTM D140/D140M for bituminous material, unless otherwise directed. Perform aggregate gradation tests on each sample in accordance with ASTM C136/C136M. Perform all other aggregate tests on the initial source samples and repeat tests when there is a change of source. Perform sieve analyses daily from material samples including an analysis of each gradation of material. Perform tests in sufficient number to ensure that materials meet specified requirements. Submit copies of test results, within 24 hours after completion of each test. Repeat aggregate testing (wear, soundness, deleterious material and stripping) for each 20,000 tons of aggregate used in the project.

1.4.3 Wear Test

Perform the wear test in accordance with ASTM C131/C131M to ensure that aggregates have a percentage of wear not exceeding 40 percent after 500 revolutions.

1.4.4 Soundness Test

Perform the soundness test as specified by ASTM C88 to ensure that aggregates have a weight loss not greater than 18 percent when subjected to five cycles of the magnesium sulfate test or 12 percent when subjected to five cycles of the sodium sulfate test.

1.4.5 Stripping Test

Perform stripping tests meeting the requirements of ASTM D3625/D3625M. Deleterious substances must not exceed the requirements of ASTM D1139/D1139M.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling. Store aggregates preventing segregation and contamination.

1.6 EQUIPMENT, TOOLS AND MACHINES

Provide equipment dependable and adequate for the purpose intended and properly maintained in satisfactory and safe operating condition at all times. Discontinue the use of equipment which fails to produce satisfactory work and replace with satisfactory equipment. Equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment, must have been calibrated by an approved calibration laboratory within 12 months prior to commencing work and every 12 months thereafter, by such laboratory from the date of last calibration, during the term of the contract.

1.6.1 Bituminous Distributors

Provide a self propelled distributor with pneumatic tires of such size and number to prevent rutting, shoving or otherwise damaging the surface being sprayed. Calibrate the distributer in accordance with ASTM D2995. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled total liquid rates from 0.03 to 1.0 gallons per square yard, with a pressure range of 25 to 75 psi and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. The distributor will be capable of circulating and agitating the bituminous material during the heating process.

1.6.2 Single-Pass, Surface-Treatment Machines

Use only machines capable of spraying bituminous material and spreading aggregate in one pass. Use only bituminous spraying equipment conforming to the requirements given above for a bituminous distributor. Use only machines capable of spreading aggregates at controlled amounts per square yard as specified. In addition, only use single-pass, surface-treatment machines capable of placing a surface treatment adjacent to an existing surface treatment, forming a joint of the same thickness and uniformity as other portions of the surface treatment. Ridges or blank spaces will not be permitted. Form joints in the second application at least 1 foot from those formed in the first application.

1.6.3 Heating Equipment for Storage Tanks

Use equipment consisting of coils and equipment for producing steam or hot oil and designed to prevent the introduction of steam or hot oil into the material. Affix an armored thermometer with a range of 100 to 400 degrees F to the tank so the temperature of the bituminous material may be determined at all times.

1.6.4 Power Rollers

Use only steel-wheeled or pneumatic-tired type power rollers conforming to the following requirements:

a. Use only steel-wheeled rollers having at least one steel drum and weigh a minimum of 5 tons. Equip steel wheels of the rollers with adjustable scrapers.

b. Use only self-propelled pneumatic-tired rollers having wheels mounted on two axles in such manner that the rear tires will not follow in the tracks of the forward group. Maintain uniform tire inflation to not less than 60 psi nor more than 80 psi pressure. Equip pneumatic-tired rollers with boxes or platforms for ballast loading. Load rollers so that the tire print width of each wheel is not less than the clear distance between tire prints.

1.6.5 Mechanical Spreaders

Use only adjustable spreaders capable of spreading aggregate at controlled amounts per square yard, as specified.

1.6.6 Brooms and Blowers

Use only power type brooms and blowers capable of cleaning surfaces to be treated.

1.6.7 Scales

Use standard truck scales of the beam type equipped with a weight-recording device. Use scales with sufficient size and capacity to accommodate the trucks used in hauling aggregates. The scales must be tested and approved by an inspector of the State Inspection Bureau charged with scale inspection within the state in which the project is located. If an official of the inspection bureau is not available, test the scales in accordance with state specifications and in the presence of the Contracting Officer. Keep the necessary number of standard weights on hand, at all times, for testing the scales.

1.6.8 Weighhouse

Provide a weatherproof weighhouse constructed in a manner to afford adequate protection for the indicating and recording devices of the scales.

1.7 ENVIRONMENTAL REQUIREMENTS

Apply bituminous surface treatment only when the existing surface or base course is dry or contains moisture not in excess of the amount that will permit uniform distribution of the asphalt material and provide the desired adhesion between the asphalt material and the materials underneath and above. Do not apply bituminous surface treatment when either the atmospheric temperature, in the shade, is below 60 degrees F or the pavement surface to be treated is below 70 degrees F unless otherwise directed.

PART 2 PRODUCTS

Use mineral aggregate and bituminous material of the following types, gradations, grades, and consistencies that meet the requirements of stripping, wear, deleterious materials and soundness tests as specified in paragraph SAMPLING AND TESTING.

2.1 MINERAL AGGREGATE

Provide aggregate consisting of crushed stone, crushed gravel, or crushed slag of such nature that thorough coating of bituminous material, used in the work, will not strip off upon contact with water when testing using ASTM D3625/D3625M. Maintain aggregate moisture content so that the aggregate will be readily coated with the bituminous material. Drying may be required, as directed. Use aggregate conforming to the gradation shown below. Determine gradation of the aggregates by ASTM C136/C136M.

AGGREGATE GRADATION SINGLE BITUMINOUS SURFACE TREATMENT (PERCENT BY WEIGHT PASSING)			
Sieve Designation	No. 1	No. 2	No. 3
1 inch	100	--	--
3/4 inch	90-100	100	--
1/2 inch	20-55	90-100	100
3/8 inch	0-15	40-70	85-100
No. 4	0-5	0-15	10-30
No. 8	--	0-5	0-10
No. 16	--	--	0-5

AGGREGATE GRADATION DOUBLE BITUMINOUS SURFACE TREATMENT (PERCENT BY WEIGHT PASSING)				
Sieve Designation	No. 1	No. 2	No. 3	No. 4
1 inch	100	--	--	--
3/4 inch	90-100	--	100	--
1/2 inch	20-55	100	90-100	--
3/8 inch	0-15	85-100	40-70	100
No. 4	0-5	10-30	0-15	85-100
No. 8	--	0-10	0-5	10-40

AGGREGATE GRADATION DOUBLE BITUMINOUS SURFACE TREATMENT (PERCENT BY WEIGHT PASSING)				
Sieve Designation	No. 1	No. 2	No. 3	No. 4
No. 16	--	0-5	--	0-10
No. 50	--	--	--	0-5

2.1.1 Crushed Stone

Provide crushed stone consisting of clean, sound, durable particles, free of soft or disintegrated pieces, dust, or foreign matter.

2.1.2 Crushed Gravel

Provide crushed gravel consisting of clean, sound, durable particles, free of soft or disintegrated pieces or foreign matter. At least 90 percent by weight of the particles must have at least two fractured faces.

2.1.3 Crushed Slag

Provide crushed slag which is an air-cooled blast-furnace product having a dry weight of not less than 70 pcf, and consists of angular particles uniform in density and quality and free of dust and foreign matter. Determine the weight of a cubic foot of slag aggregate by ASTM C29/C29M.

2.1.4 Aggregate Quantities

Spread the bituminous material and aggregate within the quantity limits shown below. The individual quantities of bituminous material and aggregate may be varied to meet specific field conditions at all times during progress of the work, as directed, without adjustments to contract unit prices. Aggregate weights shown are for aggregates having a specific gravity of 2.65. Adjust the number of pounds required if the specific gravity of the aggregate used is other than 2.65 in order to ensure a constant volume of aggregate per square yard of treatment.

QUANTITIES (PER SQUARE YARD) FOR SINGLE SURFACE TREATMENT		
Gradation No.	Bituminous Material (Gallons)	Aggregate (Pounds)
1	0.30-0.45	35-50
2	0.15-0.30	20-35
3	0.10-0.20	15-25

QUANTITIES (PER SQUARE YARD) FOR DOUBLE SURFACE TREATMENT				
Gradation No.	Bituminous Material (Gallons) First Application	Aggregate (Pounds) First Spreading	Bituminous Material (Gallons) Second Application	Aggregate (Pounds) Second Spreading
1	0.20-0.30	28-34	--	--
2	--	--	0.20-0.30	20-25
3	0.15-0.20	20-25	--	--
4	--	--	0.15-0.20	10-15

2.2 BITUMINOUS MATERIALS

2.2.1 Cutback Asphalt

Use rapid curing cutback asphalt conforming to ASTM D2028/D2028M Submit temperature-viscosity relationship of cutback asphalt.

2.2.2 Emulsified Asphalt

Use rapid-setting emulsified asphalt conforming to ASTM D977, Grade RS-1 or RS-2 or ASTM D2397/D2397M, Grade CRS-1 or CRS-2.

2.2.3 Asphalt Cement

Use asphalt cement conforming to ASTM D946/D946M, Penetration Grade [120-150] [200-300] or ASTM D6373, Performance Graded Asphalt Binder [PG 64-22] [PG 58-28] [PG 52-34]. Submit temperature-viscosity relationship of asphalt cement.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Immediately before applying the first course of bituminous material, clean the surface of loose material with power brooms or power blowers. Take care to remove all dirt, clay, and other loose or foreign matter. Flush the surface with water, when necessary to achieve a clean surface, only when directed by the Contracting Officer; allow the surface to dry after flushing.

3.2 APPLICATION OF FIRST COURSE

3.2.1 Bituminous Material

Apply bituminous material by means of a bituminous distributor at the temperature specified in paragraph APPLICATION TEMPERATURE OF MATERIALS, below or as directed; and within the limits specified in paragraph QUANTITY LIMITS in PART 1. Apply bituminous material in such a manner that uniform distribution is obtained over all surfaces treated. Unless the distributor is equipped to obtain a satisfactory result at the junction of previous and subsequent applications, spread building paper on the surface for a sufficient distance back from the ends of each application so that flow through the sprays may be started and stopped on the paper in order that all sprays will operate at full force on the surface treated. Immediately after application, remove and destroy the building paper. Properly treat areas inaccessible to the distributor with bituminous material using the hose attachment. Protect adjacent buildings, structures, and trees to prevent their being spattered or marred.

3.2.2 Spreading of Aggregate

Immediately following application of bituminous material, spread aggregate uniformly over the surface within the limits of the quantities specified in paragraph QUANTITY LIMITS in PART 1 using mechanical spreaders. Spread aggregate evenly by hand on all areas missed by the mechanical spreader. Operate equipment spreading aggregate so that the bituminous material will be covered ahead of the truck wheels. When hand spreading is employed on inaccessible areas, spread aggregate directly from trucks. Spread additional aggregate by hand over areas having insufficient cover. Continue spreading during these operations when necessary.

3.2.3 Brooming and Rolling

Roll the surface with a pneumatic-tired and a steel-wheeled roller after sufficient aggregate is spread. Continue rolling until no more aggregate can be worked into the treated surface. The use of the steel-wheeled roller will be discontinued, or a lighter weight steel wheel roller substituted, as directed, if the roller being used causes excessive crushing and shattering of the aggregate. If the aggregate is not distributed properly, broom the surface as soon as possible after the first coverage by the roller, but not until the surface has set sufficiently to prevent excessive marking. Continue brooming, rolling, and supplemental spreading of aggregate until the surface is cured and rolled sufficiently to key and set the aggregate. In places not accessible to rollers, compact the aggregate with pneumatic tampers. Remove aggregate that has become contaminated with foreign matter and replace with clean aggregate and reroll as directed. Maintain and protect the treated areas by use of barricades until properly cured.

3.3 APPLICATION OF SECOND COURSE

3.3.1 Bituminous Treatment

Apply the bituminous material for the second course within 48 hours after construction of the first course, weather permitting. Remove excess aggregate prior to the second application of bituminous material. If the treated surface is excessively moistened by rain, allow the surface to dry for such time as deemed necessary. Perform the second application of bituminous material in the manner specified in paragraph APPLICATION OF FIRST COURSE, including temperature and QUANTITY LIMITS.

3.3.2 Aggregate

Immediately following the second application of bitumen, spread aggregate conforming to the gradation and limits specified in paragraph QUANTITY LIMITS uniformly over the bituminous material and process in the manner specified for the first course.

3.3.3 Brooming and Rolling Second Course

Roll and broom the surface in the manner specified for the first course until a thoroughly bonded, smooth, even-textured surface is produced. Sweep off the surface surplus aggregate and remove it prior to final acceptance.

3.4 APPLICATION TEMPERATURE OF MATERIALS

3.4.1 Cutback Asphalt

Apply cutback asphalt in the range of 100 to 200 degrees F.

3.4.2 Emulsified Asphalt

Apply asphalt emulsions in the range of 90 to 160 degrees F.

3.4.3 Asphalt Cement

Apply asphalt cement in the range of 325 to 375 degrees F.

3.5 TRIAL APPLICATION

Preliminary to providing a complete surface treatment, treat three lengths of at least 100 feet each for the full width of the distributor bar. Use the appropriate typical application rates specified herein for one surface treatment trial. Make other surface treatment trials using various amounts of materials as may be deemed necessary.

3.6 PROTECTION

Keep all traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces. Protect the treated areas from traffic for at least 24 hours after final application of bituminous material and aggregate, or for such time as necessary to prevent picking up. Immediately prior to opening to traffic, roll the entire treated area with a self-propelled pneumatic-tired roller.

-- End of Section --

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SECTION 32 01 17.61

SEALING CRACKS IN ASPHALT PAVING
05/22

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

Determine the quantity of each sealing item to be paid for by actual measurement of the number of linear feet of approved in-place material.

1.1.2 Payment

Payment will be made at the contract unit bid prices per linear foot for the sealing items scheduled. Include in the unit bid prices the cost of all labor, materials, and the use of all equipment and tools required to complete the work.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C509	(2006; R 2021) Standard Specifiaction for Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM D789	(2015) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)
ASTM D6690	(2015) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Equipment, Tools, And Machines; G

SD-03 Product Data

Manufacturer's Instructions; G

Crack Sealant; G

Backer Rod; G

SD-06 Test Reports

Laboratory Tests; G

1.4 QUALITY ASSURANCE

Test the crack sealant and backup materials for conformance with the referenced applicable material specification. Perform testing of the materials in an approved, independent laboratory; submit certified copies of the test reports for approval 14 days prior to the use of the materials at the job site. Submit reports of all tests. Samples will be retained by the Government for possible future testing, if the materials appear defective during or after application. Furnish samples of materials, in sufficient quantity to be tested by the Government upon request. Conformance with the test requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based on the performance of materials that have been satisfactorily installed.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects; unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site to protect materials from weather and maintain them at the temperatures recommended by the manufacturer.

1.6 ENVIRONMENTAL REQUIREMENTS

Apply the materials only when the ambient air temperature and the pavement temperature within the joint wall are at least 40 degrees F and rising. Do not apply sealant if moisture is observed in the crack.

1.7 ACCEPTANCE

1.7.1 Crack Sealant

Inspect the crack sealant for proper cure and rate of set, tack free surface, bonding to the bituminous pavement, cohesive separation within the sealant, reversion to liquid, and entrapped air and voids. Remove sealants exhibiting any of these deficiencies, at any time prior to the final acceptance of the project, and replace as specified herein.

1.7.2 Test Section

Prior to the cleaning and sealing of the cracks for the entire project, construct a test section at least 200 feet long using the specified materials and approved equipment to demonstrate the proposed preparation and sealing of all cracks of the project. Following the completion of the test section and before any other crack is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. If materials or installation do not meet requirements, remove the materials and reclean and reseal the cracks. When the test section meets the requirements, it can be incorporated into the permanent work and accepted for payment. Seal all other cracks in the manner approved and successfully completed for sealing the test section.

PART 2 PRODUCTS

2.1 SEALANTS

Provide crack sealant conforming to ASTM D6690, Type as suitable over the Performance Grade temperature range for sealing cracks.

2.2 BACKER ROD MATERIALS

Provide backer rod material that is a compressible, nonshrinking, nonstaining, nonabsorptive material and nonreactive with the crack sealant. Use backer rod with a melting point temperature of at least 5 degrees F greater than the maximum pouring temperature of the sealant being used, when tested in accordance with ASTM D789. Use material that has a water absorption of not more than 5 percent by weight when tested in accordance with ASTM C509. Use backer rod material that is 25 percent (plus or minus 5 percent) larger in diameter than the nominal width of the crack.

2.3 EQUIPMENT, TOOLS, AND MACHINES

Equipment, tools, and machines used in performance of the work are subject to approval by the Government. Maintain in a satisfactory working condition at all times.

2.3.1 Routing Equipment

Provide routing equipment which is a self-powered machine operating a power driven tool or bit specifically designed for routing bituminous pavements. Use a bit rotating about a vertical axis at sufficient speed to cut a smooth vertical-walled reservoir in the pavement surface and maintain accurate cutting without damaging the sides or top edges of the reservoir. Provide a router capable of following the trace of the crack without deviation. The use of rotary impact routing devices will not be permitted for cleaning cracks.

2.3.2 Air Compressor

Provide air compressor capable of furnishing not less than 150 cubic feet per minute and maintaining a line pressure of not less than 90 psi at the nozzle. Equip the compressor with filters that maintain the compressed air free of oil and water.

2.3.3 Heat Lance

Provide a heat lance operating with propane and compressed air in combination to provide flame-free high temperature hot air up to 3000 degrees F with exit velocities of 3000 feet per second.

2.3.4 Hand Tools

Hand tools can be used, when approved, for removing defective sealant from cracks and repairing or cleaning the crack faces.

2.3.5 Crack Sealing Equipment

Provide unit applicators, used for heating and installing the hot-poured crack sealant materials, that are mobile and equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the prepared crack to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. Allow the sealant to circulate through the delivery hose and return to the inner kettle when not in use.

PART 3 EXECUTION

3.1 PREPARATION OF CRACKS

Immediately before the installation of the crack sealant, thoroughly dry and clean the cracks to remove oxidized pavement, loose aggregate and foreign debris. Prepare cracks as follows:

3.1.1 Cracks

3.1.1.1 Hairline Cracks

Cracks that are less than 1/4 inch wide do not need to be sealed.

3.1.1.2 Small and Medium Cracks

Rout cracks that are 1/4 to 1-1/2 inches wide to a nominal width 1/8 inch greater than the existing nominal width and to a depth not greater than 3/4 inch. Clean and dry using compressed air or a heat lance.

3.1.1.3 Large Cracks

Do not seal cracks that are greater than 1-1/2 inches wide. .

3.1.2 Existing Sealant Removal

Cut loose the in-place sealant from both crack faces and to a depth shown on the drawings. Remove sealant to a depth sufficient to accommodate any backer rod material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all old loose sealant remaining in the crack opening by blowing with compressed air.

3.1.3 Routing

Perform routing of the cracks using a rotary router with a bit that is at least 1/8 inch wider than the nominal width of the crack to remove all residual old sealant (resealing), oxidized pavement and any loose aggregate in the crack wall.

3.1.4 Cleaning

Use compressed air or a heat lance to clean the crack faces and the pavement surfaces extending a minimum of 1/2 inch from the crack edges. Use a multiple-pass technique until the surfaces are free of dust, dirt, old sealant residue, moisture, or foreign debris that might prevent the sealant material from bonding to the asphalt pavement. Use a heat lance when pavement temperature is less than 40 degrees F. Do not burn the pavement, a slight darkening is acceptable. Immediately follow the heat lance with the sealing operation.

3.1.5 Backer Rod Material

When required, use backer rod material in all cracks that otherwise would require excessive sealant or exceed the sealant reservoir depth. Insert the backer rod material into the lower portion of the crack as shown on the drawings. Place the backer rod so that the top of the backer rod is a maximum of 3/4 inch and a minimum width to depth ratio of 1 below the top of the pavement. Ensure that the backer rod material is placed evenly at the specified depth and is not stretched or twisted during installation.

3.1.6 Rate of Progress of Crack Preparation

Limit the stages of crack preparation, which include routing, air pressure or heat lance cleaning and placing of the backer rod material, to only that linear footage that can be sealed during the same day.

3.2 PREPARATION OF SEALANT

Do not heat hot-poured sealants in excess of the safe heating temperature recommended by the manufacturer, as shown on the sealant containers. Withdraw and waste sealant that has been overheated or subjected to application temperatures for over 4 hours or that has remained in the applicator at the end of the day's operation.

3.3 INSTALLATION OF SEALANT

Submit manufacturer's instructions 14 days prior to the use of the material on the project. Installation of the material will not be allowed until the instructions are received.

3.3.1 Time of Application

Seal cracks immediately following final cleaning and drying of the crack walls and following the placement of the backer rod material (when required). Place sealant only when cracks are dry. Reclean cracks that cannot be sealed under the conditions specified, or when rain interrupts sealing operations, and allow to dry or dry by mechanical means prior to installing the sealant.

3.3.2 Sealing the Crack

Immediately preceding, but not more than 50 feet ahead of the crack sealing operations, perform a final cleaning and drying with compressed air or heat lance. This distance can be increased if demonstrated and approved during the test section. Fill the cracks from the bottom of reservoir formed by the routing or the top of the backer rod up to 1/8 inch below the pavement surface. Remove excess or spilled sealant from the pavement by approved methods and discard it. Install the sealant in a manner which prevents the formation of voids and entrapped air. Make multiple passes with the applicator wand as necessary to obtain the specified sealant depth from the pavement surface. Do not use gravity methods or pouring pots to install the sealant material. Do not permit traffic over newly sealed pavement until authorized. Check sealed cracks frequently to ensure that the newly installed sealant is cured to a tack-free condition within 3 hours.

3.4 CLEANUP

Upon completion of the project, remove unused materials from the site and leave the pavement in a clean condition.

3.5 QUALITY CONTROL PROVISIONS

3.5.1 Crack Cleaning

Provide quality control provisions during the crack cleaning process to correct improper equipment and cleaning techniques that damage the bituminous pavement in any manner.

3.5.2 Crack Seal Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements and proper installation. If evidence of bubbling, improper installation, and failing to cure or set are identified, suspend operations until causes of the deficiencies are determined and corrected.

-- End of Section --

SECTION 32 01 18.71

GROOVING OF AIRFIELD PAVING
05/17

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment; G

Procedures; G

1.2 EQUIPMENT, TOOLS, AND MACHINES

1.2.1 Grooving Machine

Provide a grooving machine that is power driven, self-propelled, specifically designed and manufactured for pavement grooving, and has a self contained and integrated continuous slurry vacuum system as the primary method for removing waste slurry. Equip the grooving machine with diamond-saw cutting blades capable of making at least 18 inches in width of multiple parallel grooves in one pass of the machine. Use cutting blades capable of making the required width and depth of grooves in one pass of the machine. A mixture of new and worn blades or blades of unequal wear or diameter are not permitted in the cutting head. Match the blade type and configuration with the hardness of the existing airfield pavement. Use wheels on the grooving machine that will not scar or spall the pavement. Provide the machine with devices to control depth of groove and alignment within the specified tolerances.

Submit a list of proposed equipment to be used in performance of this work, including descriptive data and safety precautions required for the equipment operation.

1.3 ENVIRONMENTAL REQUIREMENTS

Grooving operations will not be permitted when freezing conditions prevent the immediate removal of debris and/or drainage of water from the grooved area. The Contractor is responsible for discharge and disposal of waste slurry. Waste slurry discharge pits may be constructed along side the pavement to be grooved, as directed by the Contracting Officer. Provide and maintain temporary storm drainage, pollution control, and erosion control features at each discharge pit in accordance with base environmental regulations. Excavate and dispose of hardened waste slurry off base after it has been dewatered. Regrade and restore to original condition all disposal pit areas.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Existing Pavements

Do not groove bumps, depressed areas, bad or faulted joints, and badly cracked and/or spalled areas in the pavement until such areas are adequately repaired or replaced.

3.1.2 New Pavements

Allow new asphalt concrete pavements to cure for a minimum of 30 days before grooving, to allow the material to become stable enough to prevent closing of the grooves under normal use. Permit new portland cement concrete pavements to cure for a minimum of 28 days before grooving.

3.2 WATER SUPPLY

The Government will provide water for the grooving operation.

3.3 GROOVING

3.3.1 Procedures

Submit grooving sequence and method of placing guide lines to control grooving operation. Cut grooves in the asphalt or portland cement areas as indicated on the drawings. Begin the grooving at one side of the usable runway or taxiway and continue for the full width of the area. Take all reasonable precautions to prevent damage to or roughening of the pavement between grooves. Spalling along or tearing or raveling of the groove edges will not be allowed. Cut grooves that are 1/4 inch, plus 1/16 inch, minus 0 inch wide by 1/4 inch, plus or minus 1/16 inch deep and 1-1/2 inches, plus 0 inches, minus 1/8 inch center to center spacing. Cut grooves that are [_____] feet plus or minus 3 inches long and normal to the longitudinal axis of the centerline of the runway or taxiway. The transverse alignment of the grooves must not vary more than 3 inches plus or minus on a 75 foot length of grooving. Do not groove within 6 inches plus or minus 3 inches of the runway centerline. Do not groove within 6 inches of transverse joints or working cracks, through compression seals, in-runway lighting fixtures or similar items, the first 10 feet either side of an arresting barrier cable or the first and last 10 feet of the runway.

3.3.2 Clean-Up

Continously clean-up debris from the grooving operation. Flush debris produced by the equipment to the edge of the grooved area or pick it up before it dries and hardens. Flush the remaining dust coating to the edge of the area if the resultant accumulation is not detrimental to the vegetation or storm drainage system. Accomplish all flushing operations in a manner to prevent erosion on the shoulders, damage to vegetation, or plugging of storm drainage.

3.3.3 Repair of Damaged Pavement

Repair at the Contractor's expense, any damage, which in the opinion of the

Contracting Officer will be detrimental to aircraft operations and/or pavement performance, occurring to the pavement as a result of the grooving operations.

3.4 CONTRACTOR QUALITY CONTROL

3.4.1 Test Section

Groove a test section [_____] feet long by two lanes wide in an area of the pavement outside of the trafficked area, as approved by the Contracting Officer. Demonstrate the setup and alignment process, the grooving operation, and the waste slurry disposal.

3.4.2 Inspections

At the beginning of each work shift, furnish a full complement of grooving blades with each saw that are capable of cutting grooves of the specified width, depth, and spacing. If during the work, a single grooving blade on a machine becomes incapable of cutting a groove, continue work for the remainder of the work shift. The Contractor is not required to cut the groove omitted because of the failed blade. Should two or more grooving blades on a machine become incapable of cutting grooves, cease operating the machine until it is repaired.

-- End of Section --

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SECTION 32 01 19.61

SEALING OF JOINTS IN RIGID PAVEMENT
11/19

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

Determine the quantity of each sealing item to be paid for by actual measurement of the number of linear ft of in-place material that has been approved.

1.1.2 Payment

Make payment at the Contract unit bid prices per linear foot for the sealing items scheduled. Include the cost of labor, materials, and the use of equipment and tools required to complete the work in the unit bid price.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C603 (2014; R 2019) Standard Test Method for Extrusion Rate and Application Life of Elastomeric Sealants

ASTM C639 (2015; R 2020)Standard Test Method for Rheological (Flow) Properties of Elastomeric Sealants

ASTM C661 (2015; R 2022) Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer

ASTM C679 (2015; R 2022) Standard Test Method for Tack-Free Time of Elastomeric Sealants

ASTM C719 (2014; R 2019) Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)

ASTM C792 (2015; R 2020) Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants

ASTM C793 (2005; R 2017) Standard Test Method for Effects of Laboratory Accelerated Weathering on Elastomeric Joint Sealants

ASTM C920 (2018) Standard Specification for

	Elastomeric Joint Sealants
ASTM C1016	(2014) Standard Test Method for Determination of Water Absorption of Sealant Backing (Joint Filler) Material
ASTM C1193	(2013) Standard Guide for Use of Joint Sealants
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D789	(2015) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)
ASTM D903	(1998; R 2017) Standard Test Method for Peel or Stripping Strength of Adhesive Bonds
ASTM D5249	(2010; R 2016) Standard Specification for Backer Material for Use with Cold-and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
ASTM D5329	(2016) Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphalt Pavements and Portland Cement Concrete Pavements
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D6690	(2015) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 525	(1989) Corps of Engineers Test Method for Evaluation of Hot-Applied Joint Sealants for Bubbling Due to Heating

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Sealants

Submit catalog cuts, specifications, Safety Data Sheets and other information documenting conformance to Contract requirements.

Manufacturer's Recommendations

SD-04 Samples

Sealants

Provide for testing a 5-gal sample of each sealant with associated primer to the Contracting Officer a minimum of 60 days prior to its use on the job. Provide factory-sealed containers with a factory applied label showing the following information:

Name of sealant

Identification of component, or primer

Specification number and type

Manufacturer's name

Manufacturer's lot and batch number

Date of Manufacture (month and year)

Shelf life retest date (month and year)

List of hazardous components

Quantity of material in container (volume)

Storage instructions

Instructions for use

Blocking Media/Backup Materials

Backer Rod

Bond Breaking Tapes

SD-06 Test Reports

Sealants

SD-07 Certificates

Equipment List

SD-08 Manufacturer's Instructions

Sealants

Provide instructions that include, but not limited to: storage requirements, ambient temperature and humidity ranges, and moisture condition of joints for successful installation; requirements for preparation of joints; safe heating temperature; mixing instructions; installation equipment and procedures; application and disposal requirements; compatibility of sealant with filler material; curing requirements; and restrictions to be adhered to in order to reduce hazards to personnel or to the environment. Submit instructions at least 30 days prior to use.

1.4 QUALITY ASSURANCE

1.4.1 Test Requirements

Test the sealant and backup or separating material for conformance with the referenced material specification. The materials will be tested by the Government. Do not use material at the project prior to receipt of written notice that the materials meet the laboratory requirements. The cost of the first test of samples will be borne by the Government. If the samples fail to meet specification requirements, replace the materials represented by the sample and test the new materials at the Contractor's expense. Perform testing of the materials in an approved independent laboratory and submit certified copies of the test reports for approval 30 days prior to the use of the materials at the job site. Submit samples to be retained by the Government for possible future testing if the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified does not constitute final acceptance of the materials. Base final acceptance on the performance of the in-place materials. Submit samples of the materials (sealant, primer if required, and backup material), in sufficient quantity for testing and approval 14 days prior to the beginning of work. Do not use material until it has been approved.

1.4.2 Trial Joint Sealant Installation

Prior to cleaning and sealing the joints for the entire project, prepare a test section at least 200 ft long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of the types of joints in the project. Following the completion of the test section and before any other joint is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. Inspect joint seal test section. Provide written notice of deficiencies and required corrections or adjustments in the joint seal installation procedures. Correct deficiencies and obtain approval of test section prior to installing joint seals. If it is determined that the materials or installation do not meet the requirements, remove the materials, and reclean and reseal the joints at no cost to the Government. Permit the test section meeting the requirements to be incorporated into the permanent work and paid for at the Contract unit price per linear foot for sealing items scheduled. Prepare and seal other joints in the manner approved for sealing the test section. Notify the Contracting Officer upon completion of the test section.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for visible damage, and unload and store with a minimum of handling. Deliver joint materials in original sealed containers and protect from freezing or overheating. Provide jobsite storage facilities capable of maintaining temperature ranges within manufacturers recommendations.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not proceed with work when weather conditions detrimentally affect the quality of cleaning joints or applying sealants. Proceed with joint preparation and sealing only when weather conditions are in accordance with manufacturer's instructions. Install joint sealant to dry surfaces and protect sealant and bond breakers from moisture.

1.7 TRAFFIC CONTROL

Do not permit vehicular or heavy equipment traffic on the pavement in the area of the joints being sealed during the protection and curing period of the sealant. Permit traffic on the pavement at the end of the curing period.

PART 2 PRODUCTS

2.1 SEALANTS

Use materials for sealing cracks in accordance with ASTM D6690 and ASTM D5893/D5893M based on the type of area as follows:

Area	Sealing Material
[______]	ASTM D6690, Type II and ASTM D5329/ COE CRD-C 525
[______]	ASTM D6690, Type III and ASTM D5329/ COE CRD-C 525
[______]	ASTM D5893/D5893M

Use self leveling, non-acid curing silicone sealant meeting the following requirements in accordance with ASTM C920 or ASTM C1193:

TEST	TEST METHOD	REQUIREMENTS
Weight Loss	ASTM C792 Modified (see Note 1 below)	10 percent max.
Flow	ASTM C639 (Type I)	Smooth and level
Extrusion Rate	ASTM C603	30 sec. max.
Tack Free Time	ASTM C679	5 hours max.
Hardness (Shore 00) (see Note 2 below)	ASTM C661	30 - 80
Tensile Stress at 150 Percent Elongation (see Note 2 below)	ASTM D412 (Die C)	30 psi max.
Percent Elongation (see Note 2 below)	ASTM D412 (Die C)	700 min.
Accelerated Weathering	ASTM C793	Pass 5000 hours
Bond and Movement Capability	ASTM C719	Pass 10 cycles at plus 50 percent movement (no adhesion or cohesion failure)

TEST	TEST METHOD	REQUIREMENTS
Peel	ASTM D903	Minimum 20 psi of width with at least 75 percent cohesive failure
NOTES: 1. Percent weight loss of wet (uncured) sample after placing in forced-draft oven maintained at 158 degrees plus 1 degree F for two hours. 2. Specimen cured 21 days at 73 degrees plus 1 degree F and 50 percent plus 5 percent humidity.		

ACCELERATED WEATHERING FACTORY TEST REPORT. For the Accelerated Weathering test, in lieu of testing of actual sealant to be used on the project, it is permitted to submit a report of a factory test, performed within two years of Contract award.

2.2 PRIMERS

Use primers in accordance with the recommendation of the manufacturer.

2.3 BOND BREAKERS

2.3.1 Blocking Media/Backup Materials

Provide backup (joint filler) material that is a compressible, nonshrinking, nonstaining, nonabsorbing, nonreactive material with the sealant. Use backup material compliant with ASTM D5249. Use material with a melting point at least 5 degrees F greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. Use material with a water absorption of not more than 5 percent of the sample weight when tested in accordance with ASTM C1016. Use backup (joint filler) material that is 25 plus or minus 5 percent larger in diameter than the nominal width of the crack. Use blocking media consistent with the sealant manufacturer's installation instructions.

2.3.2 Bond Breaking Tapes

Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. Use material with a melting point at least 5 degrees F greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. Use bond breaker tape approximately 1/8 in wider than the nominal width of the joint and that does not bond to the sealant. Use bond breaking tape consistent with the sealant manufacturer's installation instructions.

PART 3 EXECUTION

3.1 EXECUTING EQUIPMENT

Submit equipment list and description of the equipment to be used and a statement from the supplier of the sealant that the proposed equipment is acceptable for installing the specified sealant. Use equipment for heating, mixing, and installing seals in accordance with the instructions provided by the sealant manufacturer. Provide equipment, tools, and accessories necessary to clean existing joints and install liquid joint sealants. Maintain machines, tools, and other equipment in proper working condition. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, 14 days prior to use on the project.

3.1.1 Joint Cleaning Equipment

3.1.1.1 Tractor-Mounted Routing and Plowing Tool

Use routing tools for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that do not damage the sides of the joints. Use tools designed to be adjusted to remove the old material to varying depths and widths as required. Use equipment capable of maintaining accurate cutting depth and width control. Use a joint plow equipped with a spring or hydraulic mechanism to release pressure on the tool prior to spalling the concrete. Do not permit the use of V-shaped tools or rotary impact routing devices. Permit the use of hand-operated spindle routing devices to clean and enlarge random cracks.

3.1.1.2 Concrete Saw

Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified, for refacing joints, cleaning sawed joints where sandblasting does not provide a clean joint, widening, or deepening existing joints as specified without damaging the sides, bottom, or top edge of joints. Permit single or gang type blades with one or more blades mounted in tandem for fast cutting. Select saw adequately powered and sized to cut specified opening with not more than two passes of the saw through the joint.

3.1.1.3 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. Do not permit the maximum nozzle opening to exceed 1/4 in. Use a portable air compressor capable of providing not less than 150 cfm and maintaining a line pressure of not less than 90 psi at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. Use a compressor equipped with traps that maintain the compressed air free of oil and water. Use a nozzle with an adjustable guide that holds the nozzle aligned with the joint approximately 1 in above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle to secure satisfactory results.

3.1.1.4 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. Use a nozzle with an adjustable guide that holds the nozzle aligned with the joint approximately 1 in above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle to obtain satisfactory results. Use a pressure gauge mounted at the pump that shows the pressure in psi at which the equipment is operating.

3.1.1.5 Air Compressor

Use a portable air compressor capable of operating the sandblasting equipment and capable of blowing out sand, water, dust adhering to sidewalls of concrete, and other objectionable materials from the joints. Use a compressor that provides air at a pressure not less than 90 psi and a minimum rate of 150 cubic ft of air per minute at the nozzles and free of oil.

3.1.1.6 Vacuum Sweeper

Use a self-propelled, vacuum pickup sweeper capable of completely removing loose sand, water, joint material, and debris from pavement surface.

3.1.1.7 Hand Tools

Permit the use of hand tools, such as brooms and chisels, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

3.1.2 Sealing Equipment

Use joint sealing equipment of a type required by the sealant manufacturer's installation instructions. Use equipment capable of installing sealant to the depths, widths and tolerances indicated. Do not proceed with joint sealing when malfunctions are noted until the malfunctions are corrected.

3.1.2.1 Hot-Poured Sealing Equipment

Use mobile unit applicators equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer for heating and installing ASTM D6690 joint sealant materials; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording thermometer for indicating the temperature of the sealant. Use an applicator unit designed so that the sealant circulates through the delivery hose and returns to the inner kettle when not in use.

3.1.2.2 Cold-Applied, Single-Component Sealing Equipment

Use equipment for installing ASTM D5893/D5893M single component joint sealants that consists of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. Use a nozzle with dimensions that allows the tip of the nozzle to extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Use lined hoses and seals to prevent moisture penetration and withstand pumping pressures. Use equipment free of contamination from previously used or other type sealant. Permit use of small hand-held air-powered equipment (i.e., caulking guns) for small applications.

3.2 SAFETY

Do not place sealant within 25 ft of LOX equipment, LOX storage, or LOX piping. Clean joints in this area and leave them unsealed.

In accordance with the provisions of the Contract respecting "Accident

Prevention," take appropriate measures to control worker exposure to toxic substances during the work. Provide personnel protective equipment as required. Make Material Safety Data Sheets (Department of Labor Form OSHA-20 or comparable form) available on the site.

Perform sandblasting operations in accordance to paragraph entitled "Abrasive Blasting" of Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS.

3.3 PREPARATION OF JOINTS

Unless otherwise indicated, remove existing material, saw, clean and reseal joints. Do not proceed with final cleaning operations by more than one working day in advance of sealant. Clean joints by removing existing joint sealing compound, bond-breakers, dirt, laitance, curing compound, filler, and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed and other foreign material with the equipment. Do not permit cleaning procedures that damage joints or previously repaired patches by chipping or spalling. Remove existing sealant to the required depth. Precise shape and size of existing joints vary, and conditions of joint walls and edges vary and include but are not limited to rounding, square edges, sloping, chips, voids, depressions, and projections.

3.3.1 Existing Sealant Removal

Cut loose the in-place sealant from both joint faces and to the required depth, using the tractor-mounted routing equipment, concrete saw or waterblaster as specified in paragraph EQUIPMENT. Provide a depth sufficient to accommodate blocking media and bond breakers that are required to maintain the depth of new sealant to be installed. For expansion joints, remove existing sealant to a depth of not less than the indicated depth. When existing preformed expansion-joint material is more than 1 in below the surface of the pavement, remove existing sealant to the top of the preformed joint filler. Prior to further cleaning operations, remove loose old sealant remaining in the joint opening by blowing with compressed air. Permit use of hand tools to remove sealant from random cracks. Do not permit chipping, spalling, or other damage to the concrete. Clean pavement surface with vacuum sweeper. Protect previously cleaned joints from being contaminated by subsequent cleaning operations.

3.3.2 Sawing

3.3.2.1 Refacing of Joints

Accomplish refacing/facing of joints using a concrete saw as specified in paragraph EQUIPMENT to remove residual old sealant and a minimum of concrete from the joint face to provide exposure of newly cleaned concrete, and, if required, to enlarge the joint opening to the width and depth shown on the drawings. Provide exposure of newly clean concrete through removal. Remove burrs and irregularities from sides of joint faces. Stiffen the blade with a sufficient number of dummy (used) blades or washers. Clean, immediately following the sawing operation, the joint opening using a water jet to remove saw cuttings and debris and adjacent concrete surface. Protect adjacent previously cleaned joint spaces from receiving water and debris during the cleaning operation.

a. Joint Widening (Except Expansion Joints): Saw joints having grooves less than 3/8 in wide and less than 1 in deep to a minimum width of 3/8 in and to the minimum depth, 1 in.

3.3.2.2 Refacing of Random Cracks

Accomplish sawing of the cracks using a power-driven concrete saw as specified in paragraph EQUIPMENT. Use a saw blade 6 in or less in diameter to enable the saw to follow the trace of the crack. Stiffen the blade with dummy (or used) blades or washers. Immediately following the sawing operation, clean the crack opening using a water jet to remove saw cuttings and debris.

3.3.3 Final Cleaning of Joints

3.3.3.1 Sandblasting

Following removal of existing sealant, and sawing, and immediately before resealing, clean newly exposed concrete joint faces and pavement surface extending to a mimimum of 1/2 in up to 2 in from each joint edge by sandblasting until concrete surfaces in the joint space are free of sealants, dust, dirt, water and other foreign materials that prevent bonding of new sealants to the concrete. Use sand particles of the proper size and quality for the work. Perform sandblasting with specified nozzles, air compressor, and other appurtenant equipment. Position nozzles to clean the joint faces. Make at least two passes; one for each joint face. Make as many passes as required for proper cleaning. Immediately prior to sealing the joint, blow out the joint spaces with compressed air until completely free of sand, water, and dust. Install joint sealants to dry joints. Replace expansion joint filler material damaged in performing the work with new materials of the same type and dimensions as the existing material, or with appropriate blocking media.

3.3.4 Bond Breaker

At the time the joints receive the final cleaning and are dry, install bond breaker material as indicated with a steel wheel or other approved device.

3.3.4.1 Blocking Media (Backer Rod) (Except for Expansion Joints)

When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a blocking media/back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the blocking media/backup material is placed at the specified depth and is not stretched or twisted during installation.

3.3.4.2 Bond Breaking Tape

Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Bond the tape to the bottom of the joint opening to prevent it from floating up into the new sealant.

3.3.5 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, including sandblasting, air pressure cleaning and placing of the back-up material to only that lineal footage that can be sealed during the same day.

3.3.6 Disposal of Debris

Sweep pavement surface to remove excess joint material, dirt, water, sand, and other debris by vacuum sweepers or hand brooms. Remove the debris immediately to a point off station. .

3.4 PREPARATION OF SEALANT

3.4.1 Hot-Poured Sealants

Heat hot-poured sealing materials in accordance with ASTM D6690 and with safe heating temperature ranges recommended by the manufacturer. Withdraw and waste sealant that has been overheated or subjected to heating for over 3 hours or that remain in the applicator at the end of the day's operation. Heat sealant in specified equipment.

3.4.2 Single-Component, Cold-Applied Sealants

Inspect the ASTM D5893/D5893M sealant and containers prior to use. Reject materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Do not reject sealants that exhibit settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools.

3.5 INSTALLATION OF SEALANT

3.5.1 Time of Application

After approval of the test section, seal joints immediately following final cleaning and placing of bond breakers. Commence sealing joints when walls are dust free and dry, and when weather conditions meet sealant manufacturer's instructions. If the above conditions cannot be met, or when rain interrupts sealing operations, reclean and permit the joints to dry prior to installing the sealant.

3.5.2 Sealing Joints

Do not install joint sealant until joints to be sealed have been inspected and approved. Install bond breaker just prior to pouring sealant. Fill the joints with sealant from bottom up until joints are uniformly filled solid from bottom to top using the specified equipment for the type of sealant required. Fill joints to 1/8-1/4 in plus or minus 1/16 in below top of pavement, and without formation of voids or entrapped air. Do not permit gravity methods or pouring pots to be used to install the sealant material. Except as otherwise permitted, tool the sealant immediately after application to provide firm contact with the joint walls and to form the indicated sealant profile below the pavement surface. Remove excess sealant that has been inadvertently spilled on the pavement surface. Do not permit traffic over newly sealed pavement until authorized. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's recommendations. Check sealed joints frequently to ensure that newly installed sealant is cured to a tack-free condition within the specified time. Protect new sealant from rain during curing period.

3.6 INSPECTION/FIELD QUALITY CONTROL

3.6.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Approve cleaned joints prior to installation of the separating or back-up material and joint sealant.

3.6.2 Sampling Sealant

Obtain a one gal sample of each type of sealant on the project from material used for each 10,000 linear ft or less of joints sealed. Store samples according to sealant manufacturer's instructions. Retain samples until final acceptance of the work.

3.6.3 Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Suspend operations if there is evidences of bubbling, improper installation, or failure to cure or set until causes of the deficiencies are determined and corrected.

3.6.4 Joint Sealant

Inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Remove sealants exhibiting these deficiencies prior to the final acceptance of the project from the joint, wasted, and replace at no additional cost to the Government. Obtain approval for each joint seal installation.

3.7 ACCEPTANCE

Reject sealer that fails to cure properly, or fails to bond to joint walls, or reverts to the uncured state, or fails in cohesion, or shows excessive air voids, blisters, surface defects, swelling, or other deficiencies, or is not properly recessed within indicated tolerances. Remove rejected sealer and reclean and reseal joints. Perform removal and reseal work promptly by and at the expense of the Contractor.

3.8 CLEAN-UP

Upon completion of the project, remove unused materials from the site and leave the pavement in a clean condition.

-- End of Section --

SECTION 32 01 29.61

PARTIAL DEPTH PATCHING OF RIGID PAVING
05/17, CHG 1: 08/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO SDDP-1-OL	(2003) Shop Detail Drawing Presentation Guidelines

ASTM INTERNATIONAL (ASTM)

ASTM C31/C31M	(2021a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2021) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2021) Standard Specification for Portland Cement
ASTM C192/C192M	(2019) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete

ASTM C267	(2020) Standard Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C469/C469M	(2014; E 2021) Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C494/C494M	(2019) Standard Specification for Chemical Admixtures for Concrete
ASTM C531	(2018) Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings, and Polymer Concretes
ASTM C579	(2018) Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
ASTM C580	(2018) Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
ASTM C617/C617M	(2015) Standard Practice for Capping Cylindrical Concrete Specimens
ASTM C666/C666M	(2015) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C685/C685M	(2017) Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C881/C881M	(2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C882/C882M	(2020) Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM C884/C884M	(2016) Standard Test Method for Thermal Compatibility between Concrete and Epoxy-Resin Overlay
ASTM C1260	(2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1581/C1581M	(2018) Standard Test Method for

	Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage
ASTM C1602/C1602M	(2018) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D5023	(2015) Standard Test Method for Plastics: Dynamic Mechanical Properties: In Flexure (Three-Point Bending)

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G

SD-03 Product Data

Concrete Mix Design; G

Rigid Proprietary Repair Products; G

Polymeric Proprietary Repair Products; G

Pigmented Liquid Membrane-Forming Compound; G

Aggregate Service Record

SD-04 Samples

Absorbent Curing Material; G

Joint Filler; G

Joint Sealant; G

SD-05 Design Data

Concrete Mix Design; G

SD-06 Test Reports

Laboratory Test Results

Aggregate Gradation

Cement

Concrete Slump

Concrete Air Content

Concrete Compressive Strength (cylinder)

Mixer Calibration and Efficiency

Concrete Uniformity

Bond Strength

Polymeric Proprietary Repair Products; G

SD-07 Certificates

Cement

Aggregate

Admixtures

Absorbent curing material

Pigmented Liquid Membrane-Forming Compound

Joint Filler

Joint Sealant

1.3 QUALITY ASSURANCE

1.3.1 Preconstruction Testing Of Materials

Submit proposed concrete mix design at least 30 days prior to placement. Provide mix design evaluation and certification by a Government approved engineering testing laboratory, and indicate the weight of each ingredient of the mixture, aggregate gradation, slump, air content, water-cement ratio, time of trafficking and 3-day and 28-day compressive strength test results. Include a complete list of materials including admixtures and applicable reference specifications. Place no concrete prior to Government approval of the proposed mix design. No deviation from the approved mix design is permitted without prior Contracting Officer approval.

Within 24 hours of physical completion of laboratory testing, submit copies of laboratory test results for Contracting Officer approval.

1.3.1.1 Cement

Test cement as prescribed in the referenced specification under which it is furnished. Cement may be accepted on the basis of mill tests and the manufacturer's certification of compliance with the specification.

1.3.1.2 Aggregate

Take aggregate gradation samples for laboratory testing in conformance with ASTM D75/D75M.

1.3.1.3 Proprietary Repair Products

At least 30 days before the repair material is used, submit certified copies of test results for the specific lots or batches to be used on the project, not more than 6 months old prior to use in the work.

Manufacturer's certifications may be submitted rather than laboratory test results for proprietary repair products. Include in the submittals details for substrate preparation, mixing, placing, finishing, curing and testing of the material, as applicable. Include a minimum of three case histories documenting the use of the product in a similar freeze-thaw environment and pavement condition. Certify compliance with the appropriate specification referenced herein. Place no materials without prior approval from the Contracting Officer.

1.3.2 Equipment; Approval, Maintenance, and Safety

Provide and use only dependable and well maintained equipment that is appropriate to accomplish the work specified. Allow sufficient time for assembly of equipment requiring such at the work site to permit thorough inspection, calibration of weighing and measuring devices, adjustment of parts, and the making of any repairs that may be required prior to the start of work.

a. Submit volumetric mixer calibration and efficiency test results in accordance with the requirements of ASTM C685/C685M within 6 months of concrete placement. If applicable, submit concrete uniformity test data for the first load of the ready-mixed concrete to be used as the repair material.

b. Provide Safety Data Sheets (SDS) and Personal Protection Equipment (PPE) per 29 CFR 1910.

1.3.3 Shop Detail Drawings

Submit detailed Shop Drawings conforming to AASHTO SDDP-1-OL.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Cement

Deliver cement in bulk or in suitable bags used for packaging cements and store in a manner to prevent absorption of moisture.

1.4.2 Aggregate

Deliver, handle, and store aggregates in a manner to avoid breakage, segregation, inter-mingling or contamination by foreign materials.

1.4.3 Other Materials

Deliver epoxy-resin, chemical admixtures and proprietary repair products to the site in such manner as to avoid damage or loss. Provide storage areas in a windowless and weatherproof, but ventilated, insulated noncombustible building, with provision nearby for conditioning the material to 70 to 85 degrees F for a period of 48 hours prior to use. Keep the ambient temperature in the storage area no higher than 100 degrees F.

1.5 Project/Site Conditions

Do not place concrete or other repair products when weather conditions detrimentally affect the quality of the finished product. Do not place concrete when the air temperature is below 40 degrees F in the shade. When air temperature is likely to exceed 90 degrees F, provide concrete having a temperature not exceeding 90 degrees F when deposited. Keep the surface of placed concrete damp with a water fog until the approved curing medium is applied. Take similar precautions for placing other repair products, as directed by the product vendor's instructions. Do not place concrete or other repair products if the weather forecast indicates that the air temperature is expected to drop below 40 degrees F over the next 7 days.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Coarse Aggregate

2.1.1.1 Composition

Provide coarse aggregate consisting of gravel, crushed gravel, crushed stone, or a combination thereof.

2.1.1.2 Quality

Provide aggregate , as delivered to the mixers, consisting of clean, hard, unweathered, and uncoated particles. Remove dust and other coatings from the coarse aggregate by adequate washing. Meet the requirements of ASTM C33/C33M, Class 5S. Provide aggregates with an abrasion loss, when tested in accordance with ASTM C131/C131M, not exceeding 40 percent; the maximum allowable percentage for clay lumps and friable particles is 1.5 percent. Provide documentation of aggregate conforming to ASTM C136/C136M.

2.1.1.3 Particle Shape

Provide spherical or cubical shaped coarse aggregate particles. Remove all course aggregates with the largest dimension that is equal to or larger than three times the smallest dimension.

2.1.1.4 Gradation

The maximum nominal size of the coarse aggregate is 1/2 inch. Provide well graded coarse aggregate conforming to gradation size 7 in Table 3 of ASTM C33/C33M when tested in accordance with ASTM C136/C136M as delivered to the batching hoppers.

2.1.1.5 Alkali Silica Reactivity

Evaluate and test coarse aggregate, to be used in all concrete, for alkali-silica reactivity in accordance with ASTM C1260. Provide aggregate with a measured expansion not exceeding 0.08 percent at 28 days when tested. Aggregates with test data indicating an expansion greater than 0.08 percent will be rejected.

For proprietary repair products, provide documentation from the supplier that the repair product combination with the aggregates selected will not exhibit alkali-silica reactivity.

2.1.2 Fine Aggregate

2.1.2.1 Composition

Provide fine aggregate consisting of either natural sand, manufactured sand, or a combination of natural and manufactured sand, and composed of clean, hard, durable particles; conforming to Table 2 of ASTM C33/C33M.

2.1.2.2 Particle Shape

Ensure particles of the fine aggregate are generally spherical or cubical in shape.

2.1.2.3 Grading

Provide fine aggregate as delivered to the mixer conforming to the gradation in Table 1 of ASTM C33/C33M when tested in accordance with ASTM C136/C136M.

In addition, provide fine aggregate, as delivered to the mixer, with a fineness modulus of not less than 2.40 nor more than 2.90, when calculated in accordance with ASTM C136/C136M.

2.1.2.4 Alkali Silica Reactivity

Evaluate and test fine aggregate to be used in all concrete for alkali-silica reactivity in accordance with Paragraph ALKALI SILICA REACTIVITY.

2.1.3 Admixtures

2.1.3.1 Air-Entraining Admixtures

Provide air-entraining admixtures conforming to ASTM C260/C260M.

2.1.3.2 Chemical Admixtures

ASTM C494/C494M. Where not shown or specified, the use of admixtures is subject to written approval of the Contracting Officer.

2.1.4 Cement

Provide portland cement conforming to ASTM C150/C150M. Provide low alkali cement if the proposed fine or coarse aggregate are found to have greater than 0.08 percent expansion when tested in accordance with ASTM C1260, as per paragraph: Alkali Silica Reactivity.

2.1.4.1 Portland Cement ConcreteMix Design

Design the concrete mixture to produce a minimum compressive strength of 3,000 psi at 72 hrs from the time the material is screeded and finished in the repair area and a minimum compressive strength of 5,000 psi at 28 days of age, determined in conformance with ASTM C39/C39M and ASTM C192/C192M, using standard 150 by 300 mm 6 by 12 inch cylinder specimens; and providing an air content by volume of 5 percent, plus or minus 1.5 percent, based on measurements made on concrete immediately after discharge from the mixer in conformance with ASTM C231/C231M.

The allowable range of slump is 1/2 to 2 inches when tested in accordance with ASTM C143/C143M except that maximum slump may be increased to 4 inches when the Contractor has included an approved water-reducing, mid range, admixture conforming to ASTM C494/C494M in the mix design. To minimize drying shrinkage, the maximum water-cement ratio by weight is limited to 0.45.

2.1.5 Curing Materials

2.1.5.1 Pigmented Liquid Membrane-Forming Compound

Provide pigmented liquid membrane-forming compound conforming to COE CRD-C 300 or ASTM C309.

2.1.6 Bonding-Agents

2.1.6.1 Epoxy-Resin

Provide two component epoxy-resin material formulated to meet the requirements of ASTM C881/C881M, Type III, grade and class as approved, for use in bond coat applications and as a component of epoxy-resin concrete or mortar.

Mix epoxy-resin grout components in the proportions recommended by the manufacturer. Condition the components to 70 to 85 degrees F for 48 hours prior to mixing. Mix the two epoxy components with a power-driven, explosion-proof stirring device in a metal or polyethylene container having a hemispherical bottom. Add the curing-agent component gradually to the epoxy-resin component with constant stirring until a uniform mixture is obtained. Stir such that the amount of entrained air is a minimum.

2.1.7 Joint Sealant

Provide joint sealant as as specified in Section 32 01 19.61 SEALING OF JOINTS IN RIGID PAVING.

2.1.8 Joint Filler

Provide joint filler material conforming to ASTM D1751 or ASTM D1752, Type

II.

2.1.9 Water

Test water that is not approved by Public Health authorities for domestic consumption in accordance with ASTM C1602/C1602M and only use water that meets the acceptance criteria of Table 1 or 2 of ASTM C1602/C1602M or provide documentation that the water does meet the acceptance criteria of Table 2 of ASTM C1602/C1602M.

2.1.10 RigidProprietary Repair Products

A rigid proprietary repair product is defined as a rigid material in its hardened state with an elastic modulus greater than 1,000,000 psi. For partial depth repairs do not extend the product with aggregates that are or can be retained on a 3/4 inch sieve. Test the product in accordance with the following test series. Replicate each test on three specimens. Report all three results for each test and use the average value for comparison with the specification requirements. Report the curing conditions for each test type.

2.1.10.1 Compressive Strength

Cast 3 by 6 inch cylinder specimens in accordance with ASTM C192/C192M and test in accordance with ASTM C39/C39M, using bonded or unbonded caps, after 72 hours and 3 day curing period. Use only materials with a minimum compressive strength of 3,000 psi at the time traffic is returned to the repair.

2.1.10.2 Bond Strength

Cast 3 by 6 inch cylinder specimens and test in accordance with ASTM C882/C882M. Cast the candidate material against a 30-degree wedge specimen consisting of the candidate material itself or an ordinary portland cement mixture. Test specimens, using bonded caps, after 1 day curing period. For a bond consisting of the candidate material bonded to OPC mortar, a minimum bond strength of 850 psi is required at 1 day of age. For a bond consisting of the candidate material bonded to itself, a minimum bond strength of 1,000 psi is required at 1 day of age.

2.1.10.3 Modulus of Elasticity

Cast 6 by 12 inch cylinder specimens in accordance with ASTM C192/C192M and test in accordance with ASTM C469/C469M, using bonded caps, after 3 day curing period. A maximum chord modulus of elasticity of 4,000,000 psi is required at 3 days of age.

2.1.10.4 Coefficient of Thermal Expansion

Cast 1 by 1 by 10-inches prismatic bar specimens and test in accordance with ASTM C531, after 3 days curing period. Use repair product with a coefficient not exceeding 7 by 10^{-6} inch per inch per degree F at 3 days of age. Also, determine the coefficient of thermal expansion of the existing pavement concrete by testing a core or by estimating based on material composition. Use a repair product with a coefficient of expansion within 20 percent of the coefficient of the existing pavement concrete.

2.1.10.5 Shrinkage Potential

Cast 13 inch I.D. by 16 inch O.D. by 6 inch tall restrained toroidal specimens and test in accordance with ASTM C1581/C1581M. Start measuring strain after completion of casting. Use repair products with shrinkage not exceeding 40 microstrain is required at 14 days of age. No cracking is permitted at 28 days of age.

2.1.10.6 Freeze-Thaw Resistance

Use aggregate with a satisfactory service record in freezing and thawing environments of at least 5 years of sucessful service in three concrete paving projects. Provide aggregate service record certified by an independent third party professional engineer, petrographer, or concrete materials engineer along with their resume. Otherwise, cast prismatic specimens in accordance with ASTM C192/C192M and test in accordance with ASTM C666/C666M, Procedure A. Begin freeze-thaw testing after specimens have been immersed in saturated lime-water for 3 days. Report the Durability Factor (DF) and the number of cycles to failure.

2.1.11 Polymeric Proprietary Repair Products

Polymeric repair materials include epoxies, methacrylates, and urethanes with or without aggregate. Use only materials that have not reached the manufacturer's published shelf life for the material lot. Ship and store materials in areas with temperature, humidity, solar exposure and packaging integrity in accordance with manufacturer's recommendations. Use and apply primers, bond agents or bond adhesives, in accordance with manufacturer's recommendations. Procure, prepare and use aggregates and fillers in accordance with manufacturer's recommendations.

2.1.11.1 Chemical Reistance

Prepare two sets of three 2-inch cubes cured at 73 Degrees F for seven days. Measure and weigh the specimens before submerging the test solvent, JP8 fuel at 150 Degrees F for 24 hours in accordance with ASTM C267 one set of three specimen. Test compressive strength of the other three specimens for comparison. Measure, test, record and report the weight change and loss of compressive strength. Use only materials that have less than or equal to a 20 percent reduction in the average compressive strength of the three immersed sample compared to the average compressive strength of the non-immersed samples. Use only materials that have a change in weight of 10 percent or less.

2.1.11.2 Compressive Strength

Determine, record and report the compressive strength of the material using procedures contained in ASTM C579. Prepare three sets of three samples, one set per curing interval. Prepare the sample so that no sample dimension is less 2 in or 5 times the maximum aggregate size. The maximum aggregate size is the smallest standard sieve size through which 100 percent or the aggregate will pass. Cure the samples at 73 Degrees F. Test the first set of specimens after a curing period of one hour and a second set after a curing period of four hours. Test the third set of samples at the manufacturer’s published cure or trafficability time for the product at 73 Degrees F. Use only those materials which exceed 500 psi at the time of trafficking of the repair.

2.1.11.3 Flexural Strength and Modulus of Elasticity

Determine, record and report the Flexural strength and tangent modulus of elasticity of the material using procedures contained in ASTM C580 using three-point bending. Prepare three sets of three beam samples, one set per curing interval. Prepare the sample so that no sample dimension is less 2 in or 5 times the maximum aggregate size. The maximum aggregate size is the smallest standard sieve size through which 100 percent of the aggregate will pass. Cure the samples at 73 Degrees F. Test the first set of specimens after a curing period of one hour and a second set after a curing period of four hours. Test the third set of samples at the manufacturer's published cure or trafficability time for the product at C 73 Degrees F. Use only those materials with a flexural strength which exceeds 350 psi and a tangent modulus greater than 5,000 psi at the time of trafficking of the repair.

2.1.11.4 Bond Strength by Slant Shear

Test, determine, record and report the material bond strength using ASTM C882/C882M, with the following modification. In lieu of the specified testing using a layer of material sandwiched between two PCC dummies, prepare samples which contain one PCC dummy that represents half of the specimen with repair material use to produce the other half of the sample. Cast 3 by 6 inch cylinder specimens by casting the polymeric repair material against a 30-degree wedge specimen consisting of an ordinary portland cement mixture. Prepare three sets of three cylinder samples, one set per curing interval. Cure the samples at 73 Degrees F. After curing, cap the cylinders according to ASTM C617/C617M. Test the composite cylinder in compression causing a shear failure at the bond line. Test one set of specimens after a curing period of four hours. Test another set after a curing period of 24 hours. Test the other set of samples at the manufacturer's published cure or trafficability time for the product at 73 Degrees F. Use only those materials with a calculated bond strength in excess of 500 psi at the time of traffic.

2.1.11.5 Thermal Compatibility

In accordance with ASTM C884/C884M, prepare two samples by first casting and curing for 28 days two PCC blocks, each measuring 12 in x 12 in x 3 in. After 28 days of curing, apply an overlay of the repair material on each of these two PCC blocks measuring 0.5 in thick. Cure each block for seven days at 73 Degrees F. Expose the composite specimens to five freeze-thaw cycles, each cycle consisting of exposure to -6 Degrees F for 24 hours then 73 Degrees F for 24 hours. Use only those materials that do not have any signs of delamination in either specimen.

2.1.11.6 Dynamic Mechanical Analysis (DMA)

Prepare three sample in accordance with ASTM D5023 using the largest samples that will fit in the test apparatus. Prepare the sample without aggregates if possible. Test, determine, record and report the change in Modulus of Elasticity as a function of temperature at intervals of 5 Degrees C 10 Degrees F . Report any melting of the repair material over the selected temperature range. Test the pavement repair material from -60 Degrees F to 400 Degrees F. Use a sinusoidal three-point bending load on the specimen at a frequency of 0.1 second with a maximum strain of 0.01 percent. Increase the temperature linearly at a rate of 3 Degrees C per minute. Record the storage modulus (modulus of elasticity), loss modulus, and tangent delta as a function of temperature. Test the specimens after curing the specimens for seven days at 73 Degrees F. Report the temperature at which the storage modulus value decreases to 50 percent of the modulus value at 73 Degrees F. Report if the sample melts or combusts at temperatures less than or equal to 400 Degrees F. Use only materials which have 50 percent reduction in modulus at temperatures in excess of 150 Degrees F. Use only materials which do not melt or combust at temperatures less than or equal to 400 Degrees F.

2.1.12 Sand-Cement Mortar for Filling Small Popouts

Sand-cement mortars are not permitted for spall repair. For small popouts, an approved epoxy may the used as the repair material.

2.1.13 Reinforcement

Provide reinforcement as specified in Section 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE.

PART 3 EXECUTION

3.1 PATCH MATERIAL SELECTION

Use Portland cement concrete (PCC) or approved proprietary product for repair areas more than 600 cubic inches in volume after unsound concrete is removed. Use Portland cement mortar for cavities between 50 and 600 cubic inches in size after unsound concrete is removed.

3.2 BATCHING, MIXING AND PROPORTIONING OF CONCRETE REPAIR MATERIAL

Provide facilities and equipment for the accurate measurement and control of each of the materials entering the concrete, mortar, and grout. Provide free access for the Contracting Officer to the batching and mixing plant at all times. Provide mixing equipment capable of combining the aggregate, cement, admixture, and water into a uniform mixture and discharging this mixture without segregation. The concrete mixing equipment is to meet the applicable requirements of ASTM C94/C94M.

The use of volumetric batching and continous mixing is acceptable, provided all operations are in accordance with ASTM C685/C685M.

3.2.1 Equipment

Assemble dependable and operable equipment, allowing time for thorough inspection, calibration of weighing and measuring devices, adjustment of parts, and the making of any repairs that may be required prior to final approval and the commencement of work. Maintain the equipment in good working condition. Use only equipment that can ensure the water to cement ratio is within 2 percent of required.

3.2.2 Conveying

Convey concrete from mixer to repair area as rapidly as practible by methods which prevent segregation or loss of ingredients.

3.2.3 Facilities for Sampling

Provide facilities for readily obtaining representative samples of aggregate and concrete for test purposes. Furnish necessary platforms, tools, and equipment for obtaining samples.

3.2.4 Concrete Mix Proportions

Use proportions of concrete materials entering into the concrete mixture in accordance with the approved mix design. Revise the mix design whenever necessary to maintain the workability, strength, and standard of quality required, and to meet the varying conditions encountered during the construction; however, make no changes without prior approval. The water to cement ratio cannot exceed 0.45 at any time.

3.2.5 Measurement

Provide equipment necessary to measure and control the amount of each material in each batch of concrete. Weigh bulk cement. Cement in unopened bags as packed by the manufacturer may be used without weighing. One bag of portland cement is considered as weighing kg 94 pounds.

Measure mixing water and air-entraining admixtures by volume or by weight. Consider one gallon of water as weighing 8.33 pounds.

Use only equipment, sensors and measurement controls that ensure the water to cement ratio is accurately controlled within 2 percent of required.

3.2.6 Workability

Maintain the slump of the concrete at the lowest practicable value, not exceeding the value specified in Paragraph PORTLAND CEMENT CONCRETE MIX DESIGN or the manufacturer's recommendation when proprietary repair materials are used.

3.3 PREPARATION OF EXISTING PAVEMENT

3.3.1 Preparation of Existing Surfaces

In the area to be patched, remove existing concrete to a minimum depth of 2 inches below the pavement surface adjacent to spalls and to such additional depth where necessary to expose a surface of sound, unweathered, and non-delaminated concrete that is not contaminated by sealants, oils, greases, or deicing salts or solutions. Make a vertical perimeter saw cut at least 2 inches deep and at least 2 inches outside of the area needing repair. Accomplish concrete removal in spalled areas with light, hand-held, high-frequency chipping hammers weighing not more than 30 pounds or other approved hand tools. Do not use jack hammers weighing more than 30 pounds and do not use pavement breaker devices mounted on or pulled by mobile equipment. Use of milling devices such as a cold planer are allowed but require augmentation with concrete saws and jack hammers to generate the required vertical surfaces on edges of the repair which are milled at the curvature of the drum.

Clean the repair area surface by waterblasting, blowing with compressed air, sweeping, and vacuums. Use waterblasting to remove all traces of sealer, oils, grease, rust, and other contaminants.

3.3.2 Reinforcement

Clean to bare metal by sandblasting any existing reinforcement exposed in the repair area. Remove any reinforcement that cannot be properly re-embedded in the new repair concrete. Cut and remove at the joint not less than 2 inches of existing exposed reinforcement that is continuous through the repair area and is embedded in the adjacent slab.

3.3.3 Preparation of Joints Adjacent to Spalls

Remove existing joint sealing and joint filler materials. Saw as indicated and install insert board, cut to appropriate dimensions, to prevent contact between new patch material and existing concrete at the adjacent joint face. Use insert board with a thickness equal to or slightly larger than the joint width (groove) adjacent to the repair material, as indicated on the drawings. Install a bead of approved caulking material to preclude new patching material from getting around insert and into the joint from the sides and bottom of the insert. Clean up any caulking material accidentally deposited on the prepared spall surface. Repair any sawcut overcuts with an approved epoxy repair material.

3.3.4 Disposal of Debris

Sweep pavement surface to remove excess joint material, dirt, water, sand, and other debris using vacuum sweepers or hand brooms. Remove the debris immediately to a point off station.

3.3.5 Bonding Agent, Adhesive or Coat

Prior to placing concrete, wash the previously prepared surfaces with a high pressure water jet followed by an air jet to remove free water on the repair surface.

3.3.5.1 Epoxy-Resin

Limit epoxy-resin bonding coat to use on patches with a surface area of less than 2 feet square. Coat the clean and dry surface, including sawed faces, with a 20 to 40 mil thick film of the epoxy-resin bonding coat Place the epoxy-resin bonding coat in one application, just prior to concrete placement, with the use of mechanical combination, mixing and spraying equipment, or two coat application with stiff brushes. Scrub the first brush coat into the concrete surface, followed by an additional brush coat to obtain the required thickness. Apply the final coat just prior to placement of the concrete.

3.3.5.2 Proprietary Repair Products

Apply in accordance with the manufacturer's written instructions.

3.3.6 Popout Repair

Popouts, as used herein, are pavement surface defects caused by deterioration of unsatisfactory coarse aggregate, decaying of organic material such as wood or roots, mechanical accidents, or other reasons. Most popouts are indicated on the drawings by average diameter but the actual surface configuration will vary from circular to polygonal. Repair popouts as indicated using approved proprietary repair material. Clean popout cavities of all dirt and contaminants prior to filling. As indicated on drawings, prepare popout areas by chipping or overcoring surface defects in the concrete to eliminate feather edging of the mortar or concrete repair material. Core out the distressed areas at least 2 inches deep or 1 inch below the depth of the popout.

3.4 PLACING

3.4.1 Portland Cement Concrete

Place concrete within 90 minutes after the introduction of the mixing water to the cement and aggregate or the introduction of the cement to the aggregate and before the concrete has obtained its initial set. The temperature of the concrete, as deposited in the repair area, can not be not less than 50 degrees F nor more than 90 degrees F. Deposit concrete as to require a minimum of re-handling and in such a manner so as to least disturb the sand-cement grout. Place concrete as indicated to maintain existing joints and working cracks. Use an insert or other bond-breaking medium where the spalled area abuts a joint to prevent bond at the joint face and to allow movement of the slabs and to prevent stress concentrations. Do not allow new repair material to infiltrate or span existing joints and cracks indicated to remain. Place concrete continuously in each spall area. Do not allow workmen to walk on the damp repair surface or in the concrete during placing and finishing operations.

Consolidate the concrete by small spud vibrators not greater than one inch in diameter, except that repair areas less than 4 inches deep or one square foot in area may be consolidated by hand tamping or other approved means. To avoid pulling material away from patch edge and to maximize bond strength, work the finishing screed from the center of the patch out to the patch boundary. Fill all saw kerfs extending beyond the repair area with grout. Start finishing operations immediately after placement of the concrete. Match finished surface grade of patched areas to the existing surface grade of the adjacent undisturbed pavement. Keep screeding, floating, or troweling of patch material onto adjacent pavements to a minimum and remove loose or poorly bonded patch material from adjacent surfaces. Before the concrete becomes non-plastic, finish the surface with a broom to approximately match the surface finish of existing adjacent concrete pavement. Remove repair materials for surfaces adjacent to but outside the repair surface.

Popouts and spalls, both with a maximum dimension less than 6 inches, and not within 4 inches of a joint or working crack, may be prepared by drilling a core 2 inches in diameter greater than the size of the defect, centered over the defect, and 2 inches deep or 1/2 inch into sound concrete, whichever is greater. Repair the core hole as specified above for other spalls.

3.4.2 Epoxy-Resin Concrete and Mortar

Limit epoxy-resin bonding coat to use on patches with a surface area of less than 2 feet square. Place the epoxy resin materials in layers not over 2 inches thick. Make the time interval between placement of additional layers such that the temperature of the epoxy resin material does not exceed 140 degrees F at any time during hardening. Use mechanical vibrators and hand tampers to consolidate the concrete or mortar. Remove any repair material on the surrounding surfaces of the existing concrete before it hardens.

Place the repair material as indicated to maintain existing joints and working cracks. Use an insert or other bond-breaking medium where the spalled area abuts a joint to prevent bond at the joint face. Do not allow new repair material to infiltrate or span existing joints and cracks indicated to remain. Place the repair material continously in each spall area. Finish the repair material to match the grade of the adjacent concrete surface.

Spalls not adjacent to joints and popouts, both less than 6 inches in maximum dimension, may be prepared by drilling a core 2 inches in diameter greater than the size of the defect, centered over the defect, and 2 inches deep or 1/2 inch into sound concrete, whichever is greater. Repair the core hole as specified above for other spalls.

3.4.3 Proprietary Repair Products

Perform placing, consolidating, finishing, and curing operations in accordance with the manufacturer's written instructions.

Place the repair material as indicated to maintain existing joints and working cracks. Use an insert or other bond-breaking medium where the spalled area abuts a joint to prevent bond at the joint face. Do not allow new repair material to infiltrate or span existing joints and cracks. Place the repair material continuously in each spall area. Finish the repair material to match the grade of the adjacent concrete surface.

3.5 CURING

Cure the repair concrete by protection against loss of moisture and rapid temperature changes for a period of not less than 3 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. Provide all equipment needed for adequate curing and protection of the concrete on hand and ready to install before actual concrete placement begins. Cure proprietary repair products in accordance with manufacturer's recommendations. Failure to comply with curing requirements will be cause for immediate suspension of concreting operations.

3.5.1 Membrane-Forming Curing Compound

Apply membrane -forming curing compound immediately to exposed concrete surfaces. Apply the curing compound with an overlapping coverage that will give a two-coat application at a coverage of not more than 200 square feet per gallon for both coats. When application is made by hand-operated sprayers, apply the second coat in a direction approximately at right angles to the first coat.

Cure concrete properly at joints, but do not allow absorbent curing compound to enter joints that are to be sealed with a joint-sealing compounds. Provide a uniform, continuous, cohesive compound film that will not check, crack, or peel, and that will be free from pinholes and other imperfections. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied at the coverage specified above and at no additional cost to the Government. Respray areas covered with absorbent curing material that are damaged by pedestrian and vehicular traffic or by subsequent construction operations within the specified curing period at no additional cost to the Government.

3.6 JOINT RE-ESTABLISHMENT

For joint spall repairs, after the repair material has cured, saw a reservoir for the joint sealant to the dimensions required for other joints. Thoroughly clean and seal the reservoir with the sealer and backer rod specified for the joints. Construct new joints as detailed on the drawings and align with existing joints.

3.7 FINISH TOLERANCE

Provide finished surfaces of patched areas meeting the grade of the adjoining pavements without deviations more than 1/8 inch from a true plan surface within the patched area or at the interface with the adjoining pavement.

3.8 REPAIR AREA PROTECTION

Protect the patched areas against damage prior to final acceptance of the work by the Government. Exclude traffic from the patched areas by erecting and maintaining barricades and signs until the completion of the curing period of the concrete or the curing period of proprietary repair products as per the manufacturer's instructions.

3.9 FIELD QUALITY CONTROL

3.9.1 General Requirements

Test proprietary products in accordance with the manufacturer's written instructions.

3.9.2 Testing for Strength, Slump, and Air Content

Sample concrete in the field and test to determine the slump, air content, and strength of the concrete.

Make cylinders for each shift of placed concrete. Mold each group of test cylinders from the same batch of concrete, consisting of a sufficient number of specimens to provide two compressive-strength tests at each test age. Make one group of specimens during the first half of the shift, and the other during the last portion of the shift. However, at the start of paving operations and each time the aggregate source, aggregate characteristic, or mix design is changed, make one additional set of test cylinders. Mold and cure test cylinders at the site for the first 24 hours or until the testing is required if less than 24 hours of curing is required and later in the laboratory in conformance with ASTM C31/C31M. Test cylinders in accordance with ASTM C39/C39M.

Determine the air content and slump in accordance with ASTM C231/C231M and ASTM C143/C143M, respectively.

3.9.2.1 Test Results

Remove concrete not meeting strength, consistency, and air content requirements and provide concrete that meets the requirements of this specification. The removal and replacement method or methods are subject to approval of the Contracting Officer.

3.9.2.2 Acceptance

Within 30 days of spall repair or prior to final acceptance, any spall repair material that cracks, or delaminates, or loses bond partly or completely as indicated by soundings, or causes spalling of adjacent portland cement concrete, or is not separated properly from adjacent slabs at joints, or fails to cure uniformly and completely, or is otherwise defective will be rejected by the Government.

Remove all unacceptable repairs, including new damaged areas adjacent to new spall patches, and provide new repairs meeting the specifications.

-- End of Section --

SECTION 32 01 29.62

CONCRETE PAVEMENT RAISING
11/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C31/C31M	(2021a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C39/C39M	(2021) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C150/C150M	(2021) Standard Specification for Portland Cement
ASTM C266	(2020) Standard Test Method for Time of Setting of Hydraulic-Cement Paste by Gillmore Needles
ASTM C494/C494M	(2019) Standard Specification for Chemical Admixtures for Concrete
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C937	(2016) Grout Fluidifier for Preplaced-Aggregate Concrete
ASTM C939/C939M	(2016a) Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C940	(2016) Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory

ASTM C953	(2017) Standard Test Method for Time of Setting of Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C1602/C1602M	(2018) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Weigh Bills; G

Equipment; G

SD-05 Design Data

Grout Mixture; G

SD-06 Test Reports

Production Sampling and Testing

Tests, Inspections, and Verifications

SD-07 Certificates

Cement

Grout Mixture

1.3 QUALITY CONTROL

1.3.1 Bench Marks

Determine, establish, and maintain elevations of bench marks for grade control.

1.3.2 Testing Facilities

Perform sampling and testing using a commerical testing laboratory approved in accordance with Section 01 45 00.00 1001 45 00.00 2001 45 00.00 40 QUALITY CONTROL. Work requiring testing will not be permitted until the facilities have been inspected and approved. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. The laboratory is to maintain this certification for the duration of the project. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.3.3 Cement

Do not use cement until its test report is approved by the Contracting Officer. Sample cement at the mill or shipping point and at the work site. If tests prove that a cement that has been delivered is unsatisfactory, promptly remove it from the work site. Retest cement that has not been used within 6 months after testing when directed by the Contracting Officer. Cement will be rejected if test results are not satisfactory.

1.3.4 Aggregate

Sample aggregates in the presence of the Contracting Officer. Obtain samples in accordance with ASTM D75/D75M that are representative of the materials to be used for the project. Perform all aggregate tests no earlier than 30 days prior to starting grouting operations. Conduct aggregate testing in a laboratory approved by the Contracting Officer.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Provisions for Cement

Deliver and store all cementitious materials at a temperature not exceeding 150 degrees F. Furnish cement in bulk or in suitable bags used for packaging cement. Plainly mark the bags with the manufacturer's name, brand, and lot number. Furnish cement that is dry and free from lumps and caking when delivered. Check shipments of bagged cement for weight when delivered. Provide accurate scales and labor for checking the weight of bagged cement. Approximately 1 percent of each shipment will be selected at random and checked for weight except that additional weight checks will be made to determine compliance with the cement specification when deficiencies in weight are found. Deliver bulk cement, if used, in weathertight carriers and unload it into the storage facilities by means of weathertight conveyors or other suitable means that will completely protect the cement from moisture. Storage facilities are subject to approval. Provide storage facilities that permit easy access for inspection and identification. Store and use different brands of cement separately so that a complete record will be available of the grade of cement used in all batches of grout mixes.

1.4.2 Provisions for Aggregates

Handle and store aggregates at the site so that segregation, intermixing between stockpiles, or contamination by foreign materials does not occur. Prepare and maintain sites for stockpiles to prevent the inclusion of foreign materials with the aggregate. Segregated aggregate is not permitted. Discard aggregate when segregation is apparent at no cost to the Government.

1.5 ENVIRONMENTAL REQUIREMENTS

Do not perform pavement slabjacking when the ambient temperature at the bottom of the pavement slab is less than 40 degrees F or when the subgrade or aggregate base is frozen.

PART 2 PRODUCTS

2.1 EQUIPMENT

Furnish all equipment, tools, and other apparatus necessary for the proper construction and acceptable completion of the work specified under this contract. The equipment must be approved by the Contracting Officer prior to starting the work. Maintain equipment in good working condition during the progress of the work. Submit list of proposed equipment to be used in performance of construction work including descriptive data.

2.1.1 Grout Plant

Provide a grout plant consisting of a positive displacement grout injection pump capable of applying up to 250 psi pressure, a high speed colloidal mixing machine, and a grout return system. Produce the colloidal grout by mixing in a colloidal mill connected to the cone-shaped bottom of a cylindrical drum. Operate the colloidal mill between 800 and 2,000 RPM, creating a high shearing action and subsequent pressure release to make a homogeneous mixture. Provide an injection system capable of continuously pumping grout at rates as low as 1-1/2 gallons per minute and equipped with pressure monitoring devices and a quick action valving system that can be closed instantly and provide for the grout to be recirculated through the system.

2.1.2 Water Tanker

If water tanks and metered pumps are not an integral part of the plant, provide a water truck equipped with a metered pump for delivery to the grout plant.

2.1.3 Drilling

Provide an air compressor and rock drill or other device capable of drilling the grout injection holes through the pavement and base material. Keep the equipment in good condition. Provide injection holes that are vertical and round. Do not exceed a down-feed pressure of 200 psi whether by hand or mechanical means.

2.1.4 Flow Cone

Provide a flow cone with necessary components in accordance with ASTM C939/C939M so that the consistency of the mixture can be determined.

2.1.5 Miscellaneous

Provide all necessary hoses; valving, valve manifolds, and positive cut-off and bypass provisions to control pressure and volume; pressure gauges with gauge protectors; expanding packers for positive seal grout injection; wood plugs; hole washing tools; and drill steel and bits.

2.2 MATERIALS

2.2.1 Portland Cement

Provide portland cement Type [_____] meeting the requirements of ASTM C150/C150M. Do not use cement salvaged by cleaning bags mechanically or otherwise, or from discarded bags of cement. Use cement that has been stored at the site for 60 days or more before using cement of lesser age.

2.2.2 Pozzolans and Fly Ash

Provide pozzolans and fly ash meeting the requirements of ASTM C618.

2.2.3 Mineral Aggregate

Provide aggregate to be used for slabjacking consisting of natural sand, manufactured sand, or a combination of natural and manufactured sand and limestone dust. If the aggregate is a combination of separately processed sizes from the same or different sources, or a blend of different materials, batch the different components separately or blend under approved conditions prior to delivery to the batching plant.

2.2.3.1 Particle Shape

Provide particles of the aggregate that are generally spherical or cubical in shape. Aggregates containing flat platelet grains or rhombohedral grains will not be approved.

2.2.3.2 Grading

Provide aggregate conforming to the following gradation when tested in accordance with ASTM C136/C136M and ASTM C117.

Sieve designation U.S. Standard square mesh	Percentage by weight passing
No. 8	100
No. 16	80-95
No. 50	50-70
No. 200	25-45

2.2.3.3 Deleterious Materials

Do not exceed the following limits for deleterious materials in the aggregate when tested in accordance with ASTM C142/C142M.

Material	Percentage by Weight
Clay lumps	2.0
Coal and lignite	1.0

2.2.4 Chemical Admixtures

Provide chemical admixtures that are proposed to be used to assist in pumping grouts or to compensate for climatic conditions conforming to ASTM C494/C494M and ASTM C937.

2.2.5 Water

Provide water for mixing and curing that is fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations may be used if it meets the requirements of ASTM C1602/C1602M.

2.3 MIXES

2.3.1 Proportioning of Materials

Proportion the grout mixture to be used for slabjacking as follows:

a. One part (by volume) portland cement.

b. Three parts (by volume) aggregates or a mixture of aggregates and pozzolans or fly ash.

c. Water to achieve fluidity.

d. Additives (when approved), high range water reducers, water reducers, fluidifiers.

2.3.2 Grout Mixture

Submit certified mix designs by an approved commerical laboratory for each type of concrete, grout, or blended material including a complete list of ingredients, admixtures, and set time. Include certificates for cement, cementitious materials, and admixtures. Proportion and test a mix design to meet the specification requirements. Provide portland cement grout mixture used for slabjacking consisting of portland cement, pozzolan or fly ash, limestone dust, sand, and water. The use of accelerators, high range water reducers and fluidifiers are subject to the approval of the Contracting Officer. Do not produce grout until the mix design has been approved.

2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

Submit certified copies of test reports for aggregates, cement, and fly ash not less than 30 days before the material is required in the work and daily during construction. Provide certified reports of inspections and laboratory tests including analysis and interpretation of test results. Properly identify each report by contract number, location, quantity of material placed, and timed events of milestones. Describe test methods used and compliance with specified standards.

2.4.1 Daily Report

Provide daily mixture test results of the materials and additives used in the mixture including aggregate gradation, flow cone times, shrinkage and expansion observed, time of initial set, and 1-day, 3-day, and 7-day strengths of previous day's placements.

2.4.2 Compressive Strength

Provide a minimum 7-day strength not less than 600 psi as determined by tests made in accordance with ASTM C39/C39M. Fabricate test specimens from the materials being used on the project including water and admixtures. Make, cure, and test specimens as described in paragraph FIELD TEST SPECIMENS in PART 3.

2.4.3 Expansion

Determine the expansion in accordance with ASTM C940 at the beginning of the job and whenever the mix proportions are changed.

2.4.4 Set Time

Determine the time of initial set in accordance with ASTM C266 or ASTM C953 at the beginning of the job and when a different lot of cement is used.

2.4.5 Fluidity

Test the fluidity of each batch of grout slurry in accordance with ASTM C939/C939M. Provide time of efflux (fluidity) for pozzolanic grouts that range from 16 to 26 seconds. Provide time of efflux for limestone dust grouts that range from 22 to 32 seconds. A flow cone time of efflux of 9 to 15 seconds can be used during the initial injection at each hole.

PART 3 EXECUTION

3.1 PAVEMENT INSPECTION

Closely examine the slabs for any existing cracks prior to jacking any pavements. Perform this investigation with the Contracting Officer. Both parties must agree regarding the existing condition of the pavement with existing cracks noted and marked.

3.2 DRILLING HOLES FOR GROUT INJECTION

Drill grout injection holes in a pattern as shown on the drawings. Drill grout injection holesto a maximum diameter of 2 inches. Drill holes vertically to a depth sufficient to penetrate through any chemically stabilized base, but not more than 3 inches into the subgrade. Drill holes so that breakout does not occur at the bottom of the slab.

3.3 WASH HOLES

Subject to the Contracting Officer's approval, holes may be washed or air blown to create a small cavity to allow the initial spread of grout.

3.4 JACKING

Erect string lines that will be blocked up from the pavement high points to monitor movement prior to jacking operations. Lower into the holes an expanding rubber packer or other approved device providing a positive seal and connected to the discharge hose on the grout plant. Do not extend the discharge end of the packer or hose below the lower surface of the concrete pavement. Pump in a pattern and in the amount required to raise the pavement to string line grade. Continuous pressures up to 200 psi are permitted. Pressures with 200 psi to 300 psi are allowed only for short periods. In the event the pavement is bonded to the aggregate base, brief pressure rises (10 seconds or less) up to 600 psi are allowed. Loss of grout through cracks, joints, other injection holes, or from back pressure in the hose or in the shoulder area is not permitted. Do not use grout for jacking that is held for more than 1 hour in the mixer or in the injection pump or hose.

3.5 RAISING OF SLABS

Do not raise the slabs more than 1/4 inch when pumping in any one hole at any time. Do not raise any part of a slab so that it leads any other part of the slab or any adjacent slab more than 1/4 inch at any time. Keep the entire slab and all adjacent slabs on the same plane at all times within the

1/4 inch tolerance. Make observations to ensure that when pumping from one hole, the grout flows to adjacent holes filling all voids. Slabs can be cut to prevent breakage when it is bound against an adjoining slab. If the temperature is 80 degrees F or higher during the jacking operation, moisten the slabs sufficiently to prevent expansion of the slabs.

3.6 SEALING OF INJECTION HOLES

Immediately remove the packer and plug the hole temporarily with a tapered wooden plug after jacking has been completed at any one hole. Do not remove the temporary wooden plugs until the grout has set sufficiently so that back pressure will not force it through the hole. Permanently seal each hole flush with the pavement surface with a fast setting sand/cement or other patch material approved by the Contracting Officer. Provide patch material having a minimum thickness of 3 inches.

3.7 PLAN GRADE REQUIREMENTS

Provide qualified personnel and equipment for determining the proper elevations required to conform to the plan elevations. Perform jacking operations so that all slabs within the work area present an even grade at each joint and that do not vary from the plan grade elevations by more than 1/8 inch. If slabs are found that are lower than the specified tolerance from the plan grade, continue jacking these slabs until the tolerance is met. Grind individual sections of pavement that are raised above the specified tolerances. Should the overjacking be greater than 1/4 inch the Contracting Officer has the option to require removal and replacement of the pavement. Perform repairs to jacked slabs at no additional cost to the Government.

3.8 REPLACING AND REPAIR OF DAMAGED PAVEMENT

Replace or repair any slabs broken due to jacking as determined by the Contracting Officer. Cracks emanating radially from the grout injection holes will be presumed to be caused by improper injection techniques. For each 5 feet of such crack measured, the pay quantity will be reduced by 1 cubic foot of grout. In the event that transverse cracks develop between adjacent grout injection holes, repair these cracks by an epoxy injection method to the satisfaction of the Contracting Officer. The Contracting Officer may require the removal and replacement of the entire slab or a portion of the slab damaged by radial or transverse cracks at no cost to the Government. Replace the pavement in accordance with Section 32 13 14.13 CONCRETE PAVING FOR AIRFIELDS AND OTHER HEAVY DUTY PAVEMENTS.

3.9 PRODUCTION SAMPLING AND TESTING

3.9.1 Aggregates

Sample aggregates delivered to the mixer during slabjacking operations to determine compliance with specifications. Test aggregate gradation daily.

3.9.2 Field Test Specimens

Take samples of grout in the field from mixtures used for jacking to determine the adequacy of control of materials and the proportioning, consistency, and mixing of the grout. Take three sets of three cylinders from each day's operation or when the mixture proportions are changed. Make and cure the test cylinders in accordance with ASTM C31/C31M and test them in accordance with ASTM C39/C39M for strength. Additional sets of test cylinders will be required at the start of jacking operations and when the aggregate source, aggregate characteristics, or mix design is changed until the Contracting Officer is satisfied that the grout mixture being used complies with the strength requirements specified. Use an approved commerical laboratory to cure and test specimens for compressive strength. The test result will be the average of the strength of the 3 cylinders. If the average strength of cylinders falls below the specified strength, the Contracting Officer may require changes in the mix proportions.

3.10 PROTECTION OF PAVEMENT

Do not permit traffic on the pavement slab until the grout has obtained a minimum set. Include the minimum set time in the grout mixture submittal. Adjust the minimum set time daily to account for variations in temperature.

3.11 ACCEPTANCE OF WORK

Prior to acceptance, remove loose concrete, joint filler, or grout spilled on the surface or shoulder. Remove waste construction material and leave the surrounding areas in a neat and orderly condition prior to opening to traffic or final acceptance.

-- End of Section --

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SECTION 32 05 33

LANDSCAPE ESTABLISHMENT
08/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D2103	(2015) Standard Specification for Polyethylene Film and Sheeting
ASTM D5851	(1995; R 2015) Planning and Implementing a Water Monitoring Program
ASTM D6155	(2019) Nontraditional Coarse Aggregate for Bituminous Paving Mixtures

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA Z133	(2017) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

1.2 DEFINITIONS

1.2.1 Pesticide

Any substance or mixture of substances, including biological control agents, that may prevent, destroy, repel, or mitigate pests and are specifically labeled for use by the U.S. Environmental Protection Agency (EPA). Also, any substance used as a plant regulator, defoliant, disinfectant, or biocide. Examples of pesticides include fumigants, herbicides, insecticides, fungicides, nematicides, molluscicides and rodenticides.

1.2.2 Stand of Turf

100 percent ground cover of the established species.

1.2.3 Planter Beds

A planter bed is defined as an area containing one or a combination of the following plant types: shrubs, vines, wildflowers, annuals, perennials, ground cover, and a mulch topdressing excluding turf. Trees may also be found in planter beds.

1.3 RELATED REQUIREMENTS

Section 32 84 24 IRRIGATION SPRINKLER SYSTEM applies to this section for installation of irrigation equipment requirements, with additions and modifications herein.

Section 32 92 19 SEEDINGSection 32 92 23 SODDINGSection 32 92 26 SPRIGGING applies to this section for installation of seed, sod or sprigging requirements, with additions and modifications herein.

Section 32 93 00 EXTERIOR PLANTS applies to this section for installation of trees, shrubs, ground cover, vines, and wildflower, with additions and modifications herein.

Section 32 96 00 TRANSPLANTING EXTERIOR PLANTS applies to this section for transplanting of trees, shrubs, ground cover, vines, and wildflower, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Integrated Pest Management Plan; G

SD-03 Product Data

Fertilizer; G

Mulches Topdressing

Organic Mulch Materials

SD-07 Certificates

Maintenance Inspection Report

Plant Quantities; G

SD-10 Operation and Maintenance Data

Maintenance

SD-11 Closeout Submittals

Tree Staking and Guying Removal

1.5 DELIVERY, STORAGE AND HANDLING

1.5.1 Delivery

Deliver fertilizer, gypsum, iron to the site in original containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, gypsum may be furnished in bulk with a certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Fertilizer, Lime, Iron, Mulch Storage

Store material in designated areas. Store lime and fertilizer in cool, dry locations away from contaminants.

1.5.2.2 Antidesiccant's Storage

Do not store with fertilizers or other landscape maintenance materials.

1.5.3 Handling

Do not drop or dump materials from vehicles.

1.6 MAINTENANCE

Submit Operation and Maintenance (O&M) Manuals for planting materials. Include instructions indicating procedures during one typical year including variations of maintenance for climatic conditions throughout the year. Provide instructions and procedures for watering; promotion of growth, including fertilizing, pruning, and mowing; and integrated pest management. O&M Manuals must include pictures of planting materials cross referenced to botanical and common names, with a description of the normal appearance in each season.

Develop a water monitoring program for surface and ground water on the project site in accordance with ASTM D5851 and consistent with the water management program utilized during construction operations.

PART 2 PRODUCTS

2.1 POST-PLANT FERTILIZER

Fertilizer for groundcover, wildflowers, and grasses is not permitted. Provide fertilizer for trees, plants, and shrubs as recommended by plant supplier, except synthetic chemical fertilizers are not permitted. Fertilizers containing petrochemical additives or that have been treated with pesticides or herbicides are not permitted.

2.1.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

[_____] percent available nitrogen
[_____] percent available phosphorus
[_____] percent available potassium
[_____] percent sulfur
[_____] percent iron

2.2 WATER

Source of water must be approved by the Contracting Officer, and be of suitable quality for irrigation. Use collected storm water or graywater when available.

2.3 MULCHES TOPDRESSING

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.3.1 Inert Mulch Materials

Provide recycled stone, riverbank stone, crushed pit-run rock, granite chips, complying with ASTM D6155, ranging in size as indicated. Provide materials from site and construction waste to the greatest extent possible.

2.3.2 Organic Mulch Materials

Provide wood cellulose fiber, wood chips, shredded hardwood, shredded redwood bark, pine straw mulch, pine needles, or from site when available. Wood cellulose fiber must be processed to contain no growth or germination-inhibiting factors, dyed with non-toxic, biodegradable dye to an appropriate color to facilitate visual metering of materials application. Paper-based hydraulic mulch must contain a minimum of 100 percent post-consumer recycled content. Wood-based hydraulic mulch must contain a minimum of 100 percent total recovered materials content.

2.3.3 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 2-1/2 by 2-1/2 inch screen. Clean recycled mulch of all sticks a minimum one inch in diameter and plastic materials a minimum 3 inch length. The material must be treated to retard the growth of mold and fungi.

2.4 PESTICIDES

Pesticides and herbicides are not permitted. Use black sheet polyethylene conforming to ASTM D2103, minimum thickness 5/32 inch. Submit an Integrated Pest Management Plan, including weed and pest management strategies proposed alternatives to herbicides and pesticides. Use biological pest controls as approved in the Plan.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide landscape construction maintenance to include irrigation equipment cleaning and adjustments, mowing, edging, overseeding, aeration, fertilizing, watering, weeding, pruning, stake and guy adjusting, for all newly installed or renovated landscape areas and existing plant material, unless indicated otherwise, and at all areas inside or outside the limits of the construction that are disturbed by the Contractor's operations.

3.1.1 Policing

Police all landscaped areas. Policing includes removal of leaves, branches and limbs regardless of length or diameter, dead vegetation, paper, trash, cigarette butts, garbage, rocks or other debris. Policing must extend to both sides of fencing or walls. Collected debris must be promptly removed and disposed of at an approved disposal site.

3.1.2 Drainage System Maintenance

Remove all obstructions from surface and subsurface drain lines to allow water to flow unrestricted in swales, gutters, catch basins, storm drain curb inlets, and yard drains. Remove grates and clear debris in catch basins. Open drainage channels are to be maintained free of all debris and vegetation at all times. Edges of these channels must be clear of any encroachment by vegetation.

3.2 IRRIGATION ESTABLISHMENT PERIOD

The irrigation establishment period will commence on the date that inspection by the Contracting Officer shows that the new or repaired irrigation equipment furnished under this contract have been satisfactorily installed and is functional and must continue for a period of 365 days.

3.2.1 Maintenance During the Irrigation Establishment Period

Begin maintenance immediately after irrigation equipment has been installed and is functional. Inspect irrigation equipment at least once a week during the installation and establishment period and perform needed maintenance promptly. Automatic controllers not equipped with rain shut-off sensors must be turned off during periods of rain that exceed twelve hours of continuous rainfall in one day or during rain storms of one day or more. Once the rain has subsided timers must be reactivated. Irrigation controllers must be inspected and reprogrammed after power outages. Contractor must be responsible for winterization and startup. Sprinkler heads must direct water away from buildings and hard surfaced areas.

3.2.2 Water Restrictions

Abide by state, local or other water conservation regulations in force during the establishment period. Automatic controller must be adjusted to comply with the water conservation regulations schedule.

3.2.3 Fire Hydrants

To use a fire hydrant for irrigation, obtain prior clearance from the Contracting Officer and provide the tools and connections approved for use on fire hydrants. If a fire hydrant is used, Provide a reduced pressure backflow preventer for each connection between hose and fire hydrant. Backflow preventer used must be tested once per month by a certified backflow preventer tester.

3.2.4 Final Acceptance

Upon completion of the irrigation establishment period and final acceptance of groundcover and exterior plants, irrigation equipment must be removed. Operation and coverage test is acceptable if system operates through at least one complete cycle for areas to be irrigated and all leaks or repairs have been completed.

3.2.5 Controller Charts

Provide one chart for each controller supplied. Indicate in chart area controlled by the automatic controller. The chart is a reduction of the actual plans that will fit the maximum dimensions inside the controller housing. Use a black line print for the chart and a different pastel or transparent color to indicate each station zone of coverage. After chart is completed and approved for final acceptance, seal chart between two 20 mil pieces of clear plastic.

3.3 GROUNDCOVER ESTABLISHMENT PERIOD

Groundcover establishment period will commence on the date that inspection by the Contracting Officer shows that the new or renovated turf furnished under this contract has been satisfactorily installed to a 100 percent stand of coverage. The establishment period must continue for a period of 365 days.

3.3.1 Frequency of Maintenance

Begin maintenance immediately after turf has been installed or fully renovated. Inspect areas once a week during the installation and establishment period and perform needed maintenance promptly.

3.3.2 Promotion of Growth

Maintain groundcover in a manner that promotes proper health, growth, natural color. Turf must have a neat uniform manicured appearance, free of bare areas, ruts, holes, weeds, pests, dead vegetation, debris, and unwanted vegetation that present an unsightly appearance. Mow, remove excess clippings, eradicate weeds, water, fertilize, overseed, aerate, topdress and perform other operations necessary to promote growth, as approved by Contracting Officer and consistent with approved Integrated Pest Management Plan. Remove noxious weeds common to the area from planting areas by mechanical means.

3.3.3 Mowing

3.3.3.1 Turf

Mow turf at a uniform finished height. Mow turfed areas to a minimum average height of 3 inches when average height of grass becomes 6 inches for spring/summer maintenance and to a minimum average height of 3 inches when the average height of grass reaches 6 inches for fall and winter maintenance. The height of turf is measured from the soil. Perform mowing of turf in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Prior to mowing, all rubbish, debris, trash, leaves, rocks, paper, and limbs or branches on a turf area must be picked up and disposed. Adjacent paved areas must be swept/vacuumed clean.

3.3.3.2 Native Grasses

Mow above height of native grass seedlings (approximately 3.5 to 4 inches). Mow during spring or early summer. Do not mow after early summer during the second growing season.

3.3.3.3 Wildflowers

Mow three times per season above height of the wildflowers (approximately 12 to 15 inches).

3.3.4 Turf Edging and Trimming

Perimeter of planter bed edges, sidewalks, driveways, curbs, and other paved surfaces must be edged. Uniformly edge these areas to prevent encroachment of vegetation onto paved surfaces and to provide a clear cut division line between planter beds, turf, and ground cover. Edging is to be accomplished in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Perform edging on the same day that turf is mowed. Use of string line trimmers is permitted in "soft" areas such as an edge between turfgrass and a planter bed. Exercise care to avoid damage to any plant materials, structures, and other landscape features.

Trimming around trees, fences, poles, walls, irrigation valve boxes and other similar objects is to be accomplished to match the height and appearance of surrounding mowed turf growth. Trimming must be performed on the same day the turf's mowed. Care must be exercised to avoid "Girdling" trees located in turf areas. The use of protective tree collars on trees in turf areas may be utilized as a temporary means to avoid injury to tree trunks. At the end of the plant establishment period Contractor will be responsible for removing all protective tree collars.

3.3.5 Post-Fertilizer Application

Do not fertilize wildflowers, groundcover, and grasses. Apply turf fertilizer in a manner that promotes health, growth, vigor, color and appearance of cultivated turf areas. The method of application, fertilizer type and frequencies must be determined by the laboratory soil analysis results the requirements of the particular turf species. Organic fertilizer must be used. In the event that organic fertilizer is not producing the desired effect, the Contractor must contract the Contracting Officer for approval prior to the use of a synthetic type of fertilizer. Apply fertilizer by approved methods in accordance with the manufacturer's recommendations.

3.3.6 Turf Watering

Perform irrigation in a manner that promotes the health, growth, color and appearance of cultivated vegetation and that complies with all Federal, State, and local water agencies and authorities directives. The Contractor must be responsible to prevent over watering, water run-off, erosion, and ponding due to excessive quantities or rate of application. Abide by state, local or other water conservation regulations or restrictions in force during the establishment period. Adjust irrigation controllers to comply with the water conservation regulations schedule.

3.3.7 Turf Aeration

Upon completion of weed eradication operations and Contracting Officer's approval to proceed, aerate turf areas by approved device. Core, by pulling soil plugs, to a minimum depth of 2-3 inches. Leave all soil plugs that are produced in the turf area. After aeration operations are complete, topdress entire area 1/4 to 1/2 inch depth.

Blend all parts of topdressing mixture to a uniform consistency throughout. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean all soil plugs off of other paving when work is complete.

3.3.8 Turf Clearance Area

Trees located in turf areas must be maintained with a growth free clearance of 18 inches from the tree trunk base. The use of mechanical weed whips to accomplish the turf growth free bed area is prohibited.

3.3.9 Replanting

Replant in accordance with Section 32 92 19 SEEDINGSection 32 92 23 SODDING Section 32 92 26 SPRIGGING and within specified planting dates areas which do not have a satisfactory stand of turf. Replant areas which do not have a satisfactory stand of other groundcover and grasses.

3.3.10 Final Inspection and Acceptance

Final inspection will be make upon written request from the Contractor at least 10 days prior to the last day of the turf establishment period. Final turf acceptance will be based upon a satisfactory stand of turf. Final acceptance of wildflower and grass areas will be based upon a stand of 95 percent groundcover of established species.

3.3.11 Unsatisfactory Work

When work is found to not meet design intent and specifications, maintenance period will be extended at no additional cost to the Government until work has been completed, inspected and accepted by Contracting Officer.

3.4 EXTERIOR PLANT ESTABLISHMENT PERIOD

The exterior plant establishment period will commence on the date that inspection by the Contracting Officer shows that the new plants or transplanted plants furnished under this contract have been satisfactorily installed and must continue for a period of 365 days.

3.4.1 Frequency of Maintenance

Begin maintenance immediately after plants have been installed. Inspect exterior plants at least once a week during the installation and establishment period and perform needed maintenance promptly.

3.4.2 Promotion of Plant Growth and Vigor

Water, prune, fertilize, mulch, adjust stakes, guys and turnbuckles, eradicate weeds and perform other operations necessary to promote plant growth, and vigor.

3.4.3 Planter Bed Maintenance

Planter beds must be weeded, fertilized, irrigated, kept pest free, turf free, pruned, and mulch levels maintained. Planter beds will not be allowed to encroach into turf areas. A definite break must be maintained between turf areas and planter beds. Fertilize exterior planting materials to promote healthy plant growth without encouraging excessive top foliar growth. Remove noxious weeds common to the area from planting areas by mechanical means.

3.4.3.1 Shrub Selective Maintenance

In addition to the above requirements, shrubs must be selectively pruned, and shaped for health and safety when the following conditions exist: Remove growth in front of windows, over entrance ways or walks, and any growth which will obstruct vision at street intersections or of security personnel; Remove dead, damaged or diseased branches or limbs; where shrub growth obstructs pedestrian walkways; where shrub growth is found growing against or over structures; where shrub growth permits concealment of unauthorized persons. Dispose of all pruning debris in a proper manner.

3.4.3.2 Tree Maintenance

Tree maintenance must include adjustment of stakes, ties, guy supports and turnbuckles, watering, fertilizing, pest control, mulching, pruning for health and safety and fall leaf cleanup. Fertilize exterior trees to promote healthy plant growth without encouraging excessive top foliar growth. Inspect and adjust stakes, ties, guy supports and turnbuckles to avoid girdling and promote natural development. All trees within the project boundaries, regardless of caliper, must be selectively pruned for safety and health reasons. These include but are not limited to removal of dead and broken branches and correction of structural defects. Prune trees according to their natural growth characteristics leaving trees well shaped and balanced. Pruning of all trees including palm trees must be accomplished by or in the presence of a certified member of the International Society of Arboriculture and in accordance with TCIA Z133. All pruning debris generated must be disposed of in a proper manner.

3.4.4 Slope Erosion Control Maintenance

Provide slope erosion control maintenance to prevent undermining of all slopes in newly landscaped and natural growth areas. Maintenance tasks include immediate repairs to weak spots in sloped areas, and maintaining clean, clear culverts, and graded berms, and terraces to intercept and direct water flow to prevent development of large gullies and slope erosion and during periods of extended rainfall, irrigation systems must be secured. Eroded areas must be filled with amended topsoil and replanted with the same plant species. Erosion control netting or blankets damaged due to slope erosion must be reinstalled.

3.4.5 Removal of Dying or Dead Plants

Remove dead and dying plants and provide new plants immediately upon commencement of the specified planting season, and replace stakes, guys, mulch and eroded earth mound water basins. Provide an additional 90 day establishment period for replacement plants beyond the original warranty period. A tree must be considered dying or dead when the main leader has died back, or a minimum of 20 percent of the crown has died. A shrub or ground cover must be considered dying or dead when a minimum of 20 percent of the plant has died. This condition must be determined by scraping on a branch an area 1/16 inch square, maximum, to determine the cause for dying plant material and must provide recommendations for replacement. The Contractor must determine the cause for dying plant material and provide recommendations for replacement.

3.4.6 Tracking of Unhealthy Plants

Note plants not in healthy growing condition, as determined by the Contracting Officer, and as soon as seasonal conditions permit, remove and replace with plants of the same species and sizes as originally specified. Install replacement plantings in accordance with Section 32 93 00 EXTERIOR PLANTS.

3.4.7 Final Inspection

Final inspection will be made upon written request from the Contractor at least 10 days prior to the last day of the establishment period. Final inspection will be based upon satisfactory health and growth of plants and on the following:

3.4.7.1 Total Plants on Site

Plants have been accepted and required number of replacements have been installed.

3.4.7.2 Mulching and Weeding

Planter beds and earth mound water basins are properly mulched and free of weeds.

3.4.7.3 Tree Supports

Stakes guys guys and turnbuckles are in good condition.

3.4.7.4 Remedial Work

Remedial measures directed by the Contracting Officer to ensure plant material survival and promote healthy growth have been completed.

3.4.8 Unsatisfactory Work

When work is found to not meet design intent and specifications, maintenance period will be extended at no additional cost to the Government until work has been completed, inspected and accepted by Contracting Officer.

3.5 FIELD QUALITY CONTROL

3.5.1 Maintenance Inspection Report

Provide maintenance inspection report to assure that landscape maintenance is being performed in accordance with the specifications and in the best interest of plant growth and survivability. Site observations must be documented at the start of the establishment period, then quarterly following the start, and at the end of establishment period. Submit results of site observation visits to the Contracting Officer within 7 calendar days of each site observation visit.

3.5.2 Plant Quantities

Provide Contracting Officer with the number of plant quantities. In addition, provide total exterior area of hardscape and landscaping such as turf and total number of shrubs.

3.5.3 Tree Staking and Guying Removal

Provide a certified letter that all stakes and guys are removed from all project trees at the end of the establishment period.

-- End of Section --

SECTION 32 11 20

BASE COURSE FOR RIGID AND SUBBASE FOR FLEXIBLE PAVING
05/22

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

1.1.1.1 Area

Measure the quantity of subbase and select-material or rigid pavement base course completed and accepted in square yards.

1.1.1.2 Volume

Measure the quantity of subbase and select-material or rigid pavement base course completed and accepted in cubic yards. Determine the volume of material in-place and accepted by the average job thickness obtained in accordance with paragraph LAYER THICKNESS and the dimensions shown on the drawings.

1.1.2 Payment

1.1.2.1 Course Material

Quantities of subbase and select-material or rigid pavement base course, determined as specified above, will be paid for at the respective contract unit prices, which will constitute full compensation for the construction and completion of the subbase and select-material or rigid pavement base course.

1.1.2.2 Stabilization

Cohesionless subgrade or underlying courses to be stabilized, as specified in paragraph PREPARATION OF UNDERLYING COURSE OR SUBGRADE, will be paid for as a special item on a tonnage basis including extra manipulation as required.

1.1.3 Waybills and Delivery Tickets

Submit copies of waybills and delivery tickets during progress of the work. Before the final payment is allowed, file certified waybills and certified delivery tickets for all aggregates actually used.1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C117	(2017) Standard Test Method for Materials

	Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718/D4718M	(2015) Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D7928	(2017) Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.3 DEGREE OF COMPACTION

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the

3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the laboratory maximum dry density in accordance with ASTM D1557 Method C and corrected with ASTM D4718/D4718M.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools; G

Waybills and Delivery Tickets

SD-06 Test Reports

Initial Tests; G

In-Place Tests; G

Test Section Report; G

1.5 QUALITY ASSURANCE

Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Do not start work requiring testing until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. Furnish copies of test results within 24 hours of completion of the tests.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M.

1.5.2 Tests

1.5.2.1 Gradation

Perform gradation in conformance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11.

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture in accordance with paragraph DEGREE OF COMPACTION.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, or ASTM D6938.

For the method presented in ASTM D1556/D1556M, use the base plate, as shown in the drawing. For the method presented in ASTM D6938, check the calibration curves and adjust them, if necessary, using only the sand cone method as described in Annex A2, of the ASTM publication. Use ASTM D6938 to determine the moisture content of the soil. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in Annex A2, in ASTM D6938, on each different type of material to be tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.5.2.5 Wear Test

Perform wear tests on subbase course and or rigid pavement base course material in conformance with ASTM C131/C131M.

1.5.2.6 Weight of Slag

Determine weight per cubic foot of slag in accordance with ASTM C29/C29M.

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

1.7 ACCEPTANCE

1.7.1 Tolerances

Acceptance of rigid pavement base course subbase course select-material is based on compliance with the tolerances presented in Table 1. Remove and replace any course identified by the failing tests.

TABLE 1

Measurement	Tolerance
Grade	Plus 0, Minus 1/2 inch
Smoothness	Plus/Minus 1/2 inch
Total Thickness	Plus/Minus 1/2 inch
Average Job Thickness	Plus/Minus 1/4 inch
Compaction	
Subbase	Mimimum 100 percent
Rigid Pavement Base Course	Mimimum 100 percent

1.7.2 Test Section

Construct a test section consisting of 1000 square yards of rigid pavement base course subbase select-material to demonstrate the materials, equipment, and construction processes meet the requirements of this specification. Acceptance of the test section is based on compliance with the tolerances listed in Table 1. Rework, re-compact, or remove and replace test sections that do not meet specification requirements. Do not commence full operations until the test section report has been approved. Use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments are approved in advance.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Subbase Course

Provide aggregates consisting of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Provide aggregates which are free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Limit the percentage of loss to a maximum of 50 percent after 500 revolutions when tested in accordance with ASTM C131/C131M. Provide aggregate that is reasonably uniform in density and quality. Provide slag that is an air-cooled, blast-furnace product having a dry weight of not less than 70 pcf. Provide aggregates with a maximum size of 3 inch, a minimum of 70 percent passing the 3/4 inch sieve, and within the limits specified as follows:

Table 2			
Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve			
Sieve Designation	No. 1	No. 2	No. 3
No. 10	50	80	100
No. 200	8	8	8

Limit particles having diameters less than 0.02 mm to a maximum of 3 percent by weight of the total sample tested as determined in accordance with ASTM D7928. Limit the portion of any blended component and of the completed course passing the No. 40 sieve to be either nonplastic or have a Liquid Limit not greater than 25 and a Plasticity Index not greater than 5.

2.1.2 Select-Material Course

Provide materials consisting of selected soil or other materials from field excavation, stockpiles, or other sources and free from lumps and balls of clay and from organic and other objectionable matter. Provide materials with not more than 25 percent by weight passing the No. 200 sieve. Limit the portion of material passing the No. 40 sieve to a Liquid Limit less than 35 and a Plasticity Index less than 12. Provide materials having a maximum particle size not exceeding 3 inches. Limit particles having diameters less than 0.02 mm to a maximum of 3 percent by weight of the total sample tested as determined in accordance with ASTM D7928.

2.1.3 Rigid Pavement Base Course

Provide aggregates consisting of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Provide aggregates which are durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Limit the percentage of loss to a maximum of 50 percent after 500 revolutions when tested in accordance with ASTM C131/C131M. Provide aggregates with at least 75 percent by weight retained on each sieve having one freshly fractured face with the area at least equal to 75 percent of the smallest midsectional area of the piece. Provide aggregate that is reasonably uniform in density and quality. Provide slag that is an air-cooled, blast-furnace product having a dry weight of not less than 70 pcf. Provide aggregates having a maximum size of 2 inches, a minimum of 70 percent passing the 3/4 inch sieve, and within the limits specified as follows:

TABLE 3	
Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve	
Sieve Designation	Rigid Pavement Base Course
No. 10	85
No. 200	15

Limit particles having diameters less than 0.02 mm to a maximum of 3 percent by weight of the total sample tested as determined in accordance with ASTM D7928. Limit the portion of any blended component and of the completed course passing the No. 40 sieve to be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 6. Provide any additional stability required to maintain a working platform for construction equipment. If a test section can demonstrate that a material has adequate stability to support construction equipment, the fractured face requirement can be deleted, subject to approval by the Government.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Initial Tests

Perform one of each of the following Initial Tests on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements prior to installation. Complete this testing for each source if materials from more than one source are proposed.

a. Gradation including 0.02 mm size material.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

e. Weight per cubic foot of Slag.

Submit certified copies of test results for approval not less than 30 days before material is required for the work.

2.2.2 Approval of Material

Tentative approval of material will be based on initial test results.

2.3 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work are subject to approval by the Government before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Use equipment capable of minimizing segregation, producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area.

3.2 OPERATION OF AGGREGATE SOURCES

Condition aggregate sources on private lands in accordance with local laws and authorities. Clear, strip and excavate as required. Condition aggregate sources on Government property to readily drain and leave in a satisfactory condition upon completion of the work.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas designated to prevent segregation. Stockpile materials obtained from different sources separately.

3.4 PREPARATION OF UNDERLYING COURSE OR SUBGRADE

Clean the underlying course or subgrade of all foreign substances prior to constructing the subbase or select-material or rigid pavement base course. Do not construct subbase or select-material or rigid pavement base course on underlying course or subgrade that is frozen. Construct the surface of the underlying course or subgrade to meet specified compaction and surface tolerances. Correct ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the specified requirements set forth herein by loosening and removing soft or unsatisfactory material and adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in ASTM D2487, stabilize the surface prior to placement of the overlying course. Stabilize by mixing the overlying course material into the underlying course and compacting by approved methods. Consider the stabilized material as part of the underlying course and meet all requirements of the underlying course. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a satisfactory condition until the overlying course is placed.

3.5 GRADE CONTROL

Provide a finished and completed subbase select-material and or rigid pavement base courses conforming to the lines, grades, and cross sections shown. Place line and grade stakes as necessary for control.

3.6 MIXING AND PLACING MATERIALS

Mix and place the materials to obtain uniformity of the material at the water content specified. Make such adjustments in mixing or placing procedures or in equipment as directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to provide a satisfactory course.

3.7 LAYER THICKNESS

Compact the completed course to the thickness indicated. Limit individual compacted lifts to a maximum thickness of 6 inches and a minimum thickness of 3 inches. Compact the course(s) to a total thickness that is within the tolerances of paragraph ACCEPTANCE. Where the measured thickness is more than 1/2 inch deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2 inch thicker than indicated, the course will be considered as conforming to the specified thickness requirements. However, the requirements for the overlying course thickness and plan grade are still applicable. The average job thickness will be the average of all thickness measurements taken for the job and within the tolerances of paragraph ACCEPTANCE.

3.8 COMPACTION

Compact each lift of the material, as specified, with approved compaction equipment. For cohesive soils, maintain water content during the compaction procedure to within plus or minus 2 percent of optimum water content determined from laboratory tests as specified in this Section and for cohesionless soils, maintain a water content to facilitate compaction without bulking. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Slightly vary the length of alternate trips of the roller. Adjust speed of the roller as needed so that displacement of the aggregate does not occur. Compact mixture with hand-operated power tampers in all places not accessible to the rollers. Continue compaction of the subbase rigid pavement base or select-material until each lift is compacted through the full depth to meet the compaction requirements of Table 1. Make such adjustments in compacting or finishing procedures to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a compliant subbase and select-material rigid pavement base course. Remove any materials that are found to be non-compliant and replace with compliant material or rework, as directed, to meet the requirements of this specification.

3.9 PROOF ROLLING

In addition to the compaction specified, proof roll subbase course in areas designated on the drawings by application of coverages of a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi. A coverage is defined as the application of one tire print over the designated area. In the areas designated, apply proof rolling to the top lift of the completed subbase course. Maintain water content of the top lift of the subbase course as specified in paragraph COMPACTION from start of compaction to completion of proof rolling. Remove any subbase course materials that produce permanent deformation exceeding 1/2 inch and replace with satisfactory materials. Then recompact and proof roll to meet specifications.

3.10 EDGES OF SUBBASE AND SELECT-MATERIAL RIGID PAVEMENT BASE COURSE

Place approved material along the outer edges of the subbase and select-material rigid pavement base course in sufficient quantity to compact to the thickness of the course being constructed. When the course is being constructed in two or more lifts, simultaneously roll and compact at least a 2 foot width of this shoulder material with the rolling and compacting of each lift of the course, as directed.

3.11 FINISHING

Finish the surface of the top lift of rigid pavement base course after final compaction and proof rolling by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin lifts of material to the top lift of rigid pavement base course to meet grade. If the elevation of the top lift of rigid pavement base course exceeds the tolerances of paragraph ACCEPTANCE, scarify the top lift to a depth of at least 3 inches and blend new material in and compact to bring to grade. Make adjustments to rolling and finishing procedures to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable rigid pavement base course. If the surface becomes rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the non-compliant portion and rework and recompact it or replace as directed.

3.12 SMOOTHNESS TEST

Construct the top lift so that the surface shows no deviations exceeding the tolerances of paragraph ACCEPTANCE when tested with a 12 foot straightedge. Test the entire area in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines 15 feet or less apart, as directed. Perform the longitudinal lines at the centerline of each placement lane and at the 1/8th point in from each side of the lane. Hold the straightedge in contact with the surface and move ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the surface and measuring the maximum gap between the straightedge and the surface. Determine measurements along the entire length of the straight edge. Correct deviations exceeding the tolerances of Table 1 by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.13 FIELD QUALITY CONTROL

3.13.1 In-Place Tests

Perform one of each of the following In-Place Tests on samples taken from the placed and compacted subbase and select-material rigid pavement base course. Determine sample locations using random sampling in accordance with ASTM D3665. Take samples and test at the rates indicated.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 500 square yards, or portion thereof, of completed area.

b. Perform gradation including 0.02 mm size material on every lift of material placed and at a frequency of one gradation for every 1,000 square yards, or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the gradation.

d. Measure the thickness of each course at intervals providing at least one measurement for each 500 square yards or part thereof. Measure the thickness using test holes, at least 3 inches in diameter through the course.

3.13.2 Approval of Material

Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and fully compacted course(s).

3.14 TRAFFIC

Completed portions of the rigid pavement base course can be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Do not allow heavy equipment on the completed rigid pavement base course except when necessary for construction. When it is necessary for heavy equipment to travel on the completed rigid pavement base course, protect the area against marring or damage to the completed work. Repair damage to meet these specifications.

3.15 MAINTENANCE

Maintain the completed course in a satisfactory condition until the full pavement section is completed and accepted. Immediately repair any defects and repeat repairs as often as necessary to keep the area intact. Retest any course that was not paved over prior to the onset of winter to verify that it still complies with the requirements of this specification. Rework or replace any area that is damaged as necessary to comply with this specification.

3.16 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that have been removed outside the limits of Government-controlled land. No additional payments will be made for materials that have to be replaced.

-- End of Section --

SECTION 32 11 23

AGGREGATE BASE COURSE AND/ORGRADED CRUSHED AGGREGATE BASE COURSE FOR FLEXIBLE PAVING

05/22

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

1.1.1.1 Area

Measure the quantity of ABC and GCA completed and accepted, in square yards.

1.1.1.2 Volume

Measure the quantity of ABC and GCA completed and accepted, in cubic yards. Determine the volume of material in-place and accepted by the average job thickness obtained in accordance with paragraph LAYER THICKNESS and the dimensions shown on the drawings.

1.1.2 Payment

1.1.2.1 Base Course Material

Quantities of ABC and GCA, determined as specified above, will be paid for at the respective contract unit prices, which will constitute full compensation for the construction and completion of the ABC and GCA.

1.1.2.2 Stabilization

Cohesionless subgrade or subbase courses to be stabilized, as specified in paragraph PREPARATION OF UNDERLYING COURSE OR SUBGRADE, will be paid for as a special item on a tonnage basis including extra manipulation as required.

1.1.3 Waybills and Delivery Tickets

Submit copies of waybills and delivery tickets during progress of the work. Before the final payment is allowed, file certified waybills and certified delivery tickets for all aggregates actually used.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C1252	(2017) Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718/D4718M	(2015) Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5821	(2013; R 2017) Standard Test Method for

	Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D7928	(2017) Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.3 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.3.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.3.2 Graded-Crushed Aggregate Base Course

Graded-crushed aggregate (GCA) base course is well graded, crushed, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.3.3 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the laboratory maximum dry density in accordance with ASTM D1557 Method C and corrected with ASTM D4718/D4718M.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools; G

Waybills and Delivery Tickets

SD-06 Test Reports

Initial Tests; G

In-Place Tests; G

Test Section Report; G

1.5 QUALITY ASSURANCE

Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Do not start work requiring testing until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. Furnish copies of test results within 24 hours of completion of the tests.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M.

1.5.2 Tests

1.5.2.1 Gradation Analysis

Perform gradation analysis in conformance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11..

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with paragraph DEGREE OF COMPACTION.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, or ASTM D6938. For the method presented in ASTM D1556/D1556M use the base plate as shown in the drawing. For the method presented in ASTM D6938 check the calibration curves and adjust them, if necessary, using only the sand cone method as described in Annex A2 of ASTM D6938. Use ASTM D6938 to determine the moisture content of the soil. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in Annex A2 of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.5.2.5 Wear Test

Perform wear tests on ABC and GCA course material in conformance with ASTM C131/C131M.

1.5.2.6 Flat and Elongated Pieces

Determine flat and elongated pieces on ABC and GCA course material in conformance with ASTM D4791, Method A.

1.5.2.7 Soundness

Perform soundness tests on GCA in accordance with ASTM C88.

1.5.2.8 Fractured Faces

Perform fractured faces test on ABC GCA coarse aggregate in comformance with ASTM D5821.

1.5.2.9 Weight of Slag

Determine weight per cubic foot of slag in accordance with ASTM C29/C29M on the ABC and GCA course material.

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

1.7 ACCEPTANCE

1.7.1 Tolerances

Acceptance of ABC GCA is based on compliance with the tolerances presented in Table 1. Remove any materials found to be non-compliant and replace with compliant material or rework, as directed, to meet the requirements of this specification

TABLE 1

Measurement	Tolerance
Grade	Plus 1/4 inch, Minus 1/2 inch
Smoothness	Plus/Minus 3/8 inch
Individual Test Total Thickness	Plus/Minus
Average Job Thickness	Plus/Minus
Compaction	Minimum 100 percent

1.7.2 Test Section

Construct a test section consisting of 1000 square yards to demonstrate the materials, equipment, and construction processes meet the requirements of this specification. Acceptance of the test section is based on compliance with the tolerances listed in Table 1. Rework, re-compact, or remove and replace test sections that do not meet specification requirements. Do not commence full operations until a test section report has been approved. Use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments are approved in advance.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide ABC and GCA consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, crushed recycled concrete, angular sand, or other approved material. Provide ABC that is free of lumps of clay, organic matter, and other objectionable materials or coatings. The portion retained on the No. 4 sieve is known as coarse aggregate; that portion passing the No. 4 sieve is known as fine aggregate. When the coarse and fine aggregate is supplied from more than one source, provide aggregate from each source that meets the specified requirements.

2.1.1 Coarse Aggregate

Provide coarse aggregates with angular particles of uniform density. Separately stockpile coarse aggregate supplied from more than one source.

a. Crushed Gravel: Provide crushed gravel that has been manufactured by crushing gravels and that meets all the requirements specified below.

b. Crushed Stone: Provide crushed stone consisting of freshly mined quarry rock, meeting all the requirements specified below.

c. Crushed Recycled Concrete: Provide crushed recycled concrete (RCA) consisting of previously hardened portland cement concrete or other concrete containing pozzolanic binder material. Provide RCA of a consistent gradation and properties obtained from on-base stockpiles or concrete pavement demolished under this contract. Provide recycled concrete that is free of all reinforcing steel, bituminous concrete surfacing, and any other foreign material and that has been crushed and processed to meet the required gradations for coarse aggregate. Reject recycled concrete aggregate exceeding this value. Provide crushed recycled concrete that meets all other applicable requirements specified below.

d. Crushed Slag: Provide crushed slag that is an air-cooled blast-furnace product having a minimum air dry unit weight of 70 pcf as determined by ASTM C29/C29M, and meets all the requirements specified below.

2.1.1.1 Aggregate Base Course

Limit the percentage of loss of ABC coarse aggregate to a maximum of 50 percent when tested in accordance with ASTM C131/C131M. Provide aggregate that contains a maximum of 30 percent flat and elongated particles when tested in accordance with ASTM D4791, Method A. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, provide crushed aggregates containing a minimum of 50 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures is required to be a minimum of 30 degrees in order to count as two fractured faces. Manufacture crushed gravel from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve listed in TABLE 2.

2.1.1.2 Graded-Crushed Aggregate Base Course

Limit the percentage of loss of GCA coarse aggregate to a maximum of 40 percent when tested in accordance with ASTM C131/C131M. Provide GCA coarse aggregate that does not exhibit a loss greater than 18 percent weighted average, at five cycles, when tested for soundness in magnesium sulfate, or 12 percent weighted average, at five cycles, when tested in sodium sulfate in accordance with ASTM C88. . Provide aggregate that contains a maximum of 20 percent flat and elongated particles for the fraction retained on the 1/2 inch sieve nor 20 percent for the fraction passing the 1/2 inch sieve when tested in accordance with ASTM D4791, Method A. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, provide crushed aggregate containing a minimum of 90 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures is required to be a minimum of 30 degrees in order to count as two fractured faces. Manufacture crushed gravel from gravel particles 90 percent of which by weight are retained on the maximum size sieve listed in TABLE 2.

2.1.2 Fine Aggregate

Provide fine aggregates consisting of angular particles of uniform density.

2.1.2.1 Aggregate Base Course

Provide ABC fine aggregate that consists of screenings, angular sand, crushed recycled concrete fines, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

2.1.2.2 Graded-Crushed Aggregate Base Course

Provide GCA fine aggregate consisting of angular particles produced by crushing stone, slag, recycled concrete, or gravel that meets the requirements for wear and soundness specified for GCA coarse aggregate. Provide fine aggregate that contains a minimum of 45 percent by weight of uncompacted voids when tested in accordance with ASTM C1252, Method A.

2.1.3 Gradation Requirements

Apply the specified gradation requirements to the completed base course. Provide aggregates that are continuously well graded within the limits specified in TABLE 2. Use sieves that conform to ASTM E11.

TABLE 2. GRADATION OF AGGREGATES			
Percentage By Weight Passsing Square-Mesh Sieve			
Sieve Designation	No. 1	No. 2	No.3
2 inch	100	---	---
1-1/2 inch	70-100	100	---
1 inch	45-80	60-100	100

TABLE 2. GRADATION OF AGGREGATES			
1/2 inch	30-60	30-65	40-70
No. 4	20-50	20-50	20-50
No. 10	15-40	15-40	15-40
No. 40	5-25	5-25	5-25
No. 200	0-8	0-8	0-8

NOTE 1: Limit particles having diameters less than 0.02 mm to a maximum of 3 percent by weight of the total sample tested as determined in accordance with ASTM D7928.

NOTE 2: The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, test the materials in accordance with ASTM C127 and ASTM C128 to determine their specific gravities. Correct the percentages passing the various sieves as directed if the specific gravities vary by more than 10 percent.

NOTE 3: Gradations containing more than 30 percent retained on the ¾ inch sieve can produce inconsistent compacted density values when tested in accordance with paragraph DEGREE OF COMPACTION.

2.2 LIQUID LIMIT AND PLASTICITY INDEX

Apply liquid limit and plasticity index requirements to the completed course and to any component that is blended to meet the required gradation. Limit the portion of any component or of the completed course passing the No. 40 sieve to be either nonplastic or have a maximum liquid limit of 25 and a maximum plasticity index of 5.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Initial Tests

Perform one of each of the following initial tests on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements when furnished. Complete this testing for each source if materials from more than one source are proposed. Submit certified copies of test results for approval a mimimum of 30 days before material is required for the work.

a. Gradation Analysis including 0.02 mm material.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

e. Flat and Elongated Pieces.

f. Soundness.

g Fractured Faces .

h. Weight per cubic foot of Slag.

2.3.2 Approval of Material

Tentative approval of material will be based on initial test results.

2.4 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work are subject to approval by the Government before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Use equipment capable of minimizing segregation, producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

When the ABC or GCA is constructed in more than one lift, clean the previously constructed lift of loose and foreign matter by sweeping with power sweepers or power brooms. Use hand brooms in areas where power cleaning is not practicable. Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area.

3.2 OPERATION OF AGGREGATE SOURCES

Condition aggregate sources on private lands in accordance with local laws or authorities. Clear, strip, and excavate as required. Condition aggregate sources on Government property to readily drain and leave in a satisfactory condition upon completion of the work.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas designated to prevent segregation. Stockpile materials obtained from different sources separately.

3.4 PREPARATION OF UNDERLYING COURSE OR SUBGRADE

Clean the underlying course or subgrade of all foreign substances prior to constructing the base course(s). Do not construct base course(s) on underlying course or subgrade that is frozen. Construct the surface of the underlying course or subgrade to meet specified compaction and surface tolerances. Correct ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the specified requirements set forth herein by loosening and removing soft or unsatisfactory material and adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in ASTM D2487, stabilize the surface prior to placement of the base course(s). Stabilize by mixing ABC or GCA into the underlying course and compacting by approved methods. Proof roll in accordance with paragraph PROOF ROLLING. Consider the stabilized material as part of the underlying course and meet all requirements of the underlying course. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a compliant condition until the base course is placed.

3.5 GRADE CONTROL

Provide a finished and completed base course conforming to the lines, grades, and cross sections shown. Place line and grade stakes as necessary for control.

3.6 MIXING AND PLACING MATERIALS

3.6.1 Mixing

Mix the coarse and fine aggregates in a stationary plant, or in a traveling plant. Make adjustments in mixing procedures or in equipment to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to produce a satisfactory base course meeting all requirements of this specification.

3.6.2 Placing

Place the mixed material on the prepared subgrade or subbase in lifts of uniform thickness with an approved spreader. Place the lifts so that when compacted they are true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one lift, clean the previously constructed lift of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms. Make adjustments in placing procedures or equipment to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to produce an acceptable base course.

3.7 LAYER THICKNESS

Compact the completed base course to the thickness indicated. Limit individual compacted lifts to a maximum thickness of 6 inches and a minimum thickness of 3 inches. Compact the base course(s) to a total thickness that is within the tolerances of paragraph ACCEPTANCE of the thickness indicated. Where the measured thickness is more than 1/2 inch deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2 inch thicker than indicated, the course will be considered as conforming to the specified thickness requirements. However, the requirements for wearing course thickness and plan grade are still applicable. The average job thickness will be the average of all thickness measurements taken for the job and within the tolerances of paragraph ACCEPTANCE of the thickness indicated.

3.8 COMPACTION

Compact each lift of the base course, as specified, with approved compaction equipment. For cohesive soils, maintain water content during the compaction procedure to within plus or minus 2 percent of the optimum water content determined from laboratory tests as specified and for cohesionless soils, maintain the water content to facilitate compaction without bulking. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Slightly vary the length of alternate trips of the roller. Adjust speed of the roller as needed so that displacement of the aggregate does not occur. Compact mixture with hand-operated power tampers in all places not accessible to the rollers. Continue compaction until each lift is compacted through the full depth to meet the compaction requirements of Table 1. Make such adjustments in compacting or finishing procedures to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to produce a compliant base course. Remove any materials found to be non-compliant and replace with compliant material or rework, as directed, to meet the requirements of this specification.

3.9 PROOF ROLLING

In addition to the compaction specified, proof roll areas designated on the drawings by application of coverages of a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi. A coverage is defined as the application of one tire print over the designated area. In the areas designated, apply proof rolling to the top of the underlying material on which the base course is laid and to the top of each lift of base course. Maintain water content of the underlying material and each lift of the base course as specified in Paragraph COMPACTION from start of compaction to completion of proof rolling of that lift. Remove any base course materials or any underlying materials that produce permanent deformation exceeding 3/8 inch by proof rolling and replace with satisfactory materials. Then recompact and proof roll to meet these specifications.

3.10 EDGES OF BASE COURSE

Place the base course(s) so that the completed section is a minimum of 2 feet wider, on all sides, than the next lift that will be placed above it. Place approved material along the outer edges of the base course in sufficient quantity to compact to the thickness of the course being constructed. When the course is being constructed in two or more lifts, simultaneously roll and compact at least a 2 foot width of this shoulder material with the rolling and compacting of each lift of the base course.

3.11 FINISHING

Finish the surface of the top lift of base course after final compaction and proof rolling by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin lifts of material to the top lift of base course to meet grade. If the elevation of the top lift of base course exceeds the tolerances of paragraph ACCEPTANCE, scarify the top lift to a depth of at least 3 inches and blend new material in and compact and proof roll to bring to grade. Make adjustments to rolling and finishing procedures to minimize segregation and degradation, obtain grades, maintain moisture content, and produce an acceptable base course. If the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the non-compliant portion and rework and recompact it or replace as directed.

3.12 SMOOTHNESS TEST

Construct the top lift so that the surface shows no deviations exceeding the tolerances of paragraph ACCEPTANCE when tested with a 12 foot straightedge. Test the entire area in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines at a maximum spacing of 15 feet or less apart, as directed. Perform the longitudinal lines at the centerline of each placement lane, regardless of whether multiple lanes are allowed to be paved at the same time, and at the 1/8th point in from each side of the lane. Hold the straightedge in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Determine measurements along the entire length of the straight edge. Correct deviations exceeding this amount by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.13 FIELD QUALITY CONTROL

3.13.1 In-Place Tests

Perform each of the following in-place tests on samples taken from the placed and compacted ABC and GCA. Determine sample locations using random sampling in accordance with ASTM D3665. Take samples and test at the rates indicated. Perform sampling and testing of recycled concrete aggregate at twice the specified frequency until the material uniformity is established.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square yards, or portion thereof, of completed area. Gradations containing more than 30 percent retained on the ¾ inch sieve can produce inconsistent compacted density values when tested in accordance with paragraph DEGREE OF COMPACTION.

b. Perform gradation analysis including 0.02 mm size material on every lift of material placed and at a frequency of one sieve analysis for every 500 square yards, or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.

d. Measure the thickness of the base course at intervals providing at least one measurement for each 500 square yards of base course or part thereof. Measure the thickness using test holes, at least 3 inch in diameter through the base course.

3.13.2 Approval of Material

Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and fully compacted course(s).

3.14 TRAFFIC

Completed portions of the base course can be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Do not allow heavy equipment on the completed base course except when necessary for construction. When it is necessary for heavy equipment to travel on the completed base course, protect the area against marring or damage to the completed work. Repair damage to meet these specifications.

3.15 MAINTENANCE

Maintain the base course in a satisfactory condition until the full pavement section is completed and accepted. Immediately repair any defects and repeat repairs as often as necessary to keep the area intact. Retest any base course that was not paved over prior to the onset of winter to verify that it still complies with the requirements of this specification. Rework or replace any area of base course that is damaged as necessary to comply with this specification.

3.16 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that have been removed outside the limits of Government-controlled land. No additional payments will be made for materials that have to be replaced.

-- End of Section --

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SECTION 32 11 23.23

BASE COURSE DRAINAGE LAYERS
08/17

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

Deductions will be made for any material wasted, unused, rejected, or used for the convenience of the Contractor.

1.1.1.1 Aggregate Drainage Layer Material

Measure the quantity of aggregate drainage layer material, completed and accepted, as determined by the Contracting Officer, in cubic yards.

1.1.1.2 Bituminous or Cement Stabilized Drainage Layer

Measure the quantity of bituminous or cement stabilized drainage layer material, completed and accepted, in 2000 pound tons, excluding the weight of the asphalt or portland cement used in the mix.

1.1.1.3 Bituminous Material

Measure the quantity of asphalt cement, used in the bituminous stabilized mix, by the number of gallons of material used in the accepted work corrected to gallons at 60 degrees F in accordance with ASTM D1250.

1.1.1.4 Cementitious Material

Measure the quantity of portland cement, used in the cement stabilized mix, by the number of short hundred-weight (cwt) units of cement used in the accepted work.

1.1.2 Payment

The quantities of drainage layer aggregates and bituminous or cementitious materials, as specified above, will be paid for at the contract unit prices, which will constitute full compensation for the construction and completion of the drainage layer, including the test section, and the furnishing of all other necessary labor and incidentals.

1.1.3 Waybills and Delivery Tickets

Submit copies of waybills and delivery tickets during the progress of the work. Before the final payment is allowed, file certified waybills and certified delivery tickets for all aggregates, bituminous, and cementitious materials actually used.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 102	(2009; R 2013) Standard Method of Test for Spot Test of Asphaltic Materials

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2021) Standard Specification for Portland Cement
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D946/D946M	(2020) Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D1250	(2019; E 2020) Standard Guide for Use of the Joint API and ASTM Adjunct for Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils: API MPMS Chapter 11.1
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles

	in Coarse Aggregate
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plants, Equipment, and Tools; G

Waybills and Delivery Tickets

SD-06 Test Reports

Initial Tests; G

In-Place Tests; G

Test Section Construction Report

1.4 EQUIPMENT, TOOLS, AND MACHINES

Build a drainage layer under the pavements, as indicated on drawings, consisting of Rapid Draining Material (RDM)Open Graded Material (OGM) stabilized with cement or bituminous.

1.4.1 Equipment

All plants, equipment, and tools used in the performance of the work will be subject to approval before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times.

1.4.2 Placement Equipment

Use an asphalt paving machine to place drainage layer material. Alternate methods may be used if it can be demonstrated in the test section that these methods obtain the specified results.

1.4.3 Compaction Equipment

Use a dual or single smooth 10 2000 lb- tons (min.) vibratory drum roller, which provides a maximum compactive effort without crushing the drainage layer aggregate, to compact drainage layer material.

1.4.4 Bituminous Mixing Plant

Provide a bituminous mixing plant that is an automatic or semiautomatic controlled, commercially manufactured unit capable of producing a bituminous stabilized aggregate mixture consistent with the job-mix formula (JMF).

1.4.5 Cementitious Mixing Plant

Provide a cementitious mixing plant that is an automatic or semiautomatic controlled, commercially manufactured unit capable of producing a cement stabilized aggregate mixture consistent with the job mix formula determined by the Government. Dry mix aggregate and cement sufficiently to prevent cement balls from forming when water is added.

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor. Performed sampling and testing using a laboratory approved in accordance with Section 01 45 00.00 1001 45 00.00 2001 45 00.00 40 QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.5.1 Sampling

Take aggregate samples in accordance with ASTM D75/D75M. Take bituminous samples in accordance with ASTM D140/D140M. Take bituminous or cement stabilized mixture samples using methods approved by the Contracting Officer.

1.5.2 Tests

1.5.2.1 Sieve Analyses

Perform sieve analyses in accordance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11.

1.5.2.2 Field Density Tests

Perform field density tests for RDM drainage layers in accordance with ASTM D6938 by Direct Transmission Method for the full depth of the lift, use ASTM D6938 to determine the moisture content of the aggregate drainage layer material. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in paragraph "Calibration" of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed by the Contracting Officer. Submit copies of field test results within 24 hours after the tests are performed.

1.5.2.3 Soundness Test

Perform soundness tests in accordance with ASTM C88.

1.5.2.4 Wear Test

Perform wear tests in conformance with ASTM C131/C131M.

1.5.2.5 Flat or Elongated Particles Tests

Perform flat and/or elongated particles tests in accordance with ASTM D4791.

1.5.2.6 Fractured Faces Tests

When aggregates are supplied from crushed gravel, use approved test methods to ensure the aggregate meets the requirements for fractured faces in paragraph AGGREGATES.

1.5.2.7 Bitumen Content

Perform bitumen extraction tests in accordance with ASTM D2172/D2172M or ignition tests in accordance with ASTM D6307.

1.5.3 Testing Frequency

1.5.3.1 Initial Tests

Perform one of each of the following tests on the proposed material, prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, complete the following tests for each source.

a. Sieve Analysis.

b. Flat and/or elongated particles.

c. Fractured Faces.

d. Wear.

e. Soundness.

1.5.3.2 In-Place Tests

a. Aggregate Layer. Perform field density and moisture content tests at a rate of at least one test for every 2000 square yards of completed area and not less than one test for each day's production. Perform sieve analyses at a rate of at least one test for every 6000 square yards of completed area. Perform soundness tests, wear tests, fractured faces tests and flat and/or elongated particles tests at the rate of one test for every 12,000 square yards of production.

b. Stabilized Layer. Perform sieve analyses on aggregates prior to addition of asphalt or portland cement, at a rate of at least one test for every 6000 square yards of completed area and not less than one test for each days production. Make extraction tests on bituminous stabilized material at the same frequency. Perform soundness tests, Los Angeles abrasion tests, fractured faces tests, and flat and/or elongated particles tests at the rate of one test for every 12,000 square yards of production.

1.5.4 Approval of Materials

Submit material sources and material test results prior to field use.

1.5.4.1 Aggregate

Select the aggregate source at least 60 days prior to field use in the test section. Tentative approval of the source will be based on certified test results to verify that materials proposed for use meet the contract requirements. Final approval of both the source and the material will be based on test section performance and tests for gradation, soundness, wear, flat and/or elongated particles tests and fractured faces tests. For aggregate drainage layer materials, perform these tests on samples taken from the completed and compacted drainage layer course within the test section. For bituminous or cement stabilized drainage layer material, perform these tests on aggregate samples taken prior to addition of bituminous or cementitious material and subsequent placement in the test section.

1.5.4.2 Bituminous or Cementitious Materials

Submit bituminous or cementitious sources and certified material test results for approval not less than 60 days prior to field use in the test section.

1.6 ENVIRONMENTAL REQUIREMENTS

Place drainage layer material when the atmospheric temperature is above 35 degrees F. Correct areas of completed drainage layer or underlying courses that are damaged by freezing, rainfall, or other weather conditions or by contamination from sediments, dust, dirt, or foreign material to meet specified requirements.

PART 2 PRODUCTS

2.1 GOVERNMENT APPROVAL

Asphalt or cement stabilized material will require Government notification and delivery of approved materials in accordance with paragraph BITUMINOUS OR CEMENT STABILIZED JOB-MIX FORMULA.

2.2 AGGREGATES

Provide aggregates consisting of clean, sound, hard, durable, angular particles of crushed stone, crushed slag, or crushed gravel which meet the specification requirements. Slag must be an air-cooled, blast-furnace product having a dry weight of not less than 65 pcf determined by ASTM C29/C29M. Provide aggregates free of silt and clay as defined by ASTM D2487, vegetable matter, and other objectionable materials or coatings.

2.2.1 Aggregate Quality

Provide aggregate with a soundness loss not greater than 18 percent weighted averaged at 5 cycles when tested in magnesium sulfate in accordance with ASTM C88 and a percentage of loss on abrasion not exceeding 40 after 500 revolutions as determined by ASTM C131/C131M. Determine the percentage of flat and/or elongated particles by ASTM D4791 with the following modifications: 1) Separate the aggregates into two size fractions, particles greater than 1/2 inch sieve and particles passing the 1/2 inch sieve and retained on the No. 4 sieve. 2) The percentage of flat and/or elongated particles in either fraction must not exceed 20. 3) A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. 4) When the aggregate is supplied from more than one source, aggregate from each source must meet the specified requirements. When the aggregate is supplied from crushed gravel it must be manufactured from gravel particles, 90 percent of which by weight are retained on the maximum-size sieve listed in TABLE I. In the portion retained on each sieve specified, the crushed gravel must contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the face. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces.

2.2.2 Gradation Requirements

Provide drainage layer aggregates that are well graded within the limits specified in TABLE I.

TABLE I. GRADATION OF DRAINAGE LAYER MATERIAL

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Rapid draining Material (RDM)	OGM Stabilized
1-1/2 inch	100	100
1 inch	70-100	95-100
3/4 inch	55-100	---
1/2 inch	40-80	25-80
3/8 inch	30-65	---
No. 4	10-50	0-10
No. 8	0-25	0-5
No. 16	0-5	---

NOTE 1: The values are based on aggregates of uniform specific gravity, and the percentages passing the various sieves may require appropriate correction by the Contracting Officer when aggregates of varying specific gravities are used.

NOTE 2: For RDM, the coefficient of uniformity (CU) must be greater than 3.5. (CU = D60/D10). The Contractor is responsible for adjusting the RDM gradation within the ranges listed in Table I to provide a stable construction surface for the proposed equipment and method of transporting materials. The drainage layer may be stabilized with portland cement or asphalt at no additional cost to the government, if approved during the test section.

NOTE 3: Asphalt cement or portland cement will be required to stabilize the OGM.

NOTE 4: The Optional Table I gradation can be met in some areas with 77% #57 stone and 23% concrete sand blend.

2.3 BITUMINOUS MATERIALS

Asphalt cement to be mixed with aggregates must conform to ASTM D946/D946M Penetration Grade . In addition, the asphalt cement must show a negative spot when subjected to the spot test in accordance with AASHTO T 102, using the standard naphtha specified.

2.4 CEMENTITIOUS MATERIALS

Portland cement to be mixed with aggregates must conform to ASTM C150/C150M, Type I, IA, II or IIA .

2.5 BITUMINOUS OR CEMENT STABILIZED JOB-MIX FORMULA

The bituminous stabilized mix consists of a mixture of OGM and a minimum of 2 percent asphalt cement by weight. Maintain tolerances for bituminous stabilized material for field production at plus or minus 0.25 percent for asphalt cement and plus or minus 25 degrees F for mixing temperatures. Provide cement stabilized mix consisting of OGM and a minimum of 200 pounds of portland cement per cubic yard with a water/cement ratio of 0.37. Based on the test section performance, the Contractor will be responsible for adjustments (increases) in asphalt cement or portland cement quantities to ensure the stabilized drainage layer will not rut or be disturbed by the Contractor's proposed paving method. Submit a job-mix formula (JMF) with the test section report for Contracting Officer approval.

PART 3 EXECUTION

3.1 OPERATION OF AGGREGATE SOURCES

Condition aggregate sources on private lands in accordance with local laws or authorities. Clearing, stripping, and excavating are the responsiblity of the Contractor. Condition aggregate sources on Government property to readily drain and leave in a satisfactory condition upon completion of the work.

3.2 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas designated by the Contracting Officer to prevent segregation. Stockpile materials obtained from different sources separately.

3.3 PREPARATION OF UNDERLYING COURSE

Clean the underlying course of all foreign materials prior to constructing the drainage layer. Do not construct the drainage layer on underlying course that is frozen. Construct the underlying course in accordance with Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASE SELECT-MATERIAL FOR FLEXIBLE PAVING. Correct ruts or soft yielding spots in the underlying courses having inadequate compaction and deviations of the surface from the requirements set forth herein by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line, and grade, and recompacting to specified density. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a satisfactory condition until the drainage layer is placed.

3.4 TRANSPORTING MATERIAL

3.4.1 Aggregate Drainage Layer Material

Transport aggregate drainage layer material to the site in a manner which prevents segregation and contamination of materials.

3.4.2 Bituminous Stabilized Material

Transport bituminous stabilized material from the mixing plant to the site in trucks having tight, clean, smooth beds lightly coated with an approved releasing agent to prevent adhesion of the stabilized material to the truck beds. Drain excessive releasing agent prior to loading. Cover each load with canvas or other approved material of ample size to protect the stabilized material from the weather and to prevent loss of heat. Loads that have crusts of cold, unworkable material or have become wet will be rejected. Hauling over freshly placed material will not be permitted.

3.4.3 Cement Stabilized Material

Transport cement stabilized material from the mixing plant to the site in trucks equipped with protective covers. Loads that have crusts of unworkable material or have become excessively wet will be rejected. Hauling over freshly placed material will not be permitted.

3.5 PLACING

3.5.1 General Requisites

Place drainage layer material on the underlying course in lifts of uniform thickness using equipment meeting the requirements of paragraph EQUIPMENT. When a compacted layer 6 inches or less in thickness is required, place the material in a single lift. When a compacted layer in excess of 6 inches is required, place the material in lifts of equal thickness. No lift may be thicker than 6 inches nor be thinner than 3 inches in compacted thickness. Place and compact lifts true to the grades or levels required with the least possible surface disturbance. Where the drainage layer is placed in more than one lift, clean the previously constructed lift of loose and foreign material. Make adjustments in placing procedures or equipment as needed to obtain true grades and minimize segregation and degradation of the drainage layer material.

3.5.2 Placement of Stabilized Material

Bituminous stabilized material having temperatures less than 175 degrees F when dumped into the asphalt paving machine will be rejected. Adjust the paving machine so that the surface of the lift being laid will be smooth and continuous without tears and pulls. Correct irregularities in alignment of the lift left by the paving machine by trimming directly behind the machine. Immediately after trimming, thoroughly compact the edges of the lift by a method approved by the Contracting Officer. Distortion of the lift during tamping will not be permitted. If more than one lift is required, offset the longitudinal joint in one lift over that in the lift immediately below by at least 1 foot; however, construct the joint in the top layer at the centerline of the pavement. Offset transverse joints in one layer by at least 2 feet from transverse joints in the previous layer. Offset transverse joints in adjacent strips by a minimum of 10 feet. At the end of each day's construction, form a straight transverse construction joint by cutting back into the completed work to form a true vertical face free of loose or shattered material. Remove material along construction joints not properly compacted.

3.5.3 Placing Adjacent Stabilized Strips

Place the stabilized material in consecutive adjacent strips having a minimum width of 10 feet, except where edge lanes require strips less than 10 feet to complete the area. When placing adjacent strips, operate the paving machine so that the screed overlaps the previously placed strip 3 to 4 inches and is sufficiently high so that compaction will produce a smooth, dense joint. Push back the stabilized material placed on the edge of the previously placed strip by the paver to the edge of the strip being placed. Remove and waste excess stabilized material.

3.5.4 Hand Spreading

Spread by hand drainage layer material in areas where machine spreading is impractical. Spread the material uniformly in a loose layer to prevent segregation. Construct the layer so that the compacted material conforms to the required grade and thickness after compaction.

3.6 TEST SECTION

3.6.1 Data

Construct a test section to evaluate the ability to carry traffic, including placement of overlaying material and the constructability of the drainage layer including required mixing, placement, and compaction procedures. Test section data will be used by the Contracting Officer to validate the required number of compaction passes given in paragraph Compaction Requirements and the field dry density requirements for full scale production.

3.6.2 Schedule/Evaluation

Construct the test section a minimum of 30 days prior to the start of full scale production to provide sufficient time for an evaluation of the proposed materials, equipment and procedures including Government QA testing.

3.6.3 Location and Size

Place the test section inside the production paving limits. Do not construct the drainage layer in the test section until the underlying courses and subgrade preparation, required for the pavement section, have been completed, inspected and approved. Place the test section a minimum of 100 feet long and two full paving lanes wide side by side.

3.6.4 Initial Testing

Provide certified test results, approved by the Contracting Officer prior to the start of the test section, to verify that the materials proposed for use in the test section meet the contract requirements.

3.6.5 Mixing, Placement, and Compaction

Accomplish mixing, placement, and compaction using equipment meeting the requirements of paragraph EQUIPMENT. Operate compaction equipment at speeds no greater than 1.5 mph. Start compaction from the outside edges of the paving lane and proceed to the centerline of the lift being placed. Keep the roller a minimum of one half the roller width from the outside edge of the drainage layer being placed until the desired density is obtained. Then roll the outside edge.

3.6.6 Procedure

3.6.6.1 RDM Aggregate Drainage Layer Tests

Construct the test section with aggregate in a wet state so as to establish a correlation between number of roller passes and dry density achievable during field production. Designate three separate areas within the test section, test each area for density, moisture, and gradation. Complete all testing in the middle third of the test section being placed. Conduct density and moisture content tests in accordance with ASTM D6938. Conduct sieve analysis tests on samples, taken adjacent to the density test locations. Take one set of tests (i.e. density, moisture, and sieve analysis) before the third compaction pass and after each subsequent compaction pass at three separate locations as directed by the Contracting Officer. Define a pass as the movement of a roller over the drainage layer area for one direction only. Compact the RDM using a maximum of 5 passes in the vibrating state and one final pass in the static state. Continue compaction passes and density readings until the difference between the average dry densities of any two consecutive passes is less than or equal to 1.0 pcf.

3.6.6.2 Bituminous/Cement Stabilized Drainage Layer

Construct the test section with the same equipment used for production. Designate three separate areas within the test section for sampling. Complete all testing in the middle third of the test section being placed. The Contracting Officer will perform visual examination of each sample to determine if and when crushing of aggregate occurs. Take one sample before compaction and after each subsequent compaction pass at three separate locations as directed by the Contracting Officer. Continue compaction for a maximum of 6 passes. A pass is defined as the movement of a roller over the drainage layer area for one direction only. Use placement procedures and equipment as described herein. The Contracting Officer will determine the number of passes required for compaction from the test section.

3.6.7 Evaluation

Within 10 days of completion of the test section, submit to the Contracting Officer a Test Section Construction Report complete with all required test data and correlations. The Contracting Officer will evaluate the data and validate the required number of passes of the roller, the need for a final static pass of the roller, and provide the dry density for field density control during construction.

3.7 COMPACTION REQUIREMENTS

3.7.1 Field Compaction

Base field compaction requirements on the results of the test section, using the materials, methods, and equipment proposed for use in the work.

3.7.2 Number of Passes

Accomplish compaction using rollers meeting the requirements of paragraph EQUIPMENT and operating at a rolling speed of no greater than 1.5 miles per hour. Compact each lift of drainage material, including shoulders when specified under the shoulders, with the number of passes of the roller as follows: for RDM material use 4 passes in the vibratory state and one in the static. For cement or Bituminous stabilized OGM material use 3 passes in the vibratory state and one in the static state. The Contracting Officer will validate the number of roller passes after the test section is evaluated and before production starts.

3.7.3 Dry Density

In addition, maintain a minimum field dry density as specified by the Contracting Officer. If the required field dry density is not obtained, adjust the number of roller passes in accordance with paragraph DEFICIENCIES. Compact aggregate in a moisture state as determined in the test section. Avoid crushing of aggregate particles by excessive rolling. Begin compaction of bituminous stabilized material immediately when the material has cooled to 170 degrees F. Not more than 30 minutes may elapse between the start of moist mixing of cement stabilized material and the start of field compaction. Complete field compaction within 60 minutes. In all places not accessible to the rollers, compact the drainage layer material with mechanical hand operated tampers.

3.8 FINISHING

Finish the top surface of the drainage layer after final compaction, as determined from the test section. Make adjustments in rolling and finishing procedures to obtain grades and minimize segregation and degradation of the drainage layer material.

3.9 CURING OF CEMENT STABILIZED MATERIAL

Cure the completed cement stabilized drainage layer with water for a period of 12 hours following completion of compaction. Commence curing operations within 3 hours after compaction. Curing consists of one of the following: 1) Sprinkling the surface of the drainage layer with a fine spray of water every 2 hours for the required 12 hour period, 2) by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap, 3) Impervious sheet curing. Apply curing water so that the cement paste on the surface of the mixture will not be eroded. Water trucks will not be permitted on the completed cement stabilized drainage layer. Impervious sheeting curing consists of all surfaces being thoroughly wetted and then completely covered with the sheeting. Place sheeting at least 18 inches wider than the stabilized drainage layer surface to be covered. Lay covering with light-colored side up. Lap covering not less than 12 inches; securely weight covering to prevent displacement so that it remains in contact with the surface during the specified length of curing. Fold down coverings over exposed edges of slabs and secure by approved means. Immediately repair or replace sheets if tears or holes appear during the curing period

3.10 EDGES OF DRAINAGE LAYER

Place shoulder material along the edges of the drainage layer course in a quantity that will compact to the thickness of the layer being constructed. Roll and compact at least a 3 feet width of the shoulder simultaneously with the rolling and compacting of each lift of the drainage layer.

3.11 SMOOTHNESS TEST

Construct the top lift so that the surface show no deviations in excess of 3/8 inch when tested with either a 10 or 12 foot straightedge applied parallel with and at right angles to the centerline of the area to be paved. Correct deviations exceeding 3/8 inch in accordance with paragraph DEFICIENCIES.

3.12 THICKNESS CONTROL

Compact the drainage layer to a thickness that is within 1/2 inch of the thickness indicated. Measure thickness at intervals providing at least one measurement for each 500 square yards of drainage layer. Make measurements in test holes at least 3 inches in diameter unless the Contractor can demonstrate, for COR approval, that a steel rod pushed through the drainage layer clearly stops at the material interface. Where the measured thickness is more than 1/2 inch deficient, correct such areas in accordance with paragraph DEFICIENCIES. Where the measured thickness is 1/2 inch more than indicated, it will be considered as conforming to the requirements plus 1/2 inch, provided the surface of the drainage layer is within 1/2 inch of established grade. The average job thickness will be the average of all job measurements as specified above but within 1/4 inch of the thickness shown on the drawings.

3.13 DEFICIENCIES

3.13.1 Grade and Thickness

Correct deficiencies in grade and thickness so that both grade and thickness tolerances are met. Do not add thin layers of material to the top surface of the drainage layer to meet grade or increase thickness. Trim the top of the drainage layer to grade and finish in accordance with paragraph FINISHING if the surface elevation is more than 1/2 inch above the plan grade. If the elevation of the top surface of the drainage layer is 1/2 inch or more below the required grade, scarify the surface of the drainage layer to a depth of at least 3 inches, add new material , and blend and recompact the layer to bring it to grade. Where the measured thickness of the drainage layer is more than 1/2 inch deficient, correct such areas by excavating to the required depth and replace with new material to obtain a compacted lift thickness of at least 3 inches. Control the depth of required excavation to keep the final surface elevation within grade requirements and to preserve layer thicknesses of materials below the drainage layer.

3.13.2 Density

Density will be considered deficient if the field dry density test results are below the dry density specified by the Contracting Officer. Roll the layer with 2 additional passes of the specified roller if the densities are deficient. If the dry density is still deficient, work will be stopped until the cause of the low dry densities can be determined and reported to the Contracting Officer.

3.13.3 Smoothness

Correct deficiencies in smoothness as if they are deficiencies in grade or thickness. Maintain all tolerances for grade and thickness while correcting smoothness deficiencies.

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SECTION 32 11 26

HOT-MIX BITUMINOUS BASE COURSE FOR ROADS AND STREETS
05/20

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

The amount paid for will be the number of 2000-pound tons of bituminous mixture used in the accepted work. Weigh bituminous mixture after mixing. No payment will be made for defective areas until corrected.

1.1.2 Basis for Payment

The quantities of bituminous base course will be paid for at the respective contract unit prices in the bid schedule. Payment will constitute full compensation for preparing and reconditioning the underlying layer; for furnishing all material, equipment, plant, and tools; and for all labor and other incidentals necessary to complete the work required by this section.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 156	(2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures

ASPHALT INSTITUTE (AI)

AI MS-2	(2015) Asphalt Mix Design Methods

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C183/C183M	(2015) Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D242/D242M	(2009; R 2014) Mineral Filler for Bituminous Paving Mixtures
ASTM D1856	(2009; R 2015) Recovery of Asphalt from Solution by Abson Method
ASTM D2041/D2041M	(2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2726/D2726M	(2019) Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867/D4867M	(2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures

ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6373	(2016) Standard Specification for Performance Graded Asphalt Binder
ASTM D6925	(2014) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Sources of Aggregates

Job Mix Formula; G

SD-06 Test Reports

Sources of Aggregates

Bituminous Materials

Test Section; G

Service Record; G

SD-09 Manufacturer's Field Reports

Batch Tickets

1.4 QUALITY CONTROL

1.4.1 Qualifications

Perform sampling and testing using an approved commercial testing laboratory or on-site facilities. Submit accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM D3666, including all applicable test procedures. Do not start work requiring testing until the facilities have been inspected and approved. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. Maintain this certification for the duration of the project.

1.4.2 Test Results

Verify that materials comply with the specification. When a material source is changed, test the new material for compliance. When deficiencies are found, repeat the initial analysis and retest the material already placed to determine the extent of unacceptable material. Replace or repair all in-place unacceptable material to conform to the contract requirements. Submit copies of field tests results within 24 hours after the tests are performed and certified copies of tests results for approval not less than 30 days before material is required for the work.

1.4.3 Batch Tickets

Provide batch tickets in accordance with AASHTO M 156.

1.4.4 Aggregates

Select sources of aggregates and submit a plan for operation of a new source of aggregates at least 45 days in advance of starting production. If a previously developed source is selected, submit test results with evidence that central plant hot-mix bituminous pavements constructed with the aggregates have had a satisfactory service record of at least 5 years under similar climatic conditions. Include in the service record a tabulation of aggregate gradation and quality test results, typical hot-mix asphalt mix design using the aggregate, and a list of representative paving projects using the aggregate. Make such tests and other investigations as necessary to determine whether or not aggregates meeting the requirements specified can be produced from the proposed sources. Sample aggregates in accordance with ASTM D75/D75M and test them at the start of production.

1.4.5 Mineral Filler

Sample mineral filler in accordance with ASTM C183/C183M.

1.4.6 Bituminous Materials

Select sources where bituminous materials are obtained in advance of time when materials will be required in the work. Sample bituminous materials in accordance with ASTM D140/D140M. Submit test results not less than 30 days before such material is required for use in the work.

1.5 ENVIRONMENTAL REQUIREMENTS

Do not construct bituminous courses when the underlying course contains free surface water, or when temperature of the surface of the underlying course is below 40 degrees F, unless otherwise directed.

1.6 ACCEPTANCE

1.6.1 Tolerances

Acceptance of bituminous base course is based on compliance with the tolerances presented in Table 1. Remove and replace bituminous base course represented by the failing tests or submit repair plan for approval.

TABLE 1

Attribute	Measurement
Plant Mixture	
Delivery to Laydown Machine	Minimum 250 deg F

TABLE 1	
Laboratory Air Voids	3 to 5 percent
Finished Mat	
Mat Density (avg of 4 cores/lot)	Minimum 92 percent of TMD
Joint Density (avg of 4 cores/lot)	Minimum 90.5 percent of TMD
Grade	plus/minus 0.05 foot
Smoothness	plus/minus 3/8 inch
Longitudinal Joint Offset	Minimum 1 foot
Transverse Joint Offset	Minimum

1.6.2 Test Section

At the start of plant operation, prepare a quantity of the mixture sufficient to construct a test section at least 100 feet long and two spreader widths wide. Place, spread, and compact the mixture with equipment to be used in the project and in accordance with requirements specified herein. Construct a cold joint between spreader widths. Test and evaluate the test section and conform to all specified requirements. If tests indicate that the pavement does not conform to the tolerances of Table 1, remove and construct additional test sections and sample for conformance to specification requirements. Do not start production of the bituminous base course mixture without approval.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide aggregates consisting of crushed stone, crushed slag, crushed gravel screenings, sand, and mineral filler, as required. The portion of these materials retained on the No. 4 sieve is classified as coarse aggregate; the portion passing the No. 4 sieve and retained on the No. 200 sieve, as fine aggregate; and the portion passing the No. 200 sieve, as mineral filler.

2.1.1 Coarse Aggregates

Provide coarse aggregates consisting of clean, sound, durable fragments of crushed stone, crushed slag, or crushed gravel meeting the following requirements:

2.1.1.1 Aggregate Wear

Percentage of wear not exceeding 40 after 500 revolutions, as determined in accordance with ASTM C131/C131M.

2.1.1.2 Aggregate Loss

Percentage of loss not exceeding 18 after five cycles performed in accordance with ASTM C88, using magnesium sulfate.

2.1.1.3 Fractured Faces

At least 75 percent by weight of coarse aggregate containing two or more fractured faces produced by crushing when tested in accordance with ASTM D5821.

2.1.1.4 Flat and Elongated Pieces

Particle shape essentially cubical and containing not more than 20 percent, by weight, of flat particles and elongated particles (3:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791.

2.1.1.5 Dry Weight of Crushed Slag

Dry weight of crushed slag not less than 75 pcf as determined in accordance with ASTM C29/C29M.

2.1.2 Fine Aggregates

Provide fine aggregates consisting of clean, durable natural sands; manufactured sands prepared by crushing stone, slag, or gravel, or any combination of natural and manufactured sands. Natural sands consist of grains of clean, hard, durable rock. Limit the quantity of uncrushed material to a maximum of 25 percent by weight of total aggregate.

2.1.3 Mineral Filler

Mineral filler conforming to ASTM D242/D242M.

2.1.4 Liquid Limit and Plasticity Index

Measure liquid limit and plasticity index on the portion of the aggregate passing the No. 40 sieve in accordance with ASTM D4318. Requirements apply to the individual aggregate fractions and the combined blend in the completed base course. Provide aggregates classified as either nonplastic or having a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.2 BITUMINOUS MATERIALS

2.2.1 Asphalt Cement

Provide asphalt cement binder conforming to ASTM D6373 Performance Grade (PG) .

2.3 AGGREGATE GRADATION

Provide mineral aggregate of such size that percentage composition by weight, as determined by ASTM C136/C136M, conforms to the gradation specified in TABLE 2, and does not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine.

TABLE 2. AGGREGATE GRADATION			
Percent Passing			
Sieve Size	Gradation 1	Gradation 2	Gradation 3
1 inch	100	---	---
3/4 inch	90-100	100	---
1/2 inch	68-88	90-100	100
3/8 inch	60-82	72-88	90-100
No. 4	45-67	53-73	58-78
No. 8	32-54	38-60	40-60
No. 16	22-44	26-48	28-48
No. 30	15-35	18-38	18-38
No. 50	9-25	11-27	11-27
No. 100	6-18	6-18	6-18
No. 200	3-6	3-6	3-6

2.4 COMPOSITION OF MIXTURE

2.4.1 Job-Mix Formula (JMF)

2.4.1.1 Develop the JMF

Provide an asphalt mix composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt binder. Size the aggregate fractions, handle in separate size groups, and combine in such proportions that the resulting mixture meets the grading requirements of Table 2. Submit proposed JMF; do not produce hot-mix asphalt for payment until a JMF has been approved. Design the hot-mix asphalt in accordance with Marshall or Superpave procedures and the criteria shown in Table 3. Use the hand-held hammer to compact the specimens for Marshall mix design. Design Superpave mixes with the number of gyrations specified in Table 3, unless the DOT option is chosen. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867/D4867M, is less than 75, reject the aggregates or treat the asphalt mixture with an approved anti-stripping agent. Add the amount of anti-stripping agent sufficient to produce a TSR of not less than 75. Provide an antistrip agent, if required, at no additional cost. Provide sufficient materials to produce 200 pound of blended mixture for verification of mix design at least 14 days prior to construction of test section.

2.4.1.2 Option

A currently used DOT Superpave hot mix may be used in lieu of developing a

Marshall hot mix design as described herein. Design the Superpave volumetric mix in accordance with AI MS-2 and ASTM D6925. Provide a nominal maximum aggregate size (NMAS) of 3/4 inch. Other DOT hot mix design methods may be suitable, as approved. Select the number of compaction gyrations, Ndes, based on a design traffic of equivalent single axle loads (ESALs).

2.4.2 JMF Requirements

Submit in writing the job mix formula for approval at least 30 days prior to the start of the test section including as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt binder.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt performance grade viscosity grade penetration grade.

e. Number of blows of hand-held hammer per side of molded specimen. (NA for Superpave)

f. Number of gyrations of Superpave gyratory compactor, (NA for Marshall mix design)

g. Laboratory mixing temperature.

h. Lab compaction temperature.

i. Temperature-viscosity relationship of the asphalt cement.

j. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

k. Graphical plots of stability (NA for Superpave), flow (NA for Superpave), air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2.

l. Specific gravity and absorption of each aggregate.

m. Percent natural sand.

n. Percent particles with 2 or more fractured faces (in coarse aggregate).

o. Fine aggregate angularity.

p. Percent flat or elongated particles (in coarse aggregate).

q. Tensile Strength Ratio(TSR).

r. Antistrip agent (if required) and amount.

s. List of all modifiers and amount.

t. Correlation of hand-held hammer with mechanical hammer (NA for Superpave).

u. Percentage and properties (asphalt content, binder properties, and aggregate properties) of reclaimed asphalt pavement (RAP) in accordance with paragraph RECYCLED HOT-MIX ASPHALT, if RAP is used.

Table 3. Mix Design Criteria

Test Property	50 Blows or Mix Gyrations	75 Blows or Mix Gyrations
Stability, pounds, minimum (NA for Superpave)	*1350	*1800
Flow, 0.01 inch, (NA for Superpave)	8-18	8-16
Air voids, percent	3-5	3-5
Percent Voids in mineral aggregate (VMA),(minimum)		
Gradation 1	14.0	14.0
Gradation 2	15.0	15.0
Gradation 3	16.0	16.0
TSR, minimum percent	75	75
* This is a minimum requirement.		
** Calculate VMA in accordance with AI MS-2, based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate.		

2.4.2.1 Adjustment to JMF

The JMF for each mixture is in effect until a new formula is approved in writing. Should a change in sources of any materials be made, perform a new mix design and obtain approval before the new material is used. Make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF are limited to plus or minus 4 percent on the No. 4 and coarser sieves; plus or minus 3 percent on the No. 8 to No. 50 sieves; and plus or minus 1 percent on the No. 100 sieve. Adjustments to the JMF are limited to plus or minus 1.0 percent on the No. 200 sieve. Asphalt content adjustments are limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, develop a new mix design.

2.5 RECYCLED ASPHALT PAVEMENT

RAP is not permitted.

2.6 EQUIPMENT, TOOLS, AND MACHINES

2.6.1 Bituminous Plant

Provide a bituminous plant of such capacity to produce the quantities of bituminous mixtures required for the project within the completion time of the contract. Provide hauling equipment, paving machines, rollers, miscellaneous equipment, and tools in sufficient numbers and capacity and in proper working condition to place the bituminous paving mixtures at a rate equal to the plant output. Provide a sufficient number of adequately trained personnel during paving operations to produce a pavement meeting the requirements in this specification.

2.6.2 Mixing Plants

Provide mixing plants in accordance with AASHTO M 156 which are automatic or semiautomatic controlled, commercially manufactured units designed, coordinated, and operated to consistently produce a mixture within the job-mix formula (JMF). Prequalify drum or batch mixers at the production rate to be used during actual mix production. The prequalification tests include extraction in accordance with ASTM D2172/D2172M and recovery of the asphalt binder in accordance with ASTM D1856.

2.6.3 Asphalt Paver

Provide asphalt pavers which are self-propelled, with an activated screed, heated as necessary, and capable of spreading and finishing courses of hot-mix asphalt which will meet the specified thickness, smoothness, and grade, with sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface. Provide a receiving hopper of sufficient capacity to permit a uniform spreading operation and equipped with a distribution system to place the mixture uniformly in front of the screed without segregation and produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture. If screed extensions are used to increase the paving width, provide auger extensions to distribute the hot mix along the additional screed length. Equip the paver with a control system capable of automatically maintaining the specified screed elevation. Automatically actuate the control system from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface.

2.6.4 Hauling Equipment

Provide trucks for hauling hot-mix asphalt having tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, lightly coat the truck beds with a release agent specifically designed for use with hot mix asphalt. Provide each truck with a suitable cover to protect the mixture from adverse weather. When necessary to maintain the mixture at the specified temperature, insulate or heat truck beds and securely fasten covers (tarps).

2.6.5 Rollers

Provide the number, type, and weight of rollers sufficient to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate or displacement of the asphalt mixture.

2.6.6 Straightedge

Furnish and maintain at the site, in good condition, one 12 foot straightedge for each bituminous paver for use in testing the finished surface. Construct straightedges of aluminum with blades of box or box-girder cross section and a flat bottom reinforced to insure rigidity and accuracy. Provide handles to facilitate movement on pavement.

PART 3 EXECUTION

3.1 CONDITIONING OF UNDERLYING COURSE

Prior to placing the bituminous base course, clean the underlying surface of foreign or objectionable matter. Apply a prime coat or tack coat in accordance with 32 12 13 BITUMINOUS TACK AND PRIME COATS.

3.2 MIXING

3.2.1 Preparation of Mineral Aggregates

Place and maintain each aggregate stockpile in such a manner to prevent segregation. Regulate rates of feed of aggregates so that the moisture content and temperature of aggregates will be within tolerances specified herein. Provide dry storage for mineral filler.

3.2.2 Preparation of Bituminous Mixtures

Convey aggregates, mineral filler, and bitumen into the mixer in proportionate quantities required to meet the JMF. Set the mixing time as required to obtain a uniform coating of the aggregate with the bituminous material. Limit the temperature of bitumen at time of mixing not to exceed 300 degrees F. Maintain the temperature of aggregate and mineral filler in the mixer within the range of 300 to 325 degrees F when bitumen is added. Overheated and carbonized mixtures or mixtures that foam will be rejected.

3.2.3 Water Content of Aggregates

Perform drying operations to reduce the water content of mixture to less than 0.75 percent. Conduct the water content test in accordance with ASTM D2216. If the water content is determined on individual hot bin samples, calculate the water content as a weighted average based on composition of blend.

3.2.4 Storage of Bituminous Paving Mixture

Store the mixture according to the requirements of AASHTO M 156. Empty uninsulated surge bins at the end of each working day. If excessive heat loss, segregation,or oxidation of the stored asphalt mixture is observed, discontinue the use of the surge bin.

3.3 TRANSPORTATION OF BITUMINOUS MIXTURE

Transport the bituminous mixture from the paving plant to the site in trucks having tight, clean, smooth beds lightly coated with an approved release agent to prevent adhesion of mixture to truck bodies. Drain excessive release agent prior to loading. Cover each load with canvas or other approved material of ample size to protect mixture from weather and prevent loss of heat. Reject loads that have crusts of cold, unworkable material or have become wet by rain. Do not haul over freshly placed material.

3.4 PLACING

Do not place bituminous mixtures without ample time to complete placement and compaction during daylight hours, unless artificial lighting is provided.

3.4.1 Tack Coat

Spray contact surfaces of previously constructed pavement, curbs, manholes, and similar structures with a tack coat conforming to the requirements of Section 32 12 13 BITUMINOUS TACK AND PRIME COATS.

3.4.2 Offsetting Joints in Bituminous Base Course

Place the bituminous base course so that longitudinal joints are offset from joints in the underlying course by at least 1 foot. Offset transverse joints by at least 2 feet from transverse joints in the underlying course.

3.4.3 Use of Laydown Machine

Reject mixtures having temperatures less than 250 degrees F when delivered to the laydown machine. Adjust the laydown machine and regulate the speed so that the surface of the course being laid will be smooth and continuous without tears and pulls, and of such depth that, when compacted, the surface conforms to the cross section, grade, and contour indicated. Begin placement of the mixture along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture as nearly continuous as possible, and adjust the speed of placing to permit proper compaction. When segregation occurs in the mixture during placing, suspend the laydown operation until the cause is determined and corrected. Correct irregularities in alignment of the course left by the laydown machine by trimming directly behind machine. Immediately after trimming, thoroughly compact the edges of the course by tamping laterally with a lute. Do not permit distortion of the course during tamping.

3.4.4 Placing Strips Succeeding Initial Strips

In placing each succeeding strip after the initial strip has been spread and compacted as specified below, overlap the screed of the laydown machine 1/2 to 1 inch over the previously placed strip and sufficiently high so that compaction will produce a smooth, dense joint. Use a lute to push back the mixture placed on the edge of the previously placed strip to the edge of the strip being placed. Do not broadcast material onto the mat. Remove and waste excess mixture.

3.4.5 Hand Spreading in Lieu of Machine Spreading

In areas where the use of machine spreading is impractical, spread the mixture by hand. Prevent segregation during spreading. Do not broadcast material onto the mat. Remove and waste excess mixture. Maintain grade and smoothness tolerances presented in Table 1.

3.5 COMPACTION OF MIXTURE

Begin compaction as soon after placing as the mixture will bear roller without undue displacement. Do not permit delays in compacting the freshly placed mixture. After the initial rolling, perform preliminary tests of the crown, grade, and smoothness. Correct deficiencies so that the finished course will conform to requirements for the grade and smoothness specified in subpart: ACCEPTANCE. After meeting crown, grade, and smoothness requirements, continue rolling until a mat density of at least 92 percent of the theoretical maximum density (TMD) determined in accordance with ASTM D2041/D2041M is obtained. Roll the joints until until a joint density of at least 90.5 percent of the theoretical maximum density (TMD) determined in accordance with ASTM D2041/D2041M is obtained. Thoroughly compact areas inaccessible to rollers with hot hand tampers.

3.5.1 Correcting Deficient Areas

Remove mixtures that become contaminated or are defective. Do not permit skin patching of an area that has been rolled. Cut holes the full thickness of the base course so that the sides are perpendicular and parallel to the direction of traffic and the edges are vertical. Spray sides with tack coat conforming to requirements of Section 32 12 13 BITUMINOUS TACK AND PRIME COATS. Place hot mix asphalt in the holes in sufficient quantity so that the finished surface will conform to grade, smoothness, and density requirements.

3.6 JOINTS

3.6.1 General

Carefully construct joints between old and new pavements or between successive day's work or joints that have become cold to establish a continuous bond between old and new sections of the course. Construct joints having the same texture, density, and smoothness as other sections of the course. Clean contact surfaces of previously constructed pavements that have become coated with dust, sand, or other objectionable material by brushing or cut back with approved power saw, as approved. Spray the surface against which new material is placed with a thin, uniform coat of tack coat conforming to requirements of Section 32 12 13 BITUMINOUS TACK AND PRIME COATS. Apply the material far enough in advance of placement of the fresh mixture to insure adequate curing. Take care to prevent damage or contamination of sprayed surface.

3.6.2 Transverse Joints

Pass the roller over the unprotected end of freshly placed mixture only when placing of the course is discontinued or when delivery of the mixture is interrupted to the extent that the unrolled material may become cold. In all cases, cut back the edge of the previously placed course a mimimum of 2 inches to expose an even, straight, vertical surface for the full thickness of the course. In continuing placement of the strip, position the mechanical spreader on the transverse joint so that sufficient hot mixture will be spread to obtain a joint after rolling that conforms to the required density and smoothness specified herein.

3.6.3 Longitudinal Joints

Cut back edges of a previously placed strip that have cooled or are irregular, honeycombed, poorly compacted, damaged, or otherwise defective. In all cases, cut back the edge of the previously placed course a mimimum of 2 inches to expose an even, straight, vertical surface for the full thickness of the course.

3.7 EDGES OF PAVEMENT

Neatly trim outside edges adjacent to shoulders.

3.8 QUALITY CONTROL

Perform tests in sufficient numbers and at the locations and times directed to ensure that materials, mixtures and compaction meet specified requirements. Obtain samples of finished pavement, including samples that span the longitudinal joint. Sample bituminous materials during construction when shipments of bituminous materials are received or when necessary to assure that some condition of handling or storage has not been detrimental to the bituminous material.

3.8.1 Sampling

Obtain plant mix and in-place samples on a lot and sublot basis. Each full day's production or a maximum of 1000 tons is considered a lot. Divide the lot into four (4) equal sublots and obtain random samples in accordance with ASTM D3665 within each sublot. Obtain plant mix samples from the haul truck or from behind the paver. Test for grade and smoothness on a total lot basis.

3.8.2 In-Place Density

Take one random core (4 inches or larger in diameter) from the mat (interior of the lane) of each sublot, and one random core from the joint (immediately over joint) of each sublot, with each random core the full thickness of the layer being placed. When the random core is less than 1 inch thick, do not include in the analysis. In this case, take another random core. After air drying to a constant weight, determine the density of each core in accordance with ASTM D2726/D2726M. Determine percent compaction using the TMD. Evaluate for acceptance in accordance with subpart: ACCEPTANCE. Remove and replace unacceptible lots.

3.8.3 Laboratory Air Voids and Theoretical Maximum Density

Calculate laboratory air voids by determining the bulk density of each lab compacted specimen using the laboratory-prepared, thoroughly dry method of ASTM D2726/D2726M and determining the theoretical maximum density of each sublot sample using ASTM D2041/D2041M. Use the latest theoretical maximum density value to calculate the laboratory air voids for each sublot. Evaluate for acceptance in accordance with subpart: ACCEPTANCE. Complete and report all laboratory air void tests within 24 hours after completion of construction of each lot.

3.8.4 Plan Grade

Provide finished surfaces conforming, within tolerances specified, to the lines, grades, and cross sections indicated. Do not permit finished surfaces to vary more than the tolerances provided in subpart: ACCEPTANCE from the plan gradeline and elevation established and approved at the site. Maintain finished surfaces flush with finished surfaces of abutting pavements. Do not permit deviations from the plan gradeline and elevation in areas of pavements where closer conformance with plan grade and elevation is required for the proper functioning of drainage and other appurtenant structures involved.

3.8.5 Surface Smoothness

Provide finished surfaces not deviating from the testing edge of a straightedge more than the tolerances of subpart: ACCEPTANCE in any direction.

3.8.6 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.9 PROTECTION OF PAVEMENT

After final rolling of the pavement, do not permit vehicular traffic of any kind until the pavement has cooled to ambient temperature.

-- End of Section --

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SECTION 32 11 26.19

BITUMINOUS-STABILIZED BASE AND SUBBASE COURSES
05/20

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement for Payment

1.1.1.1 Bituminous Stabilization

Measurement will be by the square yard of work completed and accepted.

1.1.1.2 Bituminous Material

Submit quantity of residual bituminous material used in the job. Bituminous material to be paid for will be measured in the number of gallons of the material used in the accepted work, corrected to gallons at 60 degrees F in accordance with ASTM D1250. Use a coefficient of 0.00025 per degree F for asphalt emulsion. 2000 pound tons of the material used in the accepted work.

1.1.1.3 Select Material

Select material will be measured by the 2000 pound ton of material placed and used in the completed and accepted stabilization. Measurement will not be made for select material that is wasted or used in work determined to be defective.

1.1.2 Basis for Payment

Bituminous-stabilized mixture, constructed and accepted, and the quantities of bituminous material and select material will be paid for at the respective contract unit prices. Payment will not be made for any material wasted, used for the convenience of the Contractor, unused or rejected, or for water used. Select material obtained from grading and excavation operations at the project site will not be paid for under this section but will be included for payment under other sections specifying grading and excavating. Separate payment will not be made for sanding or dusting the bituminous prime-coated surfaces. Costs for sanding or dusting will be included in the contract unit price for bituminous material.

1.1.3 Waybills and Delivery Tickets

Submit copies of waybills and delivery tickets during the progress of the work. Before the final payment is allowed, furnish waybills and certified delivery tickets for all bituminous materials and select materials actually used in the construction.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASPHALT RECYCLING AND RECLAIMING ASSOCIATION (ARRA)

ARRA FDR201A	(2018) Recommended Mix Design Guidelines for Full Depth Reclamation (FDR) Using Emulsified Asphalt Stabilizing Agent

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D977	(2019a; E 2019) Standard Specification for Emulsified Asphalt
ASTM D979/D979M	(2015) Sampling Bituminous Paving Mixtures
ASTM D1250	(2019; E 2020) Standard Guide for Use of the Joint API and ASTM Adjunct for Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils: API MPMS Chapter 11.1
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2397/D2397M	(2019a) Standard Specification for Cationic Emulsified Asphalt
ASTM D2419	(2014) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification

	System)
ASTM D2488	(2017; E 2018) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D2940/D2940M	(2020) Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.3 DEFINITION

Degree of compaction is expressed as a percentage of the maximum density obtained by the test procedure in accordance with ASTM D1557, abbreviated in this specification as percent laboratory maximum density.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, Machines, and Tools

Mix Design; G

Waybills and Delivery Tickets

Notification Of Selected Source

SD-06 Test Reports

Sampling and Testing

1.5 QUALITY CONTROL

1.5.1 Qualifications

Perform sampling and testing using an approved commercial testing laboratory or on-site facilities. Submit accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM D3666, including all applicable test procedures. Do not start work requiring testing until the facilities have been inspected and approved. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. Maintain this certification for the duration of the project.

1.5.2 Test Results

Verify that materials comply with the specification. When a material source is changed, test the new material for compliance. When deficiencies are found, repeat the initial analysis and retest the material already placed to determine the extent of unacceptable material.

1.5.3 Aggregate

Submit notification of selected source from which aggregates are to be obtained, within 15 days after the award of contract. Perform tests for determining the suitability of aggregate including, but not limited to: sieve analysis in accordance with ASTM C136/C136M using sieves conforming to ASTM E11, liquid limits and plasticity index in accordance with ASTM D4318, and sand equivalent test in accordance with ASTM D2419. Do not submit aggregate test data older than 6 months since the testing was performed. Take aggregate samples for laboratory tests in accordance with ASTM D75/D75M. Submit certified copies of aggregate test results, not less than 30 days before the material is required in the work.

1.5.4 Bituminous Material

Submit notification of selected source of bituminous material within 15 days after the award of contract. Submit certified copies of the manufacturer's test reports indicating compliance with applicable specified requirements, not less than 30 days before the material is required in the work.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Environmental Requirements

Do not apply bituminous material when the atmospheric temperature is less than 50 degrees F or to soils that are frozen or contain frost. If the temperature falls below 35 degrees F, protect completed bitumen-treated areas against any detrimental effects of freezing.

1.7 ACCEPTANCE

1.7.1 Tolerances

Acceptance of bituminous stabilized base course subbase is based on compliance with the tolerances presented in Table 1. Remove and replace bituminous stabilized mixture represented by the failing tests or submit repair plan for approval.

TABLE 1	
Attribute	Tolerance
Field Density	minimum of 95 percent
Asphalt Content	plus/minus 0.5 percent of mix design
Smoothness	maximum of 3/8 inch
Thickness (individual measurement)	maximum of 1/2 inch
Thickness (average of all measurements)	minimum of 1/4 inch

1.7.2 Test Section

Place a test section of at least 8 by 100 feet, utilizing the equipment and procedures proposed for use, to demonstrate that bituminous stabilized mixture conforming to this specification can be produced. Acceptance of the test section is based on compliance with the tolerances listed in Table 1.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Bituminous Material

2.1.1.1 Bituminous-Stabilized Mixture

Provide emulsified asphalt conforming to ASTM D977 Type MS-1 MS-2h HFMS-1 HFMS-2h HFMS-2s SS-1 SS-1h ASTM D2397/D2397M Type CMS-2CMS-2hCSS-1CSS-1h.

2.1.1.2 Prime Coat

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 SS1h ASTM D2397/D2397M, Type CSS-1 CSS-1h. Asphalt emulsion can be diluted up to 1 part water to 1 part emulsion for prime coat use.

2.1.2 Material to be Stabilized

2.1.2.1 Select Material for Bituminous Stabilized Base Course

Select material conforming to ASTM D2940/D2940M, base course gradation Table 1. Verify select material has a liquid limit less than 25 and a Plasticity Index less than 4 when tested in accordance with ASTM D4318; the percentage of wear less than 40 percent in accordance with ASTM C131/C131M; and a sand equivalent percentage greater than 35 percent in accordance with ASTM D2419. Perform sieve analysis in accordance with ASTM C117 and ASTM C136/C136M.

2.1.2.2 Aggregate for Bituminous-Stabilized Subbase Course

In-place or imported soil or aggregate conforming to soil classifications GW, GP, GM, SW, SP, SM, or combinations thereof. Soil classification in accordance with ASTM D2487 and ASTM D2488. Verify material has a plasticity index equal to or less than 10 in accordance with ASTM D4318 and a sand equivalent percentage greater than 35 percent in accordance with ASTM D2419.

Perform sieve analysis in accordance with ASTM C117 and ASTM C136/C136M. Provide aggregates within the limits specified as follows:

TABLE 2			
Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve			
Sieve Designation	No. 1	No. 2	No. 3
2 inch	100	100	100
No. 10	50	80	100
No. 200	30	30	30

2.1.3 Stockpiling Materials

Stockpile select material, including approved material available from excavation and grading in the manner and at the locations designated. Clear, drain, and level storage sites before stockpiling material. Separately stockpile materials obtained from different sources. Maintain a separation distance or barrier between stockpiles to prevent cross-contamination.

2.1.4 Water

Furnish clean, fresh, and potable water.

2.2 MIX DESIGN

Develop and submit for approval a proposed mix design prior to stabilization work. Develop mix using samples of the material to be stabilized. Conduct mix design in accordance with ARRA FDR201A. Verify CBR bearing value.

2.2.1 Mix Design Report

Perform trial design batches, mixture proportioning studies, testing, and submit results demonstrating that the proposed mixture proportions produce a bituminous-stabilized mixture of the qualities indicated. Submit test results in a mix design report to include:

a. Gradation, sand equivalent, and Plasticity Index of soil or aggregate.
b. Maximum dry density and optimum moisture content.
c. Density, maximum specific gravity, air void content, dry and moisture conditioned indirect tensile strength and level of saturation at each emulsified asphalt stabilizing agent content.
d. Optimum emulsified asphalt stabilizing agent content as a percentage of dry materials.
e. Density, air void content, dry and moisture conditioned indirect tensile strength and CBR value at recommended moisture and emulsified asphalt stabilizing content.
f. Emulsified asphalt stabilizing agent designation, supplier name and location.
g. Emulsified asphalt residue content and certificates of compliance.

2.3 PLANT, EQUIPMENT, MACHINES, AND TOOLS

Submit list of proposed equipment to be used in performance of construction work, including descriptive data. Plant, equipment, machines, and tools used in the work are subject to approval. Maintain in a satisfactory working condition at all times. Provide equipment with the capability of producing the required compaction, meeting grade controls, thickness control and smoothness requirements indicated.

2.3.1 Central Plant

Provide a batch or continuous flow type central plant capable of producing a uniform bituminous stabilized mixture at the required asphalt emulsion and moisture contents. Equip the mixer with calibrated metering and feeding devices that introduce the aggregate, bituminous material, water, and additives (if used) into the mixer in the specified quantities. If necessary, use a screening device to remove oversized material greater than 2 inches (50 mm) from the raw aggregate feed.

2.3.2 Mechanical Spreader

Provide a steerable, self propelled, mechanical spreader having variable speeds forward and reverse. Mount the spreader on tracks, rubber tires, or drum-type steel rollers that will not disturb the underlying material. Provide a spreader containing a hopper, an adjustable screed, and outboard bumper rolls; designed to have a uniform, steady flow of material from the hopper; and capable of laying material without segregation, across the full width of the lane, to a uniform thickness and to a uniform loose density so that when compacted, the layer or layers conform to thickness and grade requirements indicated.

2.3.3 Mixer/Reclaimer

Provide a self-propelled, four-wheel drive rotary mixer/reclaimer, capable of pulverizing the soil in a single pass for the full depth to be stabilized and providing a mixing action capable of uniformly blending and mixing the required bituminous material content with the aggregate. Equip with a rotor capable of up or down cutting. Equip the mixer/reclaimer with an integrated additive injection system capable of introducing bituminous emulsion into the cutting drum during the mixing process. Provide a metering device capable of automatically adjusting the flow of the bituminous emulsion to compensate for any variation in the amount of reclaimed material introduced into the mixing chamber.

2.3.4 Traveling Plant

Provide a traveling plant capable of moving at a uniform rate of speed and accomplishing thorough mixing of the materials in one pass. Deliver water and bituminous material from supply trucks or bins at a predetermined rate. Construct windrows of prepared bituminous stabilized mixture to cover a predetermined width to the indicated compacted thickness.

2.3.5 Bituminous Distributor

Provide a distributor with pneumatic tires that prevent rutting, shoving, or otherwise damaging other layers in the pavement structure. Provide capability to spray bituminous material in a uniform double or triple lap at the specified temperature, at variable widths, and at readily determined and controlled rates from 0.05 to 2.0 gallons/square yard. Equip distributor to circulate and agitate the bituminous material during the heating process. The bituminous distributor is permitted only for applying tack, prime, and seal coats and not for applying bitumen to be mixed into the stabilized mixture.

2.3.6 Rollers

Compact the bituminous stabilized mixture using one or a combination of the following pieces of equipment: tamping or grid roller; steel-wheeled roller; vibratory roller; pneumatic-tire roller, and/or vibrating plate compactor (for areas inaccessible to rollers). Compact the bituminous stabilized mixture using the number, type, and weight of rollers and/or compactors sufficient to compact the mixture to the required density.

2.3.7 Straightedge

Furnish and maintain at the site, in good condition, one 10 or foot straightedge for each bituminous paver, for use in the testing of the finished surface. Make straightedge available for government use. Construct straightedges of aluminum or other lightweight metal having blades of box or box-girder cross section with flat bottom reinforced to insure rigidity and accuracy. Equip straightedge with handles to facilitate straightedge movement on the bituminous stabilized surface.

PART 3 EXECUTION

3.1 OPERATION OF AGGREGATE SOURCES

Select aggregate sources than can produce the quality and quantity of base course materials meeting these specification requirements in the specified time limits. Upon completion of the work, condition aggregate sources on Government property to drain readily and leave in a satisfactory condition. Obtain aggregate material from offsite sources. Condition aggregate sources on private lands in agreement with local laws or authorities.

3.2 PREPARATION OF AREAS TO BE STABILIZED

Clean area and dispose of debris and unsatisfactory in-place material as directed. Visually inspect area for adequate compaction and capability of withstanding, without displacement, compaction specified for the bituminous-stabilized base course mixture. Visually inspect the exposed material to be stabilized prior to mixing. When the stabilized course is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. Provide adequate drainage during the entire construction period to prevent water from collecting or standing on the area to be stabilized or on pulverized, mixed, or partially mixed material.

3.2.1 In-Place Material to be Stabilized

Grade and shape the entire area to conform to the lines, grades, and cross sections shown prior to being processed. Make soft or yielding areas stable before construction is begun.

3.2.2 In-Place Materials to Receive Stabilized Course

Remove and replace or rework soft or yielding areas on the surface prior to placing bituminous-stabilized mixture. Aerate material in the affected area and remove all unsatisfactory materials. Add material as directed. Shape to line, grade, and cross section and compact the new work to the specified density. Conform subgrade to Section 31 00 00 EARTHWORK. Conform subbase course to Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASE SELECT-MATERIAL FOR FLEXIBLE PAVING.

3.2.3 Select Material

Utilize sufficient select material to provide the required thickness of the bituminous-stabilized layer after compaction; process it to meet the requirements specified, before bituminous stabilization is undertaken.

3.3 GRADE CONTROL

Excavate underlying material to sufficient depth for the required bituminous-stabilized course thickness so that the finish stabilized course and the subsequent surface course will meet the fixed grade. Provide line and grade stakes as necessary for control. Place grade stakes in lines parallel to the centerline of the area under construction and suitably spaced for string lining. Verify the finished and completed stabilized area conforms to the lines, grades, cross section, and dimensions indicated.

3.4 MIXING OF MATERIALS

3.4.1 Mixed-in-Place Method

3.4.1.1 Scarifying and Pulverizing of Soil

Prior to the application of bituminous materials, scarify and pulverize the soil to thedepth shown, or as specified by the Soils Investigation. Control scarification so that the layer beneath the layer to be stabilized is not disturbed. Do not exceed the depths indicated. Unless otherwise noted, do not scarify or pulverize any area larger than can be completed in 2 working days.

3.4.1.2 Application of Water

Once soils have been scarified and pulverized, shape to cross sections and grades indicated and determine moisture content of the soils. Add water in increments and partially incorporate each increment of water in the mix to avoid concentration of water near the surface. After the last increment of water has been added, continue mixing until the water is uniformly distributed throughout the mixture, including satisfactory moisture distribution along the edges of the section.

3.4.1.3 Application of Bituminous Material

Distribute the bituminous material at the specified rate of residual asphalt by a spray bar integrated into the mixer/reclaimer cutting drum within a temperature range of 75 to 130 degrees F. Uniformly mix bituminous material with the soil. If the bituminous material is applied in more than one increment, partially mix each application into the material as directed. After the required amount of bituminous material has been added to the loose material, thoroughly mix the bituminous material and soil. After mixing is completed, verify the bituminous-stabilized mixture conforms to the mix design proportions and the moisture content is within 1 percent of the mix design. Include the water used to dilute the asphalt emulsion in the moisture content calculation. Do not permit heavy equipment, except the soil mixer, to pass over the freshly spread bituminous material.

3.4.2 Traveling Plant Method

Place the pulverized material in windrows of sufficient size to cover a predetermined width to the indicated compacted thickness. Operate the traveling plant at a constant speed and sufficiently slowly so that the soils and bitumen are thoroughly mixed. Deliver water and bituminous material separately or together at a predetermined rate.

3.4.3 Central Plant Method

3.4.3.1 Mixing

Load and haul select material from pits or stockpiles so that a uniform grade of each material is delivered to the central-mixing plant. Feed properly batched or proportioned aggregate and soil binder materials into the mixing unit together with the bituminous material and the quantity of water needed to obtain the required optimum moisture content. Continue mixing until a homogeneous mixture is obtained. Haul mixture to the job in trucks equipped with protective covers. Place mixture with mechanical spreaders.

3.4.3.2 Placing

Place the mixed material on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. When a compacted layer 6 inches or less in thickness is required, place the material in a single layer. When a compacted layer in excess of 6 inches is required, place the material in layers of equal thickness. Do not place layers more than 6 inches or less than 3 inches when compacted. When compacted, provide layers true to the grades or levels required with the least possible surface disturbance. Make such adjustments in placing procedures or equipment to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to ensure an acceptable base course.

3.5 PLACEMENT AND COMPACTION

For plant-mixed, machine laid materials, begin compaction immediately following placement. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive passes at least one-half the width of the roller. Make adjacent passes of the roller at slightly different lengths. Do not permit bituminous-stabilized materials to displace, pump, or shove. Continue compaction efforts until the compacted mixture is at least 95 percent of laboratory maximum density. Compact areas inaccessible to rollers using mechanical tamping equipment.

3.6 JOINTS

3.6.1 Longitudinal Joints

For areas where plant-mixed bituminous-stabilized material is placed in successive strips, remove 1 foot of the edge of the material prior to placing the adjacent strip. For the shoulders of the bituminous-stabilized areas, place approved material along the edges of the bituminous-stabilized course to compact to the thickness of the course being constructed, or to the thickness of each layer in a multiple-layer course. Compact at least 1 foot width of the shoulder or previously placed strip at the same time as compacting each layer of the bituminous-stabilized course.

3.6.2 Transverse Joints

At the end of each day's construction, form a straight transverse construction joint by cutting back into the completed work to obtain a true vertical face free of loose or shattered material. Remove material along construction joints not properly compacted and replace with bituminous-stabilized mixture that is mixed, moistened, and compacted in accordance with this specification.

3.7 FINISHING

Finish the surface of the top layer to grade and cross section as shown on the drawings and to a uniform texture. Light blading during compaction may be necessary for the finished surface to conform to the lines, grades, and cross sections. If the surface becomes rough, corrugated, uneven in texture, or traffic-marked prior to completion, rework or replace the unsatisfactory area, as directed. If any areas become saturated by water, immediately remove that portion, place in a windrow and aerate until a moisture content within the limits specified is obtained. Verify the moisture content is within the specified limits, replace the bituminous-stabilized mixture in layers, and compact to the specified density.

3.7.1 Smoothness

Evaluate the finished surface with a straightedge. Limit deviations in the surface of each layer to the tolerances shown in Table 1. Correct deviations exceeding this tolerance by removing and replacing with new bituminous-stabilized mixture, or by reworking existing material and compacting, as directed.

3.7.2 Thickness Control

Build the compacted thickness of the stabilized course within 1/2 inch of the thickness indicated. Where measured thickness of the stabilized course is more than 1/2 inch deficient, correct such areas by removing the full depth of the layer, replacing with new material of proper gradation, and recompacting as directed. Where the measured thickness of the stabilized course is more than 1/2 inch thicker than indicated, consider the course as conforming to the specified thickness requirements. Average job thickness is the average of all thickness measurements taken for the job, but within the tolerances of Table 1.

3.8 PRIME COAT

Before dust settles on the area, apply a prime coat of bituminous material to the finished surface. Uniformly apply bituminous material at the rate of 0.05 to 0.20 gallons/square yard. Protect bituminous material by sanding or dusting the treated surface. Uniformly apply sand at the rate of 6 to 8 pounds/square yard.

3.9 FIELD QUALITY CONTROL

3.9.1 Sampling and Testing

Perform sampling and testing in sufficient numbers and at the locations and times directed to ensure that materials and compaction meet specified requirements. Furnish certified copies of test results within 24 hours of completion of tests. Replace or repair all in-place unacceptable material.

3.9.2 Field Density

Express compaction as a percentage of the laboratory maximum density. Prepare laboratory samples from an uncompacted mixture obtained immediately prior to field compaction and compact the samples in accordance with ASTM D1557. Perform a minimum of one laboratory compaction test for each 4 hours of mixture placed. Determine as-built density of the bituminous-stabilized and compacted course in accordance with ASTM D1556/D1556MASTM D6938. When a nuclear gauge is used, check the calibration curves and adjust if necessary, using the sand cone method as described in paragraph Calibration of ASTM D6938. ASTM D6938 results in a wet unit weight of soil and is used to determine the moisture content of the soil. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. If ASTM D6938 is used, check the in-place densities by ASTM D1556/D1556M at least once per lift for each day's production of stabilized material. Furnish calibration curves and calibration test results within 24 hours of conclusion of the tests. Perform at least one field density test for each 250 square yards of each layer of stabilized material.

3.9.3 Sieve Analysis

Perform a minimum of 1 analysis for each 1000 tons of material to be stabilized until the course is completed. When the source of materials is changed or deficiencies are found, repeat the analysis and retest the material already placed to determine the extent of unacceptable material. Replace all in-place unacceptable material at no additional cost to the Government.

3.9.4 Liquid Limit and Plasticity Index

Perform one liquid limit and plasticity index for each sieve analysis in accordance with ASTM D4318.

3.9.5 Extraction Test

Conduct asphalt content tests in accordance with ASTM D2172/D2172M or ASTM D6307, to confirm the amount of bitumen and moisture in the mixture. Adjust operation as required to maintain the asphalt content within the tolerances of Table 1. Conduct one test for every 4 hours of placement for every 300 tons of mixture placed. Take samples in accordance with ASTM D979/D979M.

3.9.6 Smoothness Test

Test the entire area of the bituminous-stabilized course in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines 15 feet or less apart, as directed. Locate the longitudinal lines at the centerline of each bituminous-stabilized pass and at the 1/8th point in from each side of the pass.

3.9.7 Thickness

Measure thickness of the stabilized course at intervals of 1 measurement for each 500 square yards of stabilized course. Take measurements in 3 inch diameter test holes penetrating the stabilized course.

3.9.8 Bituminous Material

Sample the bituminous material used in accordance with ASTM D140/D140M.

3.10 MAINTENANCE

Maintain stabilized area in a satisfactory condition until accepted. Maintenance includes immediate repairs to any defects, repeated as often as necessary to keep the area intact. Correct defects as specified.

3.11 TRAFFIC

Completed portions of the bituminous-stabilized area may be opened to controlled traffic within 4 hours of completion of the course, if approved.

-- End of Section --

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SECTION 32 11 33.13

PORTLAND CEMENT-STABILIZED BASE COURSES
05/20

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

Measure by the square yard of work completed and accepted.

1.1.2 Payment

Cement stabilization, constructed and accepted, will be paid for at the respective contract unit prices in the bidding schedule. No payment will be made for any material wasted, used for convenience, unused or rejected, or for water used. No separate payment will be made for sanding or dusting the bituminous prime-coated surfaces, and all costs for sanding or dusting will be included in the contract unit price for bituminous material.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C150/C150M	(2021) Standard Specification for Portland Cement

ASTM C171	(2020) Standard Specification for Sheet Materials for Curing Concrete
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2018a) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	(2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1602/C1602M	(2018) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D558/D558M	(2019) Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures
ASTM D977	(2019a; E 2019) Standard Specification for Emulsified Asphalt
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1632	(2007) Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory
ASTM D1633	(2000; R 2007) Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders
ASTM D2487	(2017; E 2020) Standard Practice for

	Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.3 DEFINITION

Cement-stabilized mixture, as used herein, is a mixture of Portland cement and in-place or select borrow material uniformly blended and compacted as specified to produce a pavement base course or subbase which meets the criteria set forth in the drawings and specifications. The cement-stabilized mixture placed directly under the bituminous surface course or under the concrete pavement is a base course. The cement-stabilized mixture placed under a base course is a subbase course.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mix Design; G

Aggregate
Asphalt Emulsion

SD-06 Test Reports

Aggregate

Compressive Strength

1.5 QUALITY CONTROL

1.5.1 Qualifications

Perform sampling and testing using an approved commercial testing laboratory or on-site facilities that is accredited in accordance with ASTM C1077. Do not start work requiring testing until the facilities have been inspected and approved. The Government will inspect all laboratories requiring validation for equipment and test procedures prior to the start of any stabilization operations for conformance to ASTM C1077. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. Maintain this certification for the duration of the project.

1.5.2 Test Results

Verify that materials comply with the specification. When a material source is changed, test the new material for compliance . When deficiencies are found, repeat the initial analysis and retest the material already placed to determine the extent of unacceptable material. Replace or repair all in-place unacceptable material to conform to the contract requirements. Perform tests in sufficient numbers, and as specified, to ensure that materials and compaction meet specified requirements. Furnish copies of the test results within 24 hours of completion of tests.

1.5.3 Aggregate

Submit notification of sources from which aggregates are to be obtained, within 15 days after the award of contract. Perform tests for determining the suitability of aggregate including, but not limited to: sieve analysis in accordance with ASTM C136/C136M using sieves conforming to ASTM E11 and liquid limits and plasticity index in accordance with ASTM D4318. Take aggregate samples for laboratory tests in accordance with ASTM D75/D75M. Submit certified copies of aggregate test results, not less than 30 days before the material is required in the work.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not apply cement when the atmospheric temperature is less than 40 degrees F or to soils that are frozen or contain frost, or when the underlying material is frozen. If the temperature falls below 35 degrees F, protect completed cement-stabilized mixture against detrimental effects of freezing. Bring any areas of completed cement-stabilized mixture that are damaged by freezing, rainfall, or other weather conditions to a satisfactory condition in conformance with this specification.

1.7 ACCEPTANCE

1.7.1 Tolerances

Acceptance of cement-stabilized mixture is based on compliance with the tolerances presented in Table 1. Remove and replace cement-stabilized mixture represented by the failing tests or submit plan for approval.

TABLE 1

Measurement	Tolerance
Grade	plus/minus 0.05 foot
Smoothness	plus/minus 3/8 inch
Thickness (individual	plus/minus 1/2 inch

TABLE 1	
Thickness (average)	plus/minus 1/4 inch
Field Density	98 percent minimum
Compressive Strength	minus 50 psi below specified strength

1.7.2 Test Section

Place a test section of at least 8 by 100 feet, utilizing the equipment and procedures proposed for use, to demonstrate that cement stabilized mixture conforming to this specification can be produced. Acceptance of the test section is based on compliance with the tolerances listed in Table 1. .

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

2.1.1.1 Portland Cement

Provide cement conforming to ASTM C150/C150M, Type I, IA, II, or IIA low alkali or ASTM C595/C595M, Type IS or IS(A).

2.1.1.2 Slag Cement

Provide slag cement (ground-granulated blast-furnace slag) conforming to ASTM C989/C989M, Grade 100 or Grade 120.

2.1.1.3 Fly Ash

Provide fly ash conforming to ASTM C618, Class F, including the optional requirements for uniformity and a loss on ignition not exceeding 6 percent.

2.1.2 Material to be Stabilized

2.1.2.1 Aggregate for Cement Treated Base

Provide aggregate consisting of crushed or uncrushed gravel and/or stone, free of roots, sod, and weeds, meeting the requirements below:

a. Plasticity index of less than 6 and liquid limit less than 25 in accordance with ASTM D4318.
b. Percentage of wear less than 40 percent in accordance with ASTM C131/C131M.
c. Soundness loss after 5 cycles of 10 percent maximum using Sodium Sulfate or 15 percent maximum using Magnesium Sulfate in accordance with ASTM C88.
d. Flat, elongated or flat and elongated particles 10 percent maximum, by weight, for fraction retained on the 1/2 inch sieve and 20 percent maximum, by weight, for the fraction passing the 1/2 inch sieve in accordance with ASTM D4791.
e. Clay lumps and friable particles less than or equal to 3 percent in accordance with ASTM C142/C142M
f. Test virgin crushed stone or gravel sources for alkali-aggregate reactivity in accordance with ASTM C1260, and reject materials having a

measured expansion greater than 0.10 percent in 16 days.

g. Gradation meeting the limits of Table 2, in accordance with ASTM C117 and ASTM C136/C136M.

TABLE 2	
Sieve Designation	Percent Passing By Weight
2 inch	100
1 inch	90-100
No.4	45-95
No. 10	37-80
No. 40	15-50
No. 200	0-15
Note: For Cement Treated Base under concrete surfacing, limit the 1 inch size to 100 percent passing.	

2.1.2.2 Aggregate for Cement-Treated Subbase

Aggregate materials conforming to ASTM D2487, classified as GW, GP, GM, SW, SM, SP or combination(s) thereof. Sample materials in accordance with ASTM D75/D75M. Plasticity index of less than 12 and liquid limit less than 25 in accordance with ASTM D4318. Perform sieve analysis in accordance with ASTM C117 and ASTM C136/C136M. Provide aggregates with a maximum size of 2 inches and within the limits specified as follows:

TABLE 3	
Sieve Designation	Percent by Weight Passing
No. 4	55 - 100
No. 10	36 - 60
No. 100	3 - 20

2.1.3 Water

Provide water which is clean, fresh, and free from injurious amounts of oil, acid, salt, alkali, organic matter, and other substances deleterious to the hardening of the cement-stabilized mixture, and subject to approval. Test non-potable water sources for conformance with ASTM C1602/C1602M.

2.1.4 Curing Materials

2.1.4.1 Burlap

Conforming to AASHTO M 182.

2.1.4.2 Impervious Sheeting

White waterproof paper, white opaque polyethylene film or white burlap-polyethylene sheets conforming to ASTM C171.

2.1.4.3 Bituminous Material

Asphalt emulsion conforming to ASTM D977, Type RS-1 or SS-1.

2.1.4.4 Curing Compound

White-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class A or Class B (wax-based) for curing cement-stabilized mixture placed as a base course under Portland cement concrete pavement.

2.2 MIX DESIGN

Submit proposed mix design, prior to start of stabilization work. Develop the mix using the aggregate or soil-aggregate material to be stabilized. Design mix for a minimum 7-day compressive strength of 250 psi for subbase, 750 psi for base under flexible pavement, Limit weight loss to 14 percent or less after 12 cycles of the durability test.

2.2.1 Laboratory Density

Conduct moisture-density tests in accordance with the procedure contained in ASTM D558/D558M. Use the apparatus and procedures outlined in ASTM D1557 to compact the cement-stabilized mixture.

2.2.2 Unconfined Compression

Conduct three unconfined compression tests, in accordance with ASTM D1633, for each mix design tested. Prepare specimens to be used for unconfined compression tests in accordance with ASTM D1632. Use a 4 inch diameter by 8 inch high mold to prepare specimens when more than 35 percent of the material is retained on the No. 4 sieve. Cure samples at a constant moisture content and temperature for 7 days.

2.2.3 Durability

Test three specimens for each mix design.

2.2.4 Mix Design Report

Perform trial design batches, mixture proportioning studies, testing, and include results demonstrating that the proposed mixture proportions produce cement-stabilized mixture of the qualities indicated. Submit test results in a mix design report to include:

a. Coarse and fine aggregate gradations and plots.
b. Coarse aggregate quality test results, include deleterious materials.
c. Fine aggregate quality test results.
d. Durability test results.
e. Mill certificates for cement and supplemental cementitious materials.
f. Recommended proportions and volumes for proposed mixture.
g. Moisture-density curve for selected cement content.
h. Individual compressive strength test results.
i. Narrative discussing methodology on how the mix design was developed.

2.3 EQUIPMENT

Plant, equipment, machines, and tools used in the work are subject to approval. Maintain in a satisfactory working condition at all times. Provide equipment with the capability of producing the required compaction, meeting grade controls, thickness control and smoothness requirements specified.

2.3.1 Central Plant

Provide a batch or continuous flow type central plant capable of producing a uniform cement stabilized mixture at the required cement and moisture contents. Equip the mixer with calibrated metering and feeding devices that introduce the aggregate, cement, water, and cementitious additives (if used) into the mixer in the specified quantities. If necessary, use a screening device to remove oversized material from the raw aggregate feed prior to mixing.

2.3.2 Mechanical Spreader

Provide a steerable, self propelled, mechanical spreader having variable speeds forward and reverse. Mount the spreader on tracks, rubber tires, or drum-type steel rollers that will not disturb the underlying material. Provide a spreader containing a hopper, an adjustable screed, and outboard bumper rolls; designed to have a uniform, steady flow of material from the hopper; and capable of laying material without segregation, across the full width of the lane, to a uniform thickness and to a uniform loose density so that when compacted, the layer or layers conform to thickness and grade requirements indicated.

2.3.3 Pulvimixer

Provide self-propelled, four-wheel drive pulverizing and mixing equipment, capable of pulverizing the soil in a single pass for the full depth to be stabilized and providing a mixing action capable of uniformly blending and mixing the required cement content with the aggregate. Equip with a rotor capable of up or down cutting.

2.3.4 Traveling Plant

Provide a traveling plant capable of moving at a uniform rate of speed and accomplishing thorough mixing of the materials in one pass. Deliver water and cement from supply trucks or bins at a predetermined rate. Construct windrows of prepared cement stabilized mixture to cover a predetermined width to the indicated compacted thickness.

2.3.5 Rollers

Compact the cement stabilized mixture using one or a combination of the following pieces of equipment: tamping or grid roller; steel-wheeled roller; vibratory roller; pneumatic-tire roller, and/or vibrating plate compactor (for areas inaccessible to rollers). Compact the cement stabilized mixture to the required density using the number, type, and weight of rollers and/or compactors sufficient to compact the mixture to the required density.

2.3.6 Straightedge

Furnish and maintain at the site, in good condition, one 10 or 12 foot straightedge for use in the testing of the finished surface. Make straightedges available for Government use. Construct straightedges of aluminum or other lightweight metal with blades of box or box-girder cross section with flat bottom reinforced to insure rigidity and accuracy. Provide handles on straightedges to facilitate movement on pavement.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Do not apply cement if the soil moisture content exceeds optimum moisture content specified for the cement-stabilized mixture. When the stabilized course is constructed in more than 1 layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. Provide adequate drainage during the entire construction period to prevent water from collecting or standing on the areas to be stabilized or on pulverized, mixed, or partially mixed material. Provide line and grade stakes as necessary for control. Place grade stakes in lines parallel to the centerline of the area under construction and suitably spaced for string lining.

3.2 OPERATION OF BORROW PITS

Obtain borrow material from approved offsite sources.

3.3 STOCKPILING MATERIALS

Stockpile select material, including approved material available from excavation and grading, in the manner and at the locations designated. Before stockpiling of material, clear, drain and level the storage sites. Separately stockpile materials obtained from different sources.

3.4 PREPARATION OF AREA TO BE STABILIZED

Clean debris from area to be stabilized; inspect for adequate compaction; and ability to withstand, without displacement, the compaction specified for the cement stabilized mixture. Dispose of debris and removed unsatisfactory in-place material as specified.

3.4.1 In-Place Material to be Stabilized

Grade the entire area to be stabilized and shape to conform to the lines, grades, and cross sections shown in the plans, prior to being processed. Stabilize soft or yielding areas before construction is begun.

3.4.2 In-Place Materials to Receive Stabilized Course

Correct soft, yielding areas and ruts or other irregularities in the surface. Loosen material in the affected areas and remove unsatisfactory material. Add approved select material where directed. Shape the area to line, grade, and cross section, and compact to the specified density. Conform Subgrade to Section 31 00 00 EARTHWORK. Conform Subbase course to Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASE SELECT-MATERIAL FOR FLEXIBLE PAVING.

3.4.3 Select Material

Utilize sufficient select material to provide the required thickness of the cement stabilized mixture layer after compaction and process to meet the requirements specified before cement stabilization is undertaken.

3.5 INSTALLATION

3.5.1 Edges of Stabilized Course

Placed approved material along the edges of the cement-stabilized mixture in such quantity as will compact to the thickness of the course being constructed, or to the thickness of each layer in a multiple-layer course, allowing at least a 1 foot width of the shoulder to be rolled and compacted simultaneously with the rolling and compacting of each layer of the cement-stabilized mixture.

3.5.2 Mixed-in-Place Method

3.5.2.1 Scarifying and Pulverizing of Soil

Prior to the application of cement, scarify and pulverize the soil to a depth of 12 inches. Carefully control scarification so that the layer beneath the layer to be stabilized is not disturbed. Do not pulverize to a depth exceeding the depth of scarification. Unless otherwise permitted, do not scarify and pulverize an area greater than can be completed in 2 working days.

3.5.2.2 Application of Cement

Approximately shape pulverized material to the cross section indicated. Apply cement so that when uniformly mixed with the soil, the specified cement content is obtained, and a sufficient quantity of cement-treated soil is produced to construct a compacted cement-stabilized mixture conforming to the lines, grades, and cross section indicated. Do not pass over the freshly spread cement-stabilized mixture, except for equipment used in spreading and mixing operations.

3.5.2.3 Dry Mixing

Immediately after the cement has been distributed, mix with the soil. Do not mix below the required depth. Continue mixing until the cement has been sufficiently blended with the soil to prevent the formation of cement balls when water is applied.

3.5.2.4 Water Application and Moist Mixing

Determine moisture content of the cement stabilized mixture immediately after completion of mixing of the soil and cement. Provide water-supply and pressure distributing equipment that will permit the continuous application within 3 hours of all water required on the section being processed. Incorporate water in the mix so that concentration of water near the surface does not occur. After all the mixing water has been added, continue mixing until the water is uniformly distributed throughout the full depth of the mixture, with no portion of the mixture remaining undisturbed during mixing for more than 30 minutes. Dispose of any portion of the cement stabilized mixture remaining undisturbed more than 30 minutes during mixing.

3.5.3 Central-Plant Method

Haul the cement stabilized mixture to the job in trucks equipped with protective covers. Thoroughly moisten the underlying course and deposit the material on the prepared area in a quantity that will produce a compacted base of uniform density to the required grade and cross section. Operate spreading or spreading-trimming equipment to produce a layer of material which is uniform in thickness and surface contour and free from irregularities in density. Use spreading or spreading-trimming equipment in sufficient numbers and in staggered formation to obtain full-width spreading in one construction operation. Start the compaction of the treated layer within 60 minutes after the start of the moist mixing. Place cement stabilized mixture in adjacent lanes within 30 minutes.

3.5.4 Traveling-Plant Method

Move traveling plant at a uniform rate of speed to accomplish thorough mixing of the materials. Deliver water and cement from supply trucks or bins at a predetermined rate. Construct windrows of prepared cement stabilized mixture of sufficient size to cover a predetermined width to the indicated compacted thickness.

3.5.5 Layer Thickness

Compact thickness of the cement-stabilized mixture as indicated . Do not compact layers in excess of 8 inches nor less than 4 inches in compacted thickness.

3.5.6 Compaction

As a continuation of the mixing operation, thoroughly loosen the mixture to the full depth before compaction operations are started. At the beginning of compaction, process the mixture to provide a uniform blend with 100 percent passing the specified maximum aggregate size. Start compaction immediately after mixing is completed. Compact the cement stabilized mixture to at least 98 percent of the maximum density obtained from the laboratory samples prepared and tested in accordance with paragraph: LABORATORY DENSITY. Uniformly and continuously compact the loose mixture until the entire depth and width of the area are compacted to the density specified. Maintain the moisture content at the surface near optimum at all times through the rolling, but less than that quantity which will cause the cement stabilized mixture to become unstable during compaction. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Use slightly different lengths on alternate trips of the roller. Do not permit displacement of the cement stabilized mixture due to the speed of the roller. Compact areas inaccessible to rollers with mechanical tampers.

3.6 FINISHING

Moisten the surface, if necessary, and shape to the required lines, grades, and cross section. Lightly scarify the surface, if necessary, to eliminate any imprints made by the compacting or shaping equipment. Thoroughly compact the surface to the specified density with rubber-tired rollers and smooth-wheel tandem rollers to the extent necessary to provide a smooth, dense, uniform surface that is free of surface checking, ridges, or loose material, and that conforms to the crown, grade, and line indicated. Complete these finishing operations within 2 hours after completion of mixing operations. In places not accessible to finishing and shaping equipment, compact the cement-stabilized mixture with mechanical tampers to the density specified and shape and finish by hand methods. Correct, as specified below, any portion of the compacted mix that has density less than that specified, that has not properly hardened, or that is improperly finished.

3.7 CONSTRUCTION JOINTS

At the end of each day's construction, form a straight transverse construction joint by cutting back into the completed work to form a true vertical face free of loose or shattered material. Remove material along construction joints not properly compacted and replace with cement stabilized mixture mixed, moistened, and compacted as specified.

3.8 CURING AND PROTECTION

Protect the finished surface against rapid drying for 7 days by one of the methods specified.

3.8.1 Burlap

Provide burlap consisting of 2 or more layers of burlap having a combined weight of 14 ounces or more per square yard in a dry condition. Provide burlap that is either new or used only for curing concrete. Provide burlap strips with a length, after shrinkage, of at least 1 foot greater than necessary to cover the entire width and edges of the finished stabilized area. Overlap mats at least 6 inches. Thoroughly wet mats before placing and keep continuously wet and in contact with the surface and edges of the finished stabilized area for the entire curing period.

3.8.2 Impervious Sheeting

Moisten the surface of the finished stabilized area with a fine spray of water and then cover with impervious sheeting. Thoroughly saturate the burlap of the polyethylene-coated burlap with water before placing. Place sheeting with the light-colored side up. Extend sheets over the edges of the stabilized area and hold securely in place throughout the curing period. Overlap edges of sheets each other at least 12 inches and securely glue or tape to form continuous closed joints. Repair tears and holes in sheets immediately.

3.8.3 Bituminous Material

Apply bituminous material uniformly by means of a bituminous distributor within a temperature range of 75 to 130 degrees F, as directed. Uniformly apply bituminous material at the residual asphalt content rate of 0.15 to 0.30 gallon/square yard. Treat areas inaccessible to or missed by the distributor using the manually operated hose attachment. Apply bituminous material only to the top layer. At the time the bituminous material is applied, provide a surface free of loose or foreign matter and containing sufficient moisture to prevent excessive penetration of the bituminous material. When necessary, apply water in sufficient quantity to fill the surface voids immediately before the bituminous material is applied. Sand or dust treated surface to prevent the bituminous material from being picked up by traffic.

3.8.4 Liquid Membrane Forming Curing Compound

Uniformly spray the surface of the cement treated base course with the curing compound at the rate of one gallon/100 square feet to obtain a uniform cover over the surface. Provide spraying equipment of the fully atomizing type equipped with a tank agitator. Thoroughly and uniformly mix the curing compound with the pigment in the storage tank. During application, stir the compound continuously by mechanical means. Hand spray odd widths or shapes and surfaces.

3.9 FIELD QUALITY CONTROL

3.9.1 Grade Control

Excavate underlying material to sufficient depth for the required stabilized-course thickness. Provide a finished stabilized course with the subsequent surface course meeting the fixed grade. Conform finished and completed stabilized area to the lines, grades, cross section, and dimensions indicated and the tolerances of Table 1. Correct deviations exceeding the tolerances by removing and replacing the cement-stabilized mixture. Do not permit skin patching of deficient areas.

3.9.2 Smoothness Test

Take measurements for deviation from grade and cross section in successive positions parallel to the road centerline with a straightedge. Also take measurements perpendicular to the road centerline at 50 foot intervals. Correct deviations exceeding the tolerances of Table 1 by removing and replacing the cement-stabilized mixture. Do not permit skin patching of deficient areas.

3.9.3 Thickness Control

Measure the thickness of the cement stabilized mixture at intervals which ensure one measurement for each 500 square yards of cement stabilized mixture. Make measurements in 3 inch diameter test holes penetrating the cement stabilized mixture. Where the measured thickness exceeds the tolerances of Table 1, correct such areasby removing and replacing the cement-stabilized material. Where the measured thickness is more than 1/2 inch thicker than indicated, the course will be considered as conforming with the specified thickness requirements. Calculate the average job thickness as the average of all thickness measurements taken for the job, but within the tolerances of Table 1.

3.9.4 Field Density

Perform field density tests in accordance with ASTM D1556/D1556M or ASTM D6938. Use ASTM D6938 to determine the moisture content of the soil. ASTM D6938 results in a wet unit weight of soil. Check calibration curves furnished along with the density gauge described in ASTM D6938. Make calibration checks of the density gauge at the beginning of a job on each type of material encountered. If ASTM D6938 is used, check in-place densities by ASTM D1556/D1556M at least once per lift for each 1000 square yards of stabilized material. Perform at least 1 field density test for each 250 square yards of each layer of cement-stabilized mixture.

3.9.5 Compressive Strength

Test composite sample of cement stabilized mixture for compressive strength. Fabricate three test cylinders for each set of tests in accordance with ASTM D558/D558M, Method A or B (as appropriate), cure and test according to ASTM D1632 and ASTM D1633. Test specimens for compressive strength at 7 days, and submit results. If the average of the three compressive strengths is less than 350 kPa 50 psi below the required strength, stop operations and adjust the mix design. If the average of the three compressive strengths is more than 50 psi below the required strength, remove and replace the area represented by the failing tests, as directed. Take samples not less than once a day, nor less than once for each 500 cubic yards of cement stabilized mixture.

3.9.6 Sieve Analysis

Perform a minimum of one analysis for each 1000 tons of material to be stabilized, with a minimum of 3 analyses for each day's run until the course is completed. When the source of materials is changed or deficiencies are found, repeat the analysis and retest the material already placed to determine the extent of unacceptable cement-stabilized mixture. Replace all in-place unacceptable cement-stabilized mixture.

3.9.7 Liquid Limit and Plasticity Index

Perform one liquid limit and plasticity index for each sieve analysis. Test for liquid limit and plasticity index in accordance with ASTM D4318.

3.9.8 Maintenance

Maintain the cement-stabilized mixture in a satisfactory condition until the completed work is accepted. Perform immediate repairs to any defects and repeat as often as necessary to keep the area intact. Repair defects as specified.

3.9.9 Traffic

Completed portions of the cement stabilized mixture may be opened immediately to light traffic provided the curing is not impaired. After the curing period has elapsed, completed areas may be opened to all traffic provided that the cement-stabilized mixture has hardened sufficiently to prevent marring or distorting of the surface by equipment or traffic. Heavy equipment will not be permitted on the area during the curing period. Cement and water may be hauled over the area with pneumatic-tired equipment as approved. Protect finished portions of cement-stabilized mixture that are traveled on by equipment used in constructing an adjoining section in a manner that prevents equipment from marring or damaging the completed work.

3.10 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of removed in-place materials that are unsuitable for stabilization, material that is removed for the required correction of defective areas, waste material, and debris off base.

-- End of Section --

SECTION 32 12 13

BITUMINOUS TACK AND PRIME COATS
05/17

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

The bituminous material paid for will be the measured quantities of residual bituminous material used in the accepted work, provided that the measured quantities are not 10 percent over the specified quantities. Any amount of bituminous material more than 10 percent over the specified quantity will be deducted from the measured quantities. Express measured quantities in 2000 pound tons or gallons at 60 degrees F. Correct volumes measured at temperatures other than 60 degrees F in accordance with ASTM D1250 using a coefficient of expansion of 0.00025 per degree F for asphalt emulsion.

1.1.2 Payment

The quantities of bituminous material, determined as specified above, will be paid for at the respective contract unit prices. Payment will constitute full compensation for all operations necessary to complete the work as specified herein.

1.1.3 Waybills and Delivery Tickets

Submit waybills and delivery tickets, during progress of the work. Before the final statement is allowed, file with the Contracting Officer certified waybills and certified delivery tickets for all bituminous materials used in the construction of the pavement covered by the contract. These submittals are required for Unit Pricing bid only. Do not remove bituminous material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 102	(2009; R 2013) Standard Method of Test for Spot Test of Asphaltic Materials

ASTM INTERNATIONAL (ASTM)

ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D946/D946M	(2020) Standard Specification for Penetration-Graded Asphalt Cement for Use

	in Pavement Construction
ASTM D977	(2019a; E 2019) Standard Specification for Emulsified Asphalt
ASTM D1250	(2019; E 2020) Standard Guide for Use of the Joint API and ASTM Adjunct for Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils: API MPMS Chapter 11.1
ASTM D2026/D2026M	(2015) Cutback Asphalt (Slow-Curing Type)
ASTM D2027/D2027M	(2019) Cutback Asphalt (Medium-Curing Type)
ASTM D2028/D2028M	(2015) Cutback Asphalt (Rapid-Curing Type)
ASTM D2397/D2397M	(2019a) Standard Specification for Cationic Emulsified Asphalt
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D6373	(2016) Standard Specification for Performance Graded Asphalt Binder

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Waybills and Delivery Tickets

Local/Regional Materials

SD-06 Test Reports

Sampling and Testing

1.4 QUALITY ASSURANCE

Certificates of compliance for asphalt materials delivered will be obtained and checked to ensure that specification requirements are met. Quantities of applied material will be determined. Payment will be for amount of residual asphalt applied. Tack coat materials will not be diluted. Prime coat materials when emulsions are used can be diluted on site with potable water up to 1 part emulsion to 1 part water.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.6 EQUIPMENT, TOOLS AND MACHINES

1.6.1 General Requirements

Equipment, tools and machines used in the work are subject to approval. Maintain in a satisfactory working condition at all times. Calibrate equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment within 12 months of their use. If the calibration expires during project, recalibrate the equipment before work can continue.

1.6.2 Bituminous Distributor

Provide a self propelled distributor with pneumatic tires of such size and number to prevent rutting, shoving or otherwise damaging the surface being sprayed. Calibrate the distributer in accordance with ASTM D2995. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled total liquid rates from 0.03 to 1.0 gallons per square yard, with a pressure range of 25 to 75 psi and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. The distributor will be capable of circulating and agitating the bituminous material during the heating process.

1.6.3 Heating Equipment for Storage Tanks

Use steam, electric, or hot oil heaters for heating the bituminous material. Provide steam heaters consisting of steam coils and equipment for producing steam, so designed that the steam cannot come in contact with the bituminous material. Fix an armored thermometer to the tank with a temperature range from 40 to 400 degrees F so that the temperature of the bituminous material may be determined at all times.

1.6.4 Power Brooms and Power Blowers

Use power brooms and power blowers suitable for cleaning the surfaces to which the bituminous coat is to be applied.

1.7 ENVIRONMENTAL REQUIREMENTS

Apply bituminous coat only when the surface to receive the bituminous coat is dry. A limited amount of moisture (approximately 0.03 gallon/square yard) can be sprayed on the surface of unbound material when prime coat is used to improve coverage and penetration of asphalt material. Apply bituminous coat only when the atmospheric temperature in the shade is 50 degrees F or above and when the temperature has not been below 35 degrees F for the 12 hours prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 PRIME COAT

Provide asphalt conforming to one of the following grades:

2.1.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2026/D2026M, Grade SC-70 SC-250 ASTM D2027/D2027M, Grade MC-30 MC-70 MC-250 ASTM D2028/D2028M, Grade RC-70 RC-250.

2.1.2 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 SS1h ASTM D2397/D2397M, Type CSS-1 CSS-1h. Asphalt emulsion can be diluted up to 1 part water to 1 part emulsion for prime coat use. Do not dilute asphalt emulsion for tack coat use.

2.2 TACK COAT

2.2.1 Asphalt Cement

Provide asphalt cement conforming to ASTM D946/D946M or ASTM D6373 Grade CSS-1H.

2.2.2 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2028/D2028M, Grade RC-70 .

2.2.3 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 SS1h ASTM D2397/D2397M, Type CRS-1 CSS-1h. For prime coats the emulsified asphalt can be diluted with up to 1 part emulsion to 1 part water. No dilution is allowed for tack coat applications. The base asphalt used to manufacture the emulsion is required to show a negative spot when tested in accordance with AASHTO T 102 using standard naphtha.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated by means of a power broom or blower supplemented with hand brooms. Apply treatment only when the surface is dry and clean.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions, will be determined by the Contracting Officer.

3.2.1 Tack Coat

Apply bituminous material for the tack coat in quantities of not less than 0.03 gallons nor more than 0.10 gallons per square yard of residual asphalt onto the pavement surface as approved by the Contracting Officer. Do not dilute asphalt emulsion when used as a tack coat.

3.2.2 Prime Coat

Apply bituminous material for the prime coat in quantities of not less than 0.05 gallons nor more than 0.12 gallons per square yard of residual asphalt for asphalt emulsion up to a 1 to 1 dilution rate or for residual asphalt for cutback asphalt.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Apply asphalt at a temperature that will provide a viscosity between 10 and 60 seconds, Saybolt Furol, or between 20 and 120 centistokes, kinematic. Furnish the temperature viscosity relation to the Contracting Officer.

3.3.2 Temperature Ranges

The viscosity requirements determine the application temperature to be used. The following is a normal range of application temperatures:

Cutback Asphalts	
MC-30	85-190 degrees F
SC-70, MC-70, RC-70	120-225 degrees F
SC-250, MC-250, RC-250	165-270 degrees F
Asphalt Emulsion	
All Grades	70-160 degrees F
Asphalt Cement	
All Grades	275-350 degrees F

Some of these temperatures for rapid cure cutbacks are above the flash point of the material and care should be taken in their heating.

3.4 APPLICATION

3.4.1 General

Following preparation and subsequent inspection of the surface, apply the bituminous prime or tack coat with the bituminous distributor at the specified rate with uniform distribution over the surface to be treated. Properly treat all areas and spots, not capable of being sprayed with the distributor, with the hand spray. Until the succeeding layer of pavement is placed, maintain the surface by protecting the surface against damage and by repairing deficient areas at no additional cost to the Government. If required, spread clean dry sand to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from the heaters that are a part of the equipment are permitted within 25 feet of heating, distributing, and transferring operations of cutback materials. Prevent all traffic, except for paving equipment used in constructing the surfacing, from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat requirements are described herein.

3.4.2 Prime Coat

The prime coat is required if it will be at least 7 days before the asphalt mixture is constructed on the underlying (base course, etc.) compacted material. The type of liquid asphalt and application rate will be as specified herein. Protect the underlying layer from any damage (water, traffic, etc.) until the surfacing is placed. If the Contractor places the surfacing within seven days, the choice of protection measures or actions to be taken is at the Contractor's option. Repair (recompact or replace) damage to the underlying material caused by lack of, or inadequate, protection by approved methods at no additional cost to the Government. If the Contractor opts to use the prime coat, apply as soon as possible after consolidation of the underlying material. Apply the bituminous material uniformly over the surface to be treated at a pressure range of 25 to 75 psi; the rate will be as specified above in paragraph APPLICATION RATE. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, spread building paper on the surface for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper and to ensure that all sprayers will operate at full force on the surface to be treated. Immediately after application remove and destroy the building paper.

3.4.3 Tack Coat

Apply tack coat at the locations shown on the drawings. A tack coat should be applied to every bound surface (asphalt or concrete pavement) that is being overlaid with asphalt mixture and at transverse and longitudinal joints. Apply the tack coat when the surface to be treated is clean and dry. Immediately following the preparation of the surface for treatment, apply the bituminous material by means of the bituminous distributor, within the limits of temperature specified herein and at a rate as specified above in paragraph APPLICATION RATE. Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Treat lightly coated areas and spots missed by the distributor by spraying with a hand wand or using other approved method. Following the application of bituminous material, allow the surface to cure without being disturbed for period of time necessary to permit setting of the tack coat. Apply the bituminous tack coat only as far in advance of the placing of the overlying layer as required for that day's operation. Maintain and protect the treated surface from damage until the succeeding course of pavement is placed.

3.5 CURING PERIOD

Following application of the bituminous material and prior to application of the succeeding layer of asphalt mixture allow the bituminous coat to cure and water or volatiles to evaporate prior to overlaying. Maintain the tacked surface in good condition until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up excess bituminous material.

3.6 FIELD QUALITY CONTROL

Obtain certificates of compliance for all asphalt material delivered to the project. Obtain samples of the bituminous material under the supervision of the Contracting Officer. The sample may be retained and tested by the Government at no cost to the Contractor.

3.7 SAMPLING AND TESTING

Furnish certified copies of the manufacturer's test reports indicating temperature viscosity relationship for cutback asphalt or asphalt cement, compliance with applicable specified requirements, not less than 5 days before the material is required in the work.

3.7.1 Sampling

Unless otherwise specified, sample bituminous material in accordance with ASTM D140/D140M.

3.7.2 Calibration Test

Furnish all equipment, materials, and labor necessary to calibrate the bituminous distributor. Calibrate using the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibrate the bituminous distributor in accordance with ASTM D2995.

3.7.3 Trial Applications

Before applying the spray application of tack or prime coat, apply three lengths of at least 100 feet for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous tack coat materials in the amount of 0.05 gallons per square yard. Make other trial applications using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous materials in the amount of 0.15 gallon per square yard. Make other trial applications using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Perform quality control sampling and testing as required in paragraph FIELD QUALITY CONTROL.

3.8 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

-- End of Section --

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SECTION 32 12 15.13

ASPHALT PAVING FOR AIRFIELDS
11/20, CHG 1: 05/22

PART 1 GENERAL

1.1 FULL PAYMENT

1.1.1 Method of Measurement

Utilize the quantity of hot-mixwarm-mix asphalt pavement, per ton placed and accepted, for the purposes of assessing the pay factors stipulated below.

1.1.2 Basis of Payment

The measured quantity of hot-mixwarm-mix asphalt pavement will be paid for and included in the lump sum contract price. If less than 100 percent payment is due based on the pay factors stipulated in paragraph PERCENT PAYMENT and ACCEPTANCE, a unit price of 100 per ton will be used for purposes of calculating the payment reduction.

1.2 PERCENT PAYMENT

When a pavement lot of material fails to meet the specification requirements for 100 percent pay as outlined in the following paragraphs, remove and replace the lot, or accept at a reduced price which will be computed by multiplying the unit price per ton by the lot's pay factor. The lot pay factor is determined by taking the lowest computed pay factor based on either laboratory air voids, in-place density, grade or smoothness (each discussed below). At the end of the project, an average of all lot pay factors will be calculated. If this average lot pay factor exceeds 95.0 percent and no individual lot has a pay factor less than 75.0 percent, then the percent payment for the entire project will be 100 percent of the unit bid price. If the average lot pay factor is less than 95.0 percent, then each lot will be paid for at the unit price multiplied by the lot's pay factor. For any lots which are less than 2000 tons, a weighted lot pay factor will be used to calculate the average lot pay factor. When work on a lot is required to be terminated before all sublots are completed, the results from the completed sublots will be analyzed to determine the percent payment for the lot following the same procedures and requirements for full lots but with fewer test results.

1.2.1 Mat and Joint Densities

The average in-place mat and joint densities are expressed as a percentage of the average theoretical maximum density (TMD) for the lot. The average TMD for each lot will be determined as the average TMD of the four random samples per lot. The average in-place mat density and joint density for a lot are determined and compared with Table 1 to calculate a single pay factor per lot based on in-place density, as described below. All density results for a lot will be completed and reported within 24 hours after the construction of that lot. Use the following process to determine the single pay factor for in-place density:

a. Step 1: Determine the pay factors for mat density and joint density using Table 1.

b. Step 2: Determine ratio of joint area to mat area. The area associated with the joint is considered to be 10 feet wide times the length of completed longitudinal construction joint in the lot. This joint area will not exceed the total lot size. The length of joint to be considered will be that length where a new lane has been placed against an adjacent lane of asphalt pavement, either any cold joint against another lot or any other existing asphalt paved previously. The area associated with the joint is expressed as a percentage of the total lot.

c. Step 3: Compute the weighted pay factor for the joint using the formula in the example shown in paragraph PAY FACTOR BASED ON IN-PLACE DENSITY.

d. Step 4: Where freshly placed asphalt pavement abuts old (not in contract) asphalt pavement, determine density at the tie-in longitudinal joint by taking one core per sublot at a random location for each lot of material placed adjacent to the joint. If Step 4 is not applicable, move to Step 5. The size of joint area is 10 feet wide by the length of the joint being paved. Locate the center of each of the four cores 6 inches from the edge of the existing pavement. Take each core at a random location along the length of the joint. The requirements for joint density for this lot, adjacent to the existing asphalt joint, are the same as that for the mat density specified in Table 1. For the interface of new asphalt pavement abutting existing asphalt (not in contract) joints at taxiways abutting runways, aprons, or other taxiways, take two additional randomly located cores along each taxiway intersection.

e. Step 5: Compare weighted pay factor for joint density to pay factor for mat density and select the lowest. This selected pay factor is the pay factor based on density for the lot. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD values will be used as the TMD needed to calculate the percent joint density.

When 0 percent payment is determined for mat density, remove and replace the rejected lot at least 4 inches into the cold lane adjacent to the longitudinal joint. Evaluate this as a new lot per paragraph MAT AND JOINT DENSITIES.

When 0 percent payment is determined for joint density, remove and replace the rejected longitudinal joint with a 10 feet wide paving lane that is centered over the joint. This 10 feet wide placement will be evaluated as a new lot. When removing and replacing a joint that fails to meet the project requirements, the result will be two additional longitudinal joints. Determine a pay factor for these longitudinal joints by randomly selecting two cores per lot centered on the joint each side of the lot. This will result in four total cores for joint density evaluation. Take the average of the joint density of the four cores to develop a pay factor for joint density determination. Average the new lot TMD values with the adjacent lot TMD values to determine a final average for joint density evaluation. In this case do not use a weighted pay factor. Evaluate the mat density for this lot per paragraph MAT AND JOINT DENSITIES.

Table 1

Pay Factor Based on In-place Density

Average Mat Density (4 cores) (Percent of TMD)	Pay Factor, percent	Average Joint Density (4 cores)(Percent of TMD)
94.0 - 96.0	100.0	Above 92.5
93.9	100.0	92.4
93.8 or 96.1	99.9	92.3
93.7	99.8	92.2
93.6 or 96.2	99.6	92.1
93.5	99.4	92.0
93.4 or 96.3	99.1	91.9
93.3	98.7	91.8
93.2 or 96.4	98.3	91.7
93.1	97.8	91.6
93.0 or 96.5	97.3	91.5
92.9	96.3	91.4
92.8 or 96.6	94.1	91.3
92.7	92.2	91.2
92.6 or 96.7	90.3	91.1
92.5	87.9	91.0
92.4 or 96.8	85.7	90.9
92.3	83.3	90.8
92.2 or 96.9	80.6	90.7
92.1	78.0	90.6
92.0 or 97.0	75.0	90.5
below 92.0, above 97.0	0.0 (reject)	below 90.5

1.2.2 Pay Factor Based on In-place Density

An example of the computation of a pay factor (in I-P units only) based on in-place density, is as follows: Assume the following test results for field density made on the lot: (1) Average mat density = 93.2 percent (of lab TMD). (2) Average joint density = 91.5 percent (of lab TMD). (3) Total area of lot = 30,000 square feet. (4) Length of completed longitudinal construction joint = 2,000 feet.

a. Step 1: Determine pay factor based on mat density and on joint density, using Table 1:

Mat density of 93.2 percent = 98.3 pay factor.

Joint density of 91.5 percent = 97.3 pay factor.

b. Step 2: Determine ratio of joint area (length of longitudinal joint x 10 feet) to mat area (total paved area in the lot): Multiply the length of completed longitudinal construction joint by the specified 10 feet width and divide by the mat area (total paved area in the lot).

(2,000 feet x 10 feet)/30000 square feet = 0.6667 ratio of joint area to mat area (ratio).

c. Step 3: Weighted pay factor (wpf) for joint is determined as indicated below:

wpf = joint pay factor + (100 - joint pay factor) (1 - ratio) wpf = 97.3 + (100-97.3) (1-0.6667) = 98.2 percent

d. Step 4: Compare weighted pay factor for joint density to pay factor for mat density and select the smaller:

Pay factor for mat density: 98.3 percent. Weighted pay factor for joint density: 98.2 percent

Select the smaller of the two values as pay factor based on density: 98.2 percent

1.2.3 Payment Adjustment for Smoothness (Final Wearing Surface Only)

1.2.3.1 Longitudinal Smoothness

Evaluate smoothness per paragraph PROFILOGRAPH TESTING. Determine the pay factor for longitudinal smoothness by entering Table 2.

Table 2

Pay Factor for Smoothness

Profile Index of a 0.1 mile segment of a lot exceeds the tolerance specified in paragraph SURFACE SMOOTHNESS by:	Pay Factor, Percent
0.0 inch per mile	100.0
greater than 0.0 inch per mile but less than 1.0 inches per mile	95.0
1.0 inches per mile but less than	90.0
2.0 inches per mile but less than 3.0 inches per mile	75.0
3.0 inches per mile or greater	Remove and Replace

1.2.4 Laboratory Air Voids and Theoretical Maximum Density

Laboratory air voids will be calculated in accordance with ASTM D3203/D3203M by determining the density of each lab compacted specimen using the laboratory-prepared, thoroughly dry method in ASTM D2726/D2726M and determining the theoretical maximum density (TMD) of four of the sublots using ASTM D2041/D2041M. Laboratory air void calculations for each lot will use the average TMD values obtained for the lot. The mean absolute deviation of the four laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated and a pay factor determined from Table 3. All laboratory air void tests will be completed and reported within 24 hours after completion of construction of each lot. The TMD is also used for computation of in-place density, as required in paragraph MAT AND JOINT DENSITIES above.

1.2.4.1 Mean Absolute Deviation

An example of the computation of mean absolute deviation for laboratory air voids is as follows: Assume that the laboratory air voids are determined from 4 random samples of a lot (where 3 specimens were compacted from each sample). The average laboratory air voids for each sublot sample are determined to be 3.5, 3.0, 4.0, and 3.7. Assume that the target air voids from the JMF is 4.0. The mean absolute deviation is then:

$$\text{Mean Absolute Deviation} = (|3.5 - 4.0| + |3.0 - 4.0| + |4.0 - 4.0| + |3.7 - 4.0|)/4$$

$$= (0.5 + 1.0 + 0.0 + 0.3)/4 = (1.8)/4 = 0.45$$

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen from Table 3 that the lot's pay factor based on laboratory air voids, is 100 percent.

Table 3

Pay Factor Based on Laboratory Air Voids

Mean Absolute Deviation of Lab Air Voids from JMF	Pay Factor, Percent
O.60 or less	100
0.61 - 0.80	98
0.81 - 1.00	95
1.01 - 1.20	90
Above 1.20	reject (0)

1.2.5 Pay Factor Based on Plan Grade

Evaluate plan grade per paragraph PLAN GRADE. Use Table 4 for determining Pay Factor for Plan Grade. Evaluate plan grade on a lot basis.

Table 4

Pay Factor for Plan Grade

Percent of All Measurements Outside Tolerance	Pay Factor, percent
Less than 5	100
Greater than or equal to 5 but less than 10	90
Greater than or equal to 10 but less than 15	75

Table 4	
Pay Factor for Plan Grade	
Percent of All Measurements Outside Tolerance	Pay Factor, percent
Greater than or equal to 15	Remove and replace the surface lift

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 156 (2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures

AASHTO T 329 (2015) Standard Test Method for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

ASPHALT INSTITUTE (AI)

AI MS-2 (2015) Asphalt Mix Design Methods

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M (2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

ASTM C88 (2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C117 (2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing

ASTM C127 (2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate

ASTM C128 (2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

ASTM C131/C131M (2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

ASTM C136/C136M (2019) Standard Test Method for Sieve

	Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C1252	(2017) Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D242/D242M	(2009; R 2014) Mineral Filler for Bituminous Paving Mixtures
ASTM D979/D979M	(2015) Sampling Bituminous Paving Mixtures
ASTM D2041/D2041M	(2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2419	(2014) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2489/D2489M	(2016) Standard Test Method for Estimating Degree of Particle Coating of Asphalt Mixtures
ASTM D2726/D2726M	(2019) Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D3203/D3203M	(2017) Standard Test Method for Percent Air Voids in Compacted Asphalt Mixtures
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

ASTM D4867/D4867M	(2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5361/D5361M	(2016) Standard Practice for Sampling Compacted Asphalt Mixtures for Laboratory Testing
ASTM D5444	(2015) Mechanical Size Analysis of Extracted Aggregate
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6373	(2016) Standard Specification for Performance Graded Asphalt Binder
ASTM D6925	(2014) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ASTM D6926	(2020) Standard Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus
ASTM D6927	(2015) Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures
ASTM E1274	(2018) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

1.4 AIRFIELD ASPHALT PAVING WORKSHOP

Attend a one day paving workshop held in advance of asphalt paving. Acquire a facility for the workshop in the vicinity of the installation, or other appropriate location, as approved by the Government. Provide a facility that includes at a minimum, parking and seating for forty attendees, audio/visual with standard connections, including TV, projector, screen and any other items as required for display of digital presentations, and access to Wi-Fi. Coordinate schedule with the Government. Attendance requirements apply to each paving crew anticipated to be on the project. At a minimum, the following attendees are required.

a. Project Superintendent

b. Paving Superintendent or Foreman(s)

c. Paving Machine Operator(s)

d. Asphalt Plant Operator(s)

e. Airfield Asphalt Pavement Quality Control Manager

f. Airfield Asphalt Pavement Inspector

g. Airfield Asphalt Pavement Laboratory Technicians

h. Roller Operators

i. Aggregate Supplier(s)

j. MTV Operator(s)

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Equipment; G

SD-02 Shop Drawings

Placement Plan; G

SD-03 Product Data

Diamond Grinding Plan; G

Mix Design; G

Contractor Quality Control; G

SD-04 Samples

Aggregates

Asphalt Binder

Warm-mix Additive

SD-06 Test Reports

Aggregates; G

QC Monitoring

Pavement Lots; G

SD-07 Certificates

Asphalt Binder; G

Testing Laboratory

Warm-mix Additive

Airfield Asphalt Pavement QC Manager

Airfield Asphalt Pavement Inspector

Airfield Asphalt Pavement Laboratory Technician

1.6 CONTRACTOR QUALITY CONTROL STAFF

Reference Section 01 45 00.00 10 QUALITY CONTROL for Contractor personnel qualification requirements along with the information included below. The Airfield Asphalt Pavement QC Manager is a separate person and is in addition to the QC Manager identified in Section 01 45 00.00 10 QUALITY CONTROL. The Airfield Asphalt Pavement QC Manager will report to and assist the project CQC System Manager. Submit certifications for Contractor Quality Control Staff in the following areas:

a. Airfield Asphalt Pavement QC Manager[(1)]: The QC manager will oversee all QC testing and inspection, review asphalt pavement transmittals prior to submission to the Government, be responsible for making mix design adjustments, and in charge of all other activities related to performance. The QC manager will also ensure that daily reports and necessary transmittals arrive for Government review as specified.

b. Airfield Asphalt Pavement Inspector[(1)]: The Inspector will be available on the project during all paving operations. The Inspector is responsible for identifying observed paving issues and ensuring these issues are addressed by the Contractor Quality Control staff.

c. Airfield Asphalt Pavement Laboratory Technician[(1)]: The Technician will be responsible for conducting laboratory tests. The Airfield Asphalt Pavement Technician will be present in the laboratory anytime laboratory testing is underway.

[(1)]: Registration for the Airfield Asphalt Pavement Certification Program can be found at www.airfieldasphaltcert.com.

1.7 ACCEPTANCE

1.7.1 Acceptability of Work

Acquire the services of an independent commercial laboratory to perform acceptance testing. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests from split samples to validate the results of the production testing. Testing performed by the Government does not reduce the required testing of the independent commercial laboratory. Split samples will be taken for Government testing to reduce the variability between the independent commercial laboratory and the Government's test results. When the difference between the independent commercial laboratory and the Government's test results for split samples exceed the acceptable range of two results for multi-laboratory precision for the appropriate test method (i.e. ASTM) then at least one of the laboratories is determined to be in error. An evaluation of procedures and equipment in both laboratories will be made to determine the cause(s) for the differences. Develop steps to correct procedures and equipment to bring multi-laboratory precision to within acceptable limits.

1.7.2 Acceptance Requirements

Provide all sampling and testing required for acceptance and payment adjustment. Where appropriate, adjustments in payment for individual lots of asphalt pavement will be made based on laboratory air voids, in-place density, smoothness, and grade in accordance with the following paragraphs. Surface smoothness and grade determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus smoothness and grade measurements for the entire lot cannot be made.

1.7.3 Pavement Lots

A standard lot for all requirements is equal to one day's production or 2,000 tons, whichever is smaller. Divide each lot into four equal sublots in order to evaluate laboratory air voids and in-place density. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, use the following procedure to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they constitute a lot. Where one or two sublots have been completed, incorporate them into the next lot and the total number of sublots (i.e. 5 or 6 sublots) is used for acceptance criteria. Maintain 4 sublots when possible. Include partial lots at the end of asphalt production into the previous lot. When more than one plant is simultaneously producing asphalt for the project, apply the lot size separately for each plant. Complete and report all asphalt testing including but not limited to aggregate gradation, asphalt content, theoretical maximum density, laboratory air voids, and in-place density testing within 24 hours, unless otherwise stated, after construction of each lot.

1.7.4 Sublot Sampling

Obtain one random mixture sample from each sublot in accordance with ASTM D979/D979M from a loaded truck or another approved location for determining laboratory air voids, theoretical maximum density, Contractor Quality Control, and for any additional testing as directed the Government. Representative samples will be selected from random trucks, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D3203/D3203M. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

1.7.5 Additional Sampling and Testing

The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Contractor. Testing in these areas will be treated as a separate lot. Payment will be made for the quantity of asphalt pavement represented by these tests in accordance with the provisions of this section.

1.7.6 Theoretical Maximum Density (TMD)

Measure theoretical maximum density one time for each sublot in accordance with ASTM D2041/D2041M for purposes of calculating laboratory air voids and determining in-place density. The average TMD for each lot will be determined as the average TMD of the random sublot samples. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD values will be used as the TMD needed to calculate the percent joint density.

1.7.7 Laboratory Air Voids

Prepare one set of laboratory compacted specimens for each sublot in accordance with ASTM D6926 using the hand-held hammer for the Marshall Method.Prepare one set of laboratory compacted specimens for each sublot in accordance with ASTM D6925 using the Superpave gyratory compactor. Provide three test specimens prepared from the same sample for each set of laboratory compacted specimens. Compact the specimens within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Do not reheat samples prior to compaction. Provide insulated containers as necessary to maintain the sample temperature. Measure the bulk density of laboratory compacted specimens in accordance with ASTM D2726/D2726M. Determine laboratory air voids from one set (three laboratory compacted specimens) for each sublot sample in accordance with ASTM D3203/D3203M.

1.7.8 In-place Density

Obtain one random 6 inch diameter core from the mat and joint of each sublot in accordance with ASTM D5361/D5361M for determining in-place density. Where different job mix formulas are required as part of the same project, and are adjacent to one another, follow the same joint density sampling and joint density testing instructions of this specification. Cut samples neatly with a diamond core drill bit. Obtain random cores that are the full thickness of the layer being placed. Select core locations randomly using the procedures contained in ASTM D3665. Locate cores for mat density no closer than 12 inches from a transverse or longitudinal joint. Center all cores for joint density on the joint. Discard samples that are clearly defective as a result of sampling and take an additional random core. When the random core is less than 1 inch thick, it will not be included in the analysis. In this case, obtain another random core sample. Clean and tack coat dry core holes before filling with asphalt mixture. Fill all core holes with asphalt mixture and compact using a manual (hand-held) Marshall hammer to the density specified. Provide all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Measure in-place density in accordance with ASTM D2726/D2726M using each core obtained from the mat and joint.

1.7.9 Surface Smoothness

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot by use of a straightedge and/or profilograph to reveal surface irregularities exceeding the tolerances specified. Straightedge is used for all lifts. Use the profilograph method for testing longitudinal smoothness on surface lifts only, except for paving lanes less than 0.10 miles, and at the ends of the paving limits for the project. Use straightedge method for all other measurements. If any pavement areas are diamond ground, retest these areas immediately after diamond grinding and submit results to the Government for evaluation. At a minimum, provide enough information to determine exact location of grinding (station and offset from centerline), smoothness results, and the associated lot(s) pay factor for smoothness. Follow requirements of paragraph DIAMOND GRINDING if diamond grinding is required to correct smoothness. Where drawings show required deviations from a plane surface (for instance crowns, drainage inlets), finish the surface to meet the approval of the Government.

1.7.9.1 Straightedge Testing

Provide finished surfaces of the pavements within the tolerances specified in Table 5 when checked with an approved 12 foot straightedge. Start longitudinal and transverse straightedge testing with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurements. Perform continuous tests across all joints. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Use the straightedge to also measure abrupt changes in surface smoothness. Abrupt changes in the surface can be visually observed where the surface exhibits irregularities or discontinuities. Surface areas with obvious smoothness defects will be tested with the straightedge to determine the limits of the surface not meeting the tolerance requirements in Table 5. Do not perform straightedge measurements across grade changes or cross slope transitions.

Perform transverse measurements perpendicular to centerline every 50 feet or more often as determined by the Government. [For longitudinal measurements, test parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet; and at the third points of paving lanes when widths of paving lanes are 20 feet or greater.] After two full lots have been placed with an average of less than five percent of measurements out, a request can be made to reduce the testing frequency at a rate approved by the Government. Report all individual straightedge measurements coinciding with project stationing in each paving lot report.

Table 5

Straightedge Surface Smoothness

Pavement Category	Direction of Testing	Tolerance, inch
Runways, taxiways, and landing zones	Longitudinal	1/8
	Transverse	1/4
Shoulders (outside edge stripe)	Longitudinal	1/4
	Transverse	1/4
Calibration hardstands and compass swinging bases	Longitudinal	1/8
	Transverse	1/8
All other airfield pavements (including overruns) and helicopter paved areas	Longitudinal	1/4
	Transverse	1/4

1.7.9.2 Profilograph Testing

Test the entire lot in the longitudinal direction with an approved California-type profilograph per ASTM E1274. Provide equipment that utilizes electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for the pavement. Use a "blanking band" that is 0.2 inch wide and the "bump template" span 1 inch with an offset of 0.4 inch. Perform the longitudinal testing at the centerline of each paving lot. If paving widths are greater than 16 feet test at the centerline and at 1/8th points from each side of the lot. Record the location and data from all profilograph measurements. Compute the profile index for each pass of the profilograph in each 0.1 mile segment. Provide a profile index not greater than 7 inches per mile per segment for runways, taxiways and landing zones. Provide a profile index not greater than 9 inches per mile per segment for all other pavements. Reduce any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height by diamond grinding until they do not exceed 0.3 inch when retested. Taper diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding. Skin patching for correcting low areas and planing or milling for correcting high areas are not permitted. When the profile index of a lot exceeds the tolerance specified, determine pay factor using Table 2. Diamond grinding is allowed to reduce the scallop height of pavement to decrease the lot profile index as long as minimum lift thickness per Contract is met and the diamond grinding limit per paragraph SURFACE SMOOTHNESS is not exceeded. Perform additional profilograph testing in all areas corrected by diamond grinding. Provide profilograph operated by an approved, factory-trained operator. Provide a digital copy of all test results to the Government in each paving lot report.

1.7.9.3 Final Profilograph Testing

After all paving on the runway or taxiway is complete, perform final profilograph testing in the longitudinal direction per paragraph PROFILOGRAPH TESTING with the following changes. Operate the profilograph the full length of the asphalt pavement on the runway or taxiway to facilitate testing of the smoothness between lots and to evaluate the transition of any transverse joints. Provide pavements having an average total profile index less than 10 inches per mile. Operate the profilograph 1 foot left and right of centerline and 15 feet right and left of project centerline (four total traces). Correct any "must grind" areas by diamond grinding or by removing and replacing full depth of the surface course. Reevaluate the pavement with a second profilograph run after corrections to ensure an average profile index of10 inches per mile or less is achieved. Final profilograph testing is to be done in addition to the profilograph traces being performed on a lot basis. Provide a digital copy of the test results to the Government prior to full acceptance of the pavement.

1.7.10 Plan Grade

Within 5 working days after completion of a particular lot incorporating the final wearing course, test the lot for conformance with specified plan grade requirements. Provide a final wearing surface of pavement conforming to the elevations and cross sections and not vary more than 0.03 foot for runways and landing zones or 0.05 foot for taxiways, aprons and shoulders. Deviation from the plan elevations will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels at intervals of 50 feet, or less, longitudinally that coincides with the project spot elevations and lateral spacing to match the paving lane width (after cut back). In areas where the grade exceeds the tolerance by more than 50 percent, remove the surface lift full depth and replace the lift with asphalt pavement to meet specification requirements, at no additional cost to the Government. Match finished surfaces at juncture with other pavements with finished surfaces of abutting pavements except for where paragraph ASPHALT PAVEMENT-PORTLAND CEMENT CONCRETE JOINTS apply. Diamond grinding can be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas is not permitted. Provide finished surface grades in record drawing format showing design and constructed elevations which are stamped and signed by a licensed surveyor. Provide a comparison of the as-built grades to the design grades and determine a percentage of individual measurements exceeding the tolerances specified and determine pay factor per paragraph PAY FACTOR BASED ON PLAN GRADE. Submit the survey CAD files to the Government for record purposes. Submit all files including the calculation for percent measurements in each paving lot report.

1.8 Laboratory Accreditation and Validation

Provide laboratories used to develop the Job Mix Formula (JMF), perform acceptance testing, and Contractor Quality Control testing that meet the requirements of ASTM D3666. Perform all required test methods by an accredited and validated laboratory including field standards. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory accreditation is not allowed. The Government will inspect the laboratory equipment and test procedures prior to the start of asphalt pavement operations for conformance with ASTM D3666. Submit a certificate of compliance signed by the manager of the laboratory stating that it meets these requirements to the Government prior to the start of construction. At a minimum, include the following certifications:

a. Qualification(s) and certification(s) of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment, with calibration dates, to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

1.9 ENVIRONMENTAL REQUIREMENTS

Do not place asphalt pavement upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 6. The temperature requirements may be waived by the Government, if requested; provided all other requirements, including in-place density, are met.

Table 6

Surface Temperature Limitations of Underlying Course

Mat Thickness, inches	Degrees F
3 or greater	40
Less than 3	45

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of asphalt pavement. However, where the construction covered herein interfaces with other sections, construct each interface to conform to the requirements of both this section and the other section, including tolerance for both.

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. Provide hot-mix asphalt (HMA)warm-mix asphalt (WMA) pavement designed and constructed in accordance with this section conforming to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Construct each course to the depth, section, or elevation required by the drawings and rolled, finished, and approved before the placement of the next course (adjacent to or above). Submit proposed Placement Plan, indicating lane widths, longitudinal joints, and transverse joints for each course or lift.

2.2 Equipment

Provide product data for all components below.

2.2.1 Asphalt Mixing Plant

Provide plants used for the preparation of asphalt mixture conforming to the requirements of AASHTO M 156, including calibration data.

2.2.1.1 Truck Scales

Weigh the asphalt mixture on approved scales, or on certified public scales at no additional expense to the Government. Inspect and seal scales at least annually by an approved calibration laboratory.

2.2.1.2 Inspection of Plant

Provide access to the Government at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.

2.2.1.3 Storage Silos

The asphalt mixture may be stored in non-insulated storage silos for a period of time not exceeding 3 hours. The asphalt mixture may be stored in insulated storage silos for a period of time not exceeding 8 hours. No differences in the mix removed from silos and the mix loaded into trucks are allowed.

2.2.2 Hauling Equipment

Provide trucks used for hauling asphalt mixture that have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, lightly coat the truck beds with a minimum amount of paraffin oil, lime solution, or other approved material. Do not use petroleum based products as a release agent. Cover the bed of each truck with a tarp or other suitable cover at all times during transport. When necessary to ensure that the mixture is delivered to the site at the specified temperature, provide insulated or heated truck beds with covers (tarps) that are securely fastened.

2.2.3 Material Transfer Vehicle (MTV)

Provide a self-propelled MTV with a swing conveyor that delivers material to the paver from outside the paving lane and without making contact with the paver. Provide MTV capable to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. Provide Material Transfer Vehicle with remixing and a minimum onboard storage capability of 13 tons.

2.2.4 Asphalt Pavers

Provide mechanical spreading and finishing equipment consisting of a self-powered paver, capable of spreading and finishing the mixture to the specified line, grade, and cross section. Provide paver with a vibrating screed capable of placing a uniform mixture to meet the specified thickness, smoothness, and grade without physical or temperature segregation, the full width of the material being placed. Provide a screed that effectively produces a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture. Provide information on the tractor(s) and screed(s) proposed for use.

2.2.4.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and a distribution system to place the mixture uniformly in front of the screed without segregation.

2.2.4.2 Automatic Grade Controls

If an automatic grade control device is used, provide a paver equipped with a control system capable of automatically maintaining the specified screed elevation that is automatically actuated from either a reference line or through a system of mechanical sensors or sensor-directed mechanisms or devices which maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. Provide transverse slope controller capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. Do not use the transverse slope controller to control grade. Provide controls capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 30 feet in length.

b. Taut stringline set to grade.

c. Short ski or shoe for joint matching.

d. Laser control.

e. GPS control.

2.2.5 Rollers

Provide rollers in good condition and operated at slow speeds to avoid displacement of the asphalt mixture. Provide sufficient number, type, and weight of rollers to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.2.6 Diamond Grinding

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of airfield pavements. In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the asphalt pavement with approved equipment after the asphalt pavement is at a minimum age of 14 days. Perform diamond grinding by sawing with saw blades impregnated with an industrial diamond abrasive. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the asphalt pavement. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 feet wide. Diamond grinding equipment that causes raveling, fracturing of aggregate , or disturbance to the underlying material will not be allowed. The maximum area corrected by diamond grinding the surface of the asphalt pavement is 10 percent of the total area of any sublot. The maximum depth of diamond grinding is 1/2 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified.

Prior to production diamond grinding operations, perform a test section at the approved location, consisting of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish and transition between adjacent passes. Production diamond grinding operations cannot be performed prior to approval.

2.3 AGGREGATES

Sample aggregates in the presence of a Government Representative. Obtain samples in accordance with ASTM D75/D75M and be representative of the materials to be used for the project. Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The portion of material retained on the No. 4 sieve is coarse aggregate. The portion of material passing the No. 4 sieve and retained on the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve is defined as mineral filler. Submit sufficient materials to produce 200 pounds 400 pounds of blended mixture for mix design verification. Submit all aggregate test results and samples to the Government at least 14 days prior to start of construction. Aggregate tests can be no older than 6 months prior to test section.

2.3.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. Provide coarse aggregate particles meeting the following requirements:

a. The percentage of loss not greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131/C131M.

b. The sodium sulfate soundness loss not exceeding 12 percent, or the magnesium sulfate soundness loss not exceeding 18 percent after five cycles when tested in accordance with ASTM C88.

c. At least 75 percent by weight of coarse aggregate contain at least two or more fractured faces when tested in accordance with ASTM D5821 with fractured faces produced by crushing.

d. The particle shape essentially cubical and the aggregate containing not more than 5 percent, by weight, of flat particles, elongated particles, or flat and elongated particles (5:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791 Method A.

e. Slag consisting of air-cooled, blast furnace slag, with a compacted weight of not less than 75 pounds per cubic foot when tested in accordance with ASTM C29/C29M.

f. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.3.2 Fine Aggregate

Provide fine aggregate consisting of clean, sound, tough, durable particles. Provide aggregate particles that are free from coatings of clay, silt, or any objectionable material, contain no clay balls, and meet the following requirements:

a. Quantity of natural sand (noncrushed material) added to the aggregate blend not exceeding 15 percent by weight of total aggregate.

b. Individual fine aggregate sources with a sand equivalent value greater than 45 when tested in accordance with ASTM D2419.

c. Fine aggregate portion of the blended aggregate with an uncompacted void content greater than 45.0 percent when tested in accordance with ASTM C1252 Method A.

d. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.3.3 Mineral Filler

Provide mineral filler consisting of a nonplastic material meeting the requirements of ASTM D242/D242M.

2.3.4 Aggregate Gradation

Provide a combined aggregate gradation that conforms to gradations specified in Table 7, when tested in accordance with ASTM C136/C136M and ASTM C117, and does not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grades uniformly from coarse to fine. Provide a JMF within the specification limits; however, the gradation can exceed the limits when the allowable deviation from the JMF shown in Tables 10 and 11 are applied.

Table 7			
Aggregate Gradations			
	Gradation 1	Gradation 2	Gradation 3
Sieve Size, inch	Percent Passing by Mass	Percent Passing by Mass	Percent Passing by Mass
1	100	---	---
3/4	90-100	100	---
1/2	68-88	90-100	100
3/8	60-82	69-89	90-100
No. 4	45-67	53-73	58-78
No. 8	32-54	38-60	40-60
No. 16	22-44	26-48	28-48
No. 30	15-35	18-38	18-38
No. 50	9-25	11-27	11-27
No. 100	6-18	6-18	6-18
No. 200	3-6	3-6	3-6

2.4 ASPHALT BINDER

Provide asphalt binder that conforms to ASTM D6373 for Performance Grade (PG) 76-22. Provide test data indicating grade certification by the supplier at the time of delivery of each load to the mix plant. When warm-mix asphalt technology involves additives, grade the the asphalt binder with the additive included. Submit copies of these certifications to the Government. The supplier is defined as the last source of any modification to the binder. The Government may sample and test the binder at the mix plant at any time before or during mix production.

2.5 WARM-MIX ASPHALT TECHNOLOGIES/PRODUCTS

Provide warm-mix asphalt technologies/products that have a record of good performance and are included on the local state DOT's qualified products list, if the DOT maintains a qualified products list. Also, include the warm-mix asphalt technologies/products in at least two out of the following three states DOT's qualified products lists: Florida, Texas, and Virginia. These qualified products lists can be found at each state DOT's website.

2.6 MIX DESIGN

Develop the mix design and provide results of the Job Mix formula (JMF) and aggregates testing performed no earlier than 6 months prior to contract award. Provide asphalt mixture composed of well-graded aggregate, mineral filler if required, and asphalt material. Provide aggregate fractions sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of Table 7. Do not produce asphalt pavement for payment until a JMF has been approved. Design the asphalt mixture using hand-held (manual) Marshall hammer procedures contained in AI MS-2 and the criteria shown in Table 8. Mechanical hammers are not permitted during JMF development. Design the asphalt mixture using the Superpave gyratory compactor set at 50 gyrations using the procedures contained in AI MS-2 and the criteria shown in Table 8. Prepare samples at various asphalt contents and compacted in accordance with ASTM D6925ASTM D6926. Use laboratory compaction temperatures for Polymer Modified Asphalts as recommended by the asphalt binder supplier. For tensile strength ratio (TSR) testing, adjust the compactive effort, as required, to provide specimens with an air void content of 7 plus or minus 1 percent. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867/D4867M is less than 75, reject the aggregates or treat the asphalt mixture with an anti-stripping agent. Add a sufficient amount of anti-stripping agent to produce a TSR of not less than 75. If an antistrip agent is required, provide it at no additional cost to the Government. Provide sufficient materials to produce 200 pounds 400 pounds of blended mixture to the Government for verification of mix design at least 14 days prior to construction of test section.

2.6.1 JMF Requirements

Submit the proposed JMF in writing, for approval, at least 14 days prior to the start of the test section, including as a minimum:

a. Percent passing each sieve size.

b. Optimum asphalt content.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt viscosity grade, penetration grade, or performance grade and additional test requirements as specified in paragraph ASPHALT BINDER.

e. Number of blows of hammer per side of molded specimen.Number of Superpave gyratory compactor gyrations.

f. Laboratory mixing and compaction temperatures.

g. Supplier-recommended field mixing and compaction temperatures.

h. Percentage and properties (asphalt content aggregate gradation, and aggregate properties) of RAP in accordance with paragraph RECYCLED ASPHALT PAVEMENT, if RAP is used.

i. Temperature-viscosity relationship of the asphalt binder.

j. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

k. Graphical plots and summary tabulation of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2. Include summary tabulation that includes individual specimen data for each specimen tested.

l. Specific gravity and absorption of each aggregate.

m. Percent natural sand.

n. Percent particles with two or more fractured faces (in coarse aggregate).

o. Fine aggregate angularity.

p. Percent flat or elongated particles (in coarse aggregate).

q. Tensile Strength Ratio and wet/dry specimen test results.

r. Type and amount of antistrip agent (if required).

s. List of all modifiers.

t. Percentage and properties (asphalt content aggregate gradation, and aggregate properties) of RAP in accordance with paragraph RECLAIMED ASPHALT PAVEMENT, if RAP is used.

u. Date the JMF was developed. Mix designs that are not dated or which are from a prior construction season may not be accepted.

v. Warm-mix additive.

Table 8

Marshall Design Criteria

Test Property	75 Blow Mix	50 Blow Mix
Stability, pounds minimum	2150 (1)	1350 (1)
Flow, 0.01 inch	8-16 (2)	8-18 (2)
Air voids, percent	4 (4)	4 (4)
Percent Voids in mineral aggregate (minimum)	See Table 9	See Table 9
Dust Proportion (3)	0.8-1.2	0.8-1.2
TSR, minimum percent	75	75
TSR Conditioned Strength (minimum psi)	60	60

(1) This is a minimum requirement. Provide significantly higher average during construction to ensure compliance with the specifications.

(2) The flow requirement is not applicable for Polymer Modified Asphalts

Table 8		
Marshall Design Criteria		
Test Property	75 Blow Mix	50 Blow Mix
(3) Dust Proportion is calculated as the aggregate content, expressed as a percent of mass, passing the No. 200 sieve, divided by the effective asphalt content, in percent of total mass of the mixture.		
(4) Select the JMF asphalt content corresponding to an air void content of 4 percent. Verify the other properties of Table 8 meet the specification requirements at this asphalt content.		

Table 8	
Superpave Gyratory Compaction Criteria	
Test Property	Value
Air voids, percent	$4^{(1)}$
Percent Voids in mineral aggregate (minimum)	See Table 9
Dust Proportion$^{(2)}$	0.8-1.2
TSR, minimum percent	75
TSR Conditioned Strength (minimum psi)	60
(1) Select the JMF asphalt content corresponding to an air void content of 4 percent. Verify the other properties of Table 8 meet the specification requirements at this asphalt content.	
(2) Dust Proportion is calculated as the aggregate content, expressed as a percent of mass, passing the No. 200 sieve, divided by the effective asphalt content, in percent of total mass of the mixture.	

Table 9	
Minimum Percent Voids in Mineral Aggregate (VMA)$^{(1)}$	
Aggregate (See Table 7)	Minimum VMA, percent
Gradation 1	13.0
Gradation 2	14.0
Gradation 3	15.0
(1) Calculate VMA in accordance with AI MS-2, based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate.	

2.6.2 Adjustments to JMF

The JMF for each mixture is in effect until a new formula is approved in writing by the Government. Should a change in sources of any materials be made, perform a new mix design and a new JMF approved before the new material is used. Make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF are limited to plus or minus 4 percent on the No. 4 and coarser sieves; plus or minus 3 percent on the No. 8 to No. 50 sieves; and plus or minus 1 percent on the No. 100 sieve. Adjustments to the JMF are limited to plus or minus 1.0 percent on the No. 200 sieve. Asphalt content adjustments are limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, develop a new mix design.

2.7 RECLAIMED ASPHALT PAVEMENT

Reclaimed asphalt is not allowed for the project.

2.7.1 RAP Aggregates and Asphalt Binder

Provide a blend of aggregates used in the reclaimed mix that meet the requirements of paragraph AGGREGATES. Establish the percentage of asphalt in the RAP for the mixture design according to ASTM D2172/D2172M using the appropriate dust correction procedure.

2.7.2 RAP Mix

Do not make adjustments to the virgin binder selection for 0-20 percent recycled binder content.

2.8 RECYCLED ASPHALT SHINGLES

Recycled asphalt shingles (RAS) is not allowed for the project.

PART 3 EXECUTION

3.1 CONTRACTOR QUALITY CONTROL

3.1.1 General Quality Control Requirements

Submit the Pavement Quality Control Plan. The Quality Control Plan is specific to this specification and supplements the overall Quality Control Plan required by Section 01 45 00.00 10. Do not produce hot-mixwarm-mix asphalt pavement for payment until the quality control plan has been approved. In the quality control plan, address all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design and unique JMF identification code

b. Aggregate Grading

c. Quality of Materials

d. Stockpile Management and procedures to prevent contamination

e. Proportioning including percent of warm-mix additive

f. Mixing and Transportation

g. Mixture Volumetrics

h. Moisture Content of Mixtures

i. Placing and Finishing

j. Joints

k. Compaction, including Asphalt Pavement-Portland Cement Concrete joints

l. Surface Smoothness

m. Truck bed release agent

n. Correlation of mechanical hammer to hand-held (manual) hammer. Determine the number of blows of the mechanical hammer required to provide the same density of the JMF as provided by the hand-held (manual) hammer. Use the average of three specimens per trial blow application.

3.1.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site that is equipped with heating and air conditioning units to maintain a temperature of 75 plus or minus 5 degrees F. Provide laboratory facilities that are kept clean and all equipment maintained in proper working condition. Provide the Government with unrestricted access to inspect the laboratory facility, to witness quality control activities, and to perform any check testing desired. The Government will advise in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, immediately suspend the incorporation of the materials into the work. Incorporation of the materials into the work will not be permitted to resume until the deficiencies are corrected.

3.1.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The quality control (QC) testing is separate and distinct from the acceptance testing in paragraph ACCEPTANCE. Use in-house capabilities or the independent commercial laboratory for quality control testing. Required elements of the testing program include, but are not limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability, flow, in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.1.3.1 Asphalt Content

Determine asphalt content a minimum of twice per lot (a lot is defined in paragraph PAVEMENT LOTS) by one of the following methods: extraction method in accordance with ASTM D2172/D2172M, Method A or B, the ignition method in accordance with ASTM D6307, or the nuclear method in accordance with ASTM D4125/D4125M, provided each method is calibrated for the specific mix being used. For the extraction method, determine the weight of ash, as described in ASTM D2172/D2172M, as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. Use the last weight of ash value in the calculation of the asphalt content for the mixture. The asphalt content for the lot will be determined by averaging the test results.

3.1.3.2 Aggregate Properties

Determine aggregate gradations a minimum of twice per lot (a lot is defined in paragraph PAVEMENT LOTS) from mechanical analysis of recovered aggregate in accordance with ASTM D5444, ASTM C136/C136M, and ASTM C117. Determine the specific gravity of each aggregate size grouping for each 20,000 tons in accordance with ASTM C127 or ASTM C128. Determine fractured faces for gravel sources for each 20,000 tons in accordance with ASTM D5821. Determine the uncompacted void content of fine aggregate (including manufactured sand and blending aggregate) for each 20,000 tons in accordance with ASTM C1252 Method A.

3.1.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt binder in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.1.3.4 Moisture Content of Aggregate

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with ASTM C566.

3.1.3.5 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in accordance with AASHTO T 329.

3.1.3.6 Laboratory Air Voids, TMD, and VMA VMA, Marshall Stability and Flow

Obtain mixture samples at least four times per lot and compacted into specimens, using 50 blows per side with the Marshall hand-held (manual) hammer as described in ASTM D6926. The mechanical Marshall hammer can be used only after JMF development and after correlation from hand-held (manual) Marshall hammer to mechanical Marshall hammer per guidance in AI MS-2.using 50 gyrations of the Superpave gyratory compactor as described in ASTM D6925. After compaction, measure the bulk density of laboratory compacted specimens in accordance with ASTM D2726/D2726M. Determine the laboratory air voids from the set (three laboratory compacted specimens) for each sample in accordance with ASTM D3203/D3203M. Also calculate the VMA of each specimen in accordance with AI MS-2 based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate, as well as the Marshall stability and flow, as described in ASTM D6927. Provide VMA within the limits of Table 9.

3.1.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge or other non-destructive testing device may be used to monitor pavement density for Contractor Quality Control purposes only.

3.1.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraph ACCEPTANCE.

3.1.3.9 Additional Testing

Perform any additional testing, deemed necessary to control the process.

3.1.3.10 QC Monitoring

Submit all QC test results to the Government on a daily basis as the tests are performed. The Government reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.1.4 Sampling

When directed by the Government, sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected. Perform all sampling in accordance with standard procedures specified.

3.1.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 10, as a minimum. Post the control charts as directed by the Government and maintain current at all times. Identify the following on the control charts, the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 10 applicable to the test parameter being plotted, and the test results. Also show target values (JMF) on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. When the Suspension Limit is exceeded for individual values or running average values, the Government has the option to require removal and replacement of the material represented by the samples or to leave in place and base acceptance on mixture volumetric properties and in place density. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. In the Quality Control Plan, indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 10

Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
No. 4 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	6	8	4	5
No. 30 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	4	6	3	4
No. 200 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	1.4	2.0	1.1	1.5
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine			
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine			
VMA, percent deviation from JMF target				
Gradation 1, 2 & 3	-0.5	-1.0	-0.25	-0.5
$P_{0.075}/P_{be}$ Ratio, deviation from 1.0; plus or minus values	0.7	0.8	0.3	0.4

Table 10 cont'd

Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts - Marshall Compaction

Stability, pounds (minimum)				
75 blow JMF	1760	1640	2150	2030
50 blow JMF	950	830	1350	1230
Flow, 0.01 inch				
75 blow JMF	8 min.	7 min.	9 min.	8 min.
	16 max.	17 max.	15 max.	16 max.

Table 10 cont'd				
Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts - Marshall Compaction				
50 blow JMF	8 min.	7 min.	9 min.	8 min.
	18 max.	19 max.	17 max.	18 max.

3.2 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt binder material while avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. Maintain the temperature of unmodified asphalts to no more than 325 degrees F when added to the aggregates. The temperature of modified asphalts is not to exceed 350 degrees F.

3.3 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage to the aggregates due to the maximum temperature and rate of heating used is allowed. Maintain the temperature no lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.4 PREPARATION OF ASPHALT MIXTURE

Weigh or meter the aggregates and the asphalt binder and introduce into the mixer in the amount specified by the JMF. Limit the temperature of the asphalt mixture to 350 degrees F 270 degrees F when the asphalt binder is added. Mix the combined materials until the aggregate obtains a thorough and uniform coating of asphalt binder (testing in accordance with ASTM D2489/D2489M may be required by the Contracting Officer) and is thoroughly distributed throughout the mixture. The moisture content of all asphalt mixture upon discharge from the plant is not to exceed 0.5 percent by total weight of mixture as measured by AASHTO T 329.

3.5 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing asphalt pavement, clean the underlying course of dust and debris. Apply a prime coat or tack coat in accordance with Section 32 12 13 BITUMINOUS TACK AND PRIME COATS.

3.6 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section 500 feet long and two paver passes wide with a longitudinal cold joint. Do not place the second lane of test section until the temperature of pavement edge is less than 175 degrees F. Construct the test section with the same depth as the course which it represents. Ensure the underlying grade or pavement structure upon which the test section is to be constructed is the same or very similar to the underlying layer for the project. Use the same equipment in construction of the test section as on the remainder of the course represented by the test section. Construct the test section as part of the project pavement as approved by the Government.

3.6.1 Sampling and Testing for Test Section

Obtain one representative sample from random trucks at the plant, compact triplicate specimens, and test for stability, flow, and laboratory air voids. Test a portion of the same sample for theoretical maximum density (TMD), aggregate gradation and asphalt content. Test an additional portion of the sample to determine the TSR. Adjust the compactive effort as required to provide TSR specimens with an air void content of 7 plus or minus 1 percent. Obtain four randomly selected cores from the finished pavement mat, and four from the longitudinal joint, and test for density. Perform random sampling in accordance with procedures contained in ASTM D3665. Construction may continue provided the test results are within the tolerances or exceed the minimum values shown in Table 11. If all test results meet the specified requirements, the test section may remain as part of the project pavement. If test results exceed the tolerances shown, remove and replace the test section and construct another test section at no additional cost to the Government.

Table 11

Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
No. 4 and larger	JMF plus or minus 8
No. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
No. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	See Table 9
Tensile Strength Ratio (TSR) (At 7 percent plus/minus 1 percent air void content)	75 percent minimum
Conditioned Strength	60 psi minimum
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 minimum

Table 11 cont'd	
Test Section Requirements for Material and Mixture Properties Marshall Compaction	
Stability, (Average of 3 specimens)	1350 pounds minimum for 50-blow
Flow, 0.01 inch (Average of 3 specimens)	8 - 18 for 50-blow

3.6.2 Additional Test Sections

If the initial test section proves to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and rolling procedures before beginning construction of a second test section. Construct and evaluate additional test sections, as required, for conformance to the specifications. Full production paving is not allowed to begin until an acceptable test section has been constructed and accepted.

3.7 TRANSPORTING AND PLACING

3.7.1 Transporting

Transport asphalt mixture from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material is not permitted until the material has been compacted as specified, and allowed to cool to 140 degrees F.

3.7.2 Placing

Place the mix in lifts of adequate thickness and compacted at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Place the mixture to the full width by an asphalt paver; strike off in a uniform layer of such depth that, when the work is complete, the required thickness conforms to the grade and contour indicated. Do not broadcast waste mixture onto the mat or recycle it into the paver hopper. Collect waste mixture and dispose off site. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Begin placement of the mixture along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 10 feet. Offset the longitudinal joint in one course from the longitudinal joint in the course immediately below by at least 1 foot; however, locate the joint in the surface course at the centerline of the pavement. Offset transverse joints in one course by at least 10 feet from transverse joints in the previous course. Offset transverse joints in adjacent lanes a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools. Construct the free edge of shoulder pavements following a guide (e.g. plumb-bob, stringline, etc.) to prevent various widths of the asphalt shoulder. Contractor may elect to cut-back the asphalt edge to maintain consistent shoulder dimensions shown on the plans.

3.8 COMPACTION OF MIXTURE

3.8.1 General

a. After placing, thoroughly and uniformly compact the mixture by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. Determine the sequence of rolling operations and the type of rollers used, except as specified in paragraph ASPHALT PAVEMENT-PORTLAND CEMENT CONCRETE JOINTS. Maintain the speed of the roller, at all times, sufficiently slow to avoid displacement of the asphalt mixture and be effective in compaction. Correct at once any displacement occurring as a result of reversing the direction of the roller, or from any other cause.

b. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the drums properly moistened, but excessive water is not permitted. In areas not accessible to the roller, thoroughly compact the mixture with hand tampers. Remove the full depth of any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective, replace with fresh asphalt mixture and immediately compact to conform to the surrounding area. Perform this work at no expense to the Government. Skin patching is not allowed.

3.8.2 Segregation

The Government can sample and test any material that looks deficient. When the in-place material appears to be segregated, the Government has the option to sample the material and have it tested and compared to the aggregate gradation, asphalt content, and in-place density requirements in Table 11. If the material fails to meet these specification requirements, remove and replace the extent of the segregated material the full depth of the layer of asphalt mixture at no additional cost to the Government. When segregation occurs in the mat, take appropriate action to correct the process so that additional segregation does not occur.

3.9 JOINTS

Construct joints to ensure a continuous bond between the courses and to obtain the required density. Provide all joints with the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.9.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, construct by means of placing a bulkhead or by tapering the course. Utilize a dry saw cut on the transverse joint full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. Neither cutting equipment that uses water as a cooling or cutting agent nor milling equipment is permitted. Remove the cutback material and cutting debris from the project. Provide a tack coat in accordance with Section 32 12 13 BITUMINOUS TACK AND PRIME COATS to all contact surfaces before placing any fresh mixture against the joint.

3.9.2 Longitudinal Joints

Cut back longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing the adjacent lane), or otherwise defective, a minimum of 3 inches and a maximum of 6 inches from the top edge of the lift with a cutting wheel to expose a clean, sound, near vertical surface for the full depth of the course. Remove all cutback material from the project. Neither cutting equipment that uses water as a cooling or cutting agent nor milling equipment is permitted. Remove the cutback material and cutting debris from the project. Provide tack coat in accordance with Section 32 12 13 BITUMINOUS TACK AND PRIME COATS to all contact surfaces prior to placing any fresh mixture against the joint.

3.9.3 Echelon Paving

If echelon paving is accomplished to minimize longitudinal cold joints, visually inspect the interface between the two paving lanes to ensure that the interface is not segregated or appears to be visually different from other sections of the course. If visual inspection identifies quality concerns, extract 1 randomly selected cores per sublot centered over the interface between the two paving lanes being placed. The requirements for density at the interface between the two echelon paved lanes are the same as that for the joint density specified in paragraph MAT AND JOINT DENSITIES.

3.9.4 Asphalt Pavement-Portland Cement Concrete Joints

Joints between asphalt pavement and Portland Cement Concrete (PCC) require specific construction procedures for the asphalt pavement. The following criteria are applicable to the first 10 feet or paver width of asphalt pavement adjacent to the PCC.

a. For all lifts, place the asphalt pavement side of the joint in a direction parallel to the joint.

b. For non-surface lifts (e.g. base or intermediate lifts), compact the mixture per paragraph MAT AND JOINT DENSITIES.

b. For the surface lift place the asphalt pavement side sufficiently high so that when fully compacted the asphalt pavement is greater than 1/8 inch but less than 1/4 inch higher than the PCC side of the joint.

c. For the surface lift, compact with steel wheel rollers and at least one rubber tire roller. Compact with a rubber tire roller that weights at least 20 tons with tires inflated to at least 90 psi. Avoid spalling the PCC during placement and compaction of the asphalt pavement. Operate steel wheel rollers in a way that prevents spalling the PCC. Repair any damage to PCC edges or joints as directed by the Government. If damage to the PCC joint or panel edge exceeds a total of 3 feet, remove and replace the PCC panel at no additional expense to the Government.

d. For the surface lift, after compaction is finished, diamond grind a minimum width of 3 feet of the asphalt pavement so that the asphalt pavement side is less than 1/8 inch higher than the PCC side. Perform diamond grinding in accordance with subparagraph DIAMOND GRINDING above. The asphalt pavement immediately adjacent to the joint is not allowed to be lower than the PCC after the grinding operation. Transition the grinding into the asphalt pavement in a way that ensures good smoothness and provides drainage of water. The joint and adjacent materials when completed is required to meet all of the requirements for grade and smoothness. Measure smoothness across the asphalt pavement-PCC joint using a 12 feet straightedge. The acceptable tolerance is 1/8 inch.

e. For all lifts, consider the asphalt pavement next to the PCC as a separate weighted pay factor associated with the lot being placed for evaluation. Lots are based on individual lifts. Do not commingle cores from different lifts for density evaluation purposes. Take four cores for each lot of material placed adjacent to the asphalt pavement-PCC joint. The size of lot is 10 feet wide by the length of the joint being paved. Perform the same computation as displayed in paragraph PAY FACTOR BASED ON IN-PLACE DENSITY above to determine the weighted pay factor. Select the lowest computed pay factor for the lot. Locate the center of each of the four cores 6 inches from the edge of the concrete. Take each core at a random location along the length of the joint. The requirements for joint density, adjacent to the PCC joint, are the same as that for the mat density specified in Table 1. For asphalt pavement-PCC joints at taxiways abutting runways, aprons, or other taxiways, take two additional randomly located cores along each taxiway intersection.

f. All procedures, including repair of damaged PCC, are required to be in accordance with the approved Quality Control Plan.

-- End of Section --

SECTION 32 12 16.16

ROAD-MIX ASPHALT PAVING
11/20

PART 1 GENERAL

1.1 PERCENT PAYMENT

1.1.1 Method of Measurement

The amount paid for will be the number of tons of hot-mix warm-mix asphalt pavement mixture used in the accepted work. Weigh the hot-mix warm-mix asphalt pavement mixture after mixing. No separate payment will be made for weight of asphalt cement material incorporated herein.

1.1.2 Basis of Payment

Quantities of hot-mix warm-mix asphalt pavement, determined as specified above, will be paid for at respective contract unit prices or at reduced prices adjusted in accordance with paragraphs PERCENT PAYMENT and ACCEPTANCE. Payment will constitute full compensation for furnishing all materials, equipment, plant, and tools; and for all labor and other incidentals necessary to complete work required by this section of the specification. The measured quantity of hot-mixed warm-mixed asphalt pavement will be paid for and included in the lump sum contract price. If less than 100 percent payment is due based on the pay factors stipulated in paragraph PERCENT PAYMENT, a unit price as specified by the Contracting Officer will be used for purposes of calculating the payment reduction.

1.1.3 Lot Pay Factor

The lot pay factor is determined by taking the lowest computed pay factor based on either laboratory air voids, in-place density, smoothness, or grade (each discussed below). Remove and replace lots when the lowest computed pay factor requires rejection. At the end of the project calculate the average pay factor for all lots. If this average lot pay factor exceeds 95.0 percent and no individual lot has a pay factor less than 75.0 percent, then the percent payment for the entire project will be 100 percent of the unit bid price. If the average lot pay factor is less than 95.0 percent, then each lot will be paid for at the unit price multiplied by the lot's pay factor. For any lots which are less than 2,000 tons, a weighted lot pay factor will be used to calculate the average lot pay factor. When work on a lot is required to be terminated before all four sublots are completed, the results from the completed sublots will be analyzed to determine the percent payment for the lot following the same procedures and requirements for full lots but with fewer or more test results as determined in paragraph PAVEMENT LOTS.

1.1.4 Payment Adjustment for Laboratory Air Voids

Laboratory air void calculations for each lot will use the average theoretical maximum density values obtained for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). The mean absolute deviation of the laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated as shown in the example below and a pay factor will be determined from Table

1. When 0 percent payment is determined, remove and replace the rejected lot at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint.

Table 1. Pay Factor Based on Laboratory Air Voids	
Mean Absolute Deviation of Lab Air Voids from JMF	Pay Factor, percent
0.60 or less	100
0.61 - 0.80	98
0.81 - 1.00	95
1.01 - 1.20	90
Above 1.20	reject (0)

1.1.4.1 Pay Factor Example for Laboratory Air Voids

An example of the computation of mean absolute deviation for laboratory air voids is as follows: Assume that the laboratory air voids are determined from 4 sublots where one set of laboratory compacted specimens is from a single sublot. The laboratory air voids for the 4 sublots are determined to be 3.5, 3.0, 4.0, and 3.7. Assume that the target air voids from the JMF is 4.0. The mean absolute deviation is then:

$$\text{Mean Absolute Deviation} = (|3.5 - 4.0| + |3.0 - 4.0| + |4.0 - 4.0| + |3.7 - 4.0|)/4$$

$$\text{Mean Absolute Deviation} = (0.5 + 1.0 + 0.0 + 0.3)/4 = (1.8)/4 = 0.45$$

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen from Table 1 that the lot's pay factor based on laboratory air voids is 100 percent.

1.1.5 Payment Adjustment for In-place Densities

The average in-place mat and joint densities are expressed as a percentage of the average theoretical maximum density (TMD) for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). The average in-place mat density and joint density for a lot are determined and compared with Table 2 to calculate a single pay factor per lot. Use the following process to determine the single pay factor for in-place density:

a. Step 1: Determine the pay factors for mat density and joint density using Table 2.

b. Step 2: Determine ratio of joint area to mat area. The area associated with the joint is considered to be 10 feet wide times the length of completed longitudinal construction joint in the lot. This joint area will not exceed the total lot size. The length of joint to be considered will be that length where a new lane has been placed against an adjacent lane of asphalt pavement, either an adjacent freshly paved lane or one paved at any time previously.

c. Step 3: Compute the weighted pay factor for the joint using the formula in the example below.

d. Step 4: Compare weighted pay factor for joint density to pay factor for mat density and select the smaller. This selected pay factor is the pay factor based on density for the lot.

When 0 percent payment is determined for mat density, remove and replace the rejected lot at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint. When 0 percent payment is determined for joint density, remove and replace the rejected longitudinal joint with a 10 feet wide paving lane that is centered over the joint.

Table 2. Pay Factor Based on In-place Density

Average Mat Density (4 Cores) (Percent of TMD)	Pay Factor, Percent	Average Joint Density (4 Cores) (Percent of TMD)
93.0 - 96.0	100.0	91.5 or above
92.9	100.0	91.4
92.8 or 96.1	99.9	91.3
92.7	99.8	91.2
92.6 or 96.2	99.6	91.1
92.5	99.4	91.0
92.4 or 96.3	99.1	90.9
92.3	98.7	90.8
92.2 or 96.4	98.3	90.7
92.1	97.8	90.6
92.0 or 96.5	97.3	90.5
91.9	96.3	90.4
91.8 or 96.6	94.1	90.3
91.7	92.2	90.2
91.6 or 96.7	90.3	90.1
91.5	87.9	90.0
91.4 or 96.8	85.7	89.9
91.3	83.3	89.8
91.2 or 96.9	80.6	89.7
91.1	78.0	89.6
91.0 or 97.0	75.0	89.5
below 91.0, above 97.0	0.0 (reject)	below 89.5

1.1.5.1 Pay Factor Example for In-place Density

An example of the computation of a pay factor (in I-P units only) based on in-place density, is as follows: Assume the following test results for field density made on the lot: (1) Average mat density = 92.2 percent (of lab TMD). (2) Average joint density = 90.5 percent (of lab TMD). (3)

Total area of lot = 30,000 square feet. (4) Length of completed longitudinal construction joint = 2,000 feet.

a. Step 1: Determine pay factor based on mat density and on joint density, using Table 2:

   Mat density of 92.2 percent = 98.3 pay factor.

   Joint density of 90.5 percent = 97.3 pay factor.

b. Step 2: Determine ratio of joint area to mat area. Multiply the length of completed longitudinal construction joint by the specified 10 foot width and divide by the mat area (total paved area in the lot).

   Ratio = Ratio of joint area to mat area

   Ratio = (2,000 feet x 10 feet)/30,000 square feet

   Ratio = 0.6667

c. Step 3: Weighted pay factor (wpf) for joint is determined as indicated below:

   wpf = joint pay factor + (100 - joint pay factor) x (1 - ratio)

   wpf = 97.3 + (100-97.3) x (1-0.6667) = 98.2 percent

d. Step 4: Compare weighted pay factor for joint density to pay factor for mat density and select the smaller:

   Pay factor for mat density: 98.3 percent.

   Weighted pay factor for joint density: 98.2 percent

   Selected pay factor: 98.2 percent

1.1.6 Payment Adjustment for Smoothness (Final Wearing Surface Only)

Profilograph Testing. Record the location and data from all profilograph measurements. When the Profile Index of a lot exceeds the tolerance specified in paragraph SMOOTHNESS REQUIREMENTS by 1.0 inch per mile, but less than 2.0 inches per mile, after any reduction of high spots or removal and replacement, the computed pay factor for that lot based on surface smoothness will be 95 percent. When the Profile Index exceeds the tolerance by 2.0 inches per mile, but less than 3.0 inches per mile, the computed pay factor will be 90 percent. When the Profile Index exceeds the tolerance by 3.0 inches per mile, but less than 4.0 inches per mile, the computed pay factor will be 75 percent. Remove and replace the lot when the Profile Index exceeds the tolerance by 4.0 inches per mile or more, at no additional cost to the Government. Regardless of the above, correct any small individual area with surface deviation which exceeds the tolerance given above by more than 5.0 inches per mile or more, by grinding to meet the specification requirements above or remove and replace at no additional cost to the Government.

1.1.7 Payment Adjustment for Plan Grade

When more than 5 percent of all measurements made within a lot are outside the 0.05 foot tolerance, the pay factor based on grade for that lot will be

95 percent. For individual locations where the grade exceeds 0.075 foot tolerance, remove the surface lift full depth and replace the lift with asphalt pavement to meet specification requirements at no additional cost to the Government. High spots can be diamond ground as an alternative to remove and replace in order to meet grade requirements for the lot and at individual locations.

1.2 PAYMENT

1.2.1 Method of Measurement

The amount paid for will be the number of tons of hot-mix warm-mix asphalt pavement mixture used in the accepted work. Weigh the hot-mix warm-mix asphalt pavement mixture after mixing. No separate payment will be made for weight of asphalt cement material incorporated herein.

1.2.2 Basis of Payment

The measured quantity of hot-mixed warm-mixed asphalt pavement will be paid for and included in the lump sum contract price.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 156	(2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO T 304	(2011; R 2015) Standard Method of Test for Uncompacted Void Content of Fine Aggregate
AASHTO T 329	(2015) Standard Test Method for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

ASPHALT INSTITUTE (AI)

AI MS-2	(2015) Asphalt Mix Design Methods

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing

ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D242/D242M	(2009; R 2014) Mineral Filler for Bituminous Paving Mixtures
ASTM D979/D979M	(2015) Sampling Bituminous Paving Mixtures
ASTM D2041/D2041M	(2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2419	(2014) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2726/D2726M	(2019) Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D3203/D3203M	(2017) Standard Test Method for Percent Air Voids in Compacted Asphalt Mixtures
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4791	(2019) Flat Particles, Elongated

	Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867/D4867M	(2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5361/D5361M	(2016) Standard Practice for Sampling Compacted Asphalt Mixtures for Laboratory Testing
ASTM D5444	(2015) Mechanical Size Analysis of Extracted Aggregate
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6373	(2016) Standard Specification for Performance Graded Asphalt Binder
ASTM D6925	(2014) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ASTM D8239	(2018) Standard Specification for Performance-Graded Asphalt Binder Using the Multiple Stress Creep and Recovery (MSCR) Test
ASTM E1274	(2018) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Placement Plan; G

SD-03 Product Data

Diamond Grinding Plan; G

Mix Design; G

Contractor Quality Control; G

SD-04 Samples

Aggregates

Asphalt Cement Binder

Warm-mix Additive

SD-06 Test Reports

Aggregates; G

QC Monitoring

SD-07 Certificates

Asphalt Cement Binder; G

Laboratory Accreditation and Validation

Warm-mix Additive

1.5 ACCEPTANCE

1.5.1 Acceptability of Work

Acquire the services of an independent commercial laboratory to perform acceptance testing. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests from split samples to validate the results of the production testing. Testing performed by the Government does not reduce the required testing of the independent commercial laboratory. Split samples will be taken for Government testing to reduce the variability between the independent commercial laboratory and the Government's test results. When the difference between the independent commercial laboratory and the Government's test results for split samples exceed the acceptable range of two results for multilaboratory precision for the appropriate test method (i.e. ASTM) then at least one of the laboratories is determined to be in error. An evaluation of procedures and equipment in both laboratories will be made to determine the cause(s) for the differences. Develop steps to correct procedures and equipment to bring multilaboratory precision to within acceptable limits.

1.5.2 Acceptance Requirements

Provide all sampling and testing required for acceptance and payment adjustment. Where appropriate, adjustments in percent payment acceptance for individual lots of asphalt pavement will be made based on laboratory air voids, in-place density, smoothness, and grade in accordance with the following paragraphs. Surface smoothness and grade determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus smoothness and grade measurements for the entire lot cannot be made.

1.5.3 Pavement Lots

A standard lot for all requirements is equal to one day's production or 2,000 tons, whichever is smaller. Divide each lot into four equal sublots in order to evaluate laboratory air voids and in-place density. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, use the following procedure to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they constitute a lot. Where one or two sublots have been completed, incorporate them into the next lot and the total number of sublots (i.e. 5 or 6 sublots) is used for acceptance criteria. Include partial lots at the end of asphalt production into the previous lot. Complete and report all theoretical maximum density, laboratory air voids, and in-place density testing within 24 hours after construction of each lot.

1.5.4 Sublot Sampling

Take one mixture sample for each sublot in accordance with ASTM D979/D979M from a random truck or another location for determining theoretical maximum density, laboratory air voids, any additional testing the Government desires, and Contractor Quality Control. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs.

1.5.5 Additional Sampling and Testing

The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be treated as a separate lot. Payment Acceptance will be made for the quantity of asphalt pavement represented by these tests in accordance with the provisions of this section.

1.5.6 Theoretical Maximum Density (TMD)

Measure theoretical maximum density one time for each sublot in accordance with ASTM D2041/D2041M for purposes of calculating laboratory air voids and determining in-place density. The average TMD for each lot will be determined as the average TMD of the random sublot samples. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD values will be used as the TMD needed to calculate the percent joint density.

1.5.7 Laboratory Air Voids

Provide three test specimens prepared from the same sample for each set of laboratory compacted specimens. Compact the specimens within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Do not reheat samples prior to compaction. Provide insulated containers as necessary to maintain the sample temperature. Measure the bulk density of laboratory compacted specimens in accordance with ASTM D2726/D2726M. Determine laboratory air voids from one set (three laboratory compacted specimens) for each sublot sample in accordance with ASTM D3203/D3203M.

1.5.7.1 Tolerance

Provide laboratory air voids with a mean absolute deviation of 1.00 percent or less from the JMF for each lot. Remove and replace lots that do not meet the laboratory air voids requirement at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint, at no additional cost to the Government. The mean absolute deviation of the laboratory air void contents from the JMF air void content will be evaluated as shown in the example below.

1.5.7.2 Calculating Laboratory Air Voids

Laboratory air void calculations for each lot will use the average theoretical maximum density values obtained for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). The mean absolute deviation of the laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated as in the following example:

Assume that the laboratory air voids are determined from 4 sublots where one set of laboratory compacted specimens is from a single sublot. The laboratory air voids for the 4 sublots are determined to be 3.5, 3.0, 4.0, and 3.7. Assume that the target air voids from the JMF is 4.0. The mean absolute deviation is then:

$$\text{Mean Absolute Deviation} = (|3.5 - 4.0| + |3.0 - 4.0| + |4.0 - 4.0| + |3.7 - 4.0|)/4$$

$$\text{Mean Absolute Deviation} = (0.5 + 1.0 + 0.0 + 0.3)/4 = (1.8)/4 = 0.45$$

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen that 0.45 is less than 1.00 percent. The lot is acceptable for laboratory air voids.

1.5.8 In-place Density

Obtain one random 4 inch or 6 inch diameter core from the mat and joint of each sublot in accordance with ASTM D5361/D5361M for determining in-place density. Cut samples neatly with a diamond core drill bit. Obtain random cores that are the full thickness of the layer being placed. Select core locations randomly using the procedures contained in ASTM D3665. Locate cores for mat density no closer than 12 inches from a transverse or longitudinal joint including the pavement edge. Center all cores for joint density on the joint. Discard samples that are clearly defective as a result of sampling and take an additional random core. When the random core is less than 1 inch thick, it will not be included in the analysis. In this case, obtain another random core sample. Clean and tack coat dry core holes before filling with asphalt mixture. Fill all core holes with asphalt mixture and compact using a standard Marshall hammer to the density specified. Provide all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Measure in-place density in accordance with ASTM D2726/D2726M using each core obtained from the mat and joint.

1.5.8.1 Tolerance

Provide a minimum in-place mat density of 93.0 percent and a minimum in-place joint density of 90.0 percent for each lot. The average in-place mat and joint densities are expressed as a percentage of the average theoretical maximum density (TMD) for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). Remove and replace lots that do not meet the in-place mat density requirement at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint, at no additional cost to the Government. Remove and replace the longitudinal joint when the lot does not meet the in-place joint density, at no additional cost to the Government. Use a 10 feet wide paving lane that is centered over the joint.

1.5.9 Surface Smoothness

Use a straightedge and profilograph for measuring surface smoothness. Use the profilograph method for all longitudinal testing, except for paving lanes less than 0.25 miles in length. Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 0.25 miles, and at the ends of the paving limits for the project. Smoothness requirements do not apply over crowns or grade breaks. Maintain detailed notes of the testing results and provide a copy to the Government immediately after each day's testing.

1.5.9.1 Smoothness Requirements

1.5.9.1.1 Straightedge Testing

Provide finished surfaces of the pavements with no abrupt change of 1/4 inch or more when checked with an approved 12 foot straightedge. Remove and replace surface lift lots when the surface smoothness exceeds 3/8 inch, at no additional cost to the Government. High spots can be diamond ground as an alternative to remove and replace in order to meet surface smoothness requirements at individual locations.

1.5.9.1.2 Profilograph Testing

Provide finished surfaces with a Profile Index not greater than 9 inches per mile when tested with an approved California-type profilograph. Remove and replace the lot when the Profile Index exceeds the tolerance by 4.0 inches per mile or more, at no additional cost to the Government. Correct any small individual area with surface deviation which exceeds the tolerance given above by more than 5.0 inches per mile or more by diamond grinding to meet the specification requirements above or remove and replace at no additional cost to the Government.

1.5.9.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in a manner to reveal surface irregularities exceeding the tolerances specified above. If any pavement areas are diamond ground, retest these areas immediately after diamond grinding. The maximum area allowed to be corrected by diamond grinding is 10 percent of the total area of the lot. Test the entire area of the pavement with a profilograph. Check a number of random locations along with any observed suspicious locations primarily at transverse and longitudinal joints with the straightedge.

1.5.9.2.1 Straightedge Testing

Use the straightedge to measure abrupt changes in surface smoothness. Hold the straightedge in contact with the pavement surface and measure the maximum distance between the straightedge and the pavement surface. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

1.5.9.2.2 Profilograph Testing

Perform profilograph testing using an approved California profilograph and procedures described in ASTM E1274. Provide equipment that utilizes electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for the pavement. Use a "blanking band" that is 0.2 inch wide and the "bump template" spanning 1 inch with an offset of 0.4 inch. Provide profilograph operated by an approved, factory-trained operator on the alignments specified above. Provide a copy of the reduced tapes to the Government at the end of each day's testing.

1.5.9.2.3 Bumps ("Must Grind" Areas)

Reduce any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height by diamond grinding until they do not exceed 0.3 inch when retested. Taper diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding. The following will not be permitted: (1) skin patching for correcting low areas, (2) planing or milling for correcting high areas. Perform additional profilograph testing in all areas corrected by diamond grinding.

1.5.10 Plan Grade

Provide a final wearing surface of pavement conforming to the elevations and cross sections shown and not vary more than 0.05 foot from the plan grade established and approved at site of work. Within 5 working days after completion of a particular lot incorporating the final wearing course, test the final wearing surface of the pavement for conformance with specified plan grade requirements. Match finished surfaces at juncture with other pavements with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. For roads, the grade will be determined by running lines of levels along the centerline at intervals of 25 feet or less longitudinally to determine the elevation of the completed pavement surface. Measure transverse grades at appropriate intervals. For parking lots, the grade will be determined by running lines of levels at intervals of 25 feet or less longitudinally and transversely to determine the elevation of the completed pavement surface. Diamond grinding can be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted. Maintain detailed notes of the results of the testing and provide a copy to the Government immediately after each day's testing. Remove and replace surface lift lots when individual locations exceed 0.05 foot tolerance, at no additional cost to the Government. High spots can be diamond ground as an alternative to remove and replace in order to meet plan grade requirements at individual locations.

1.5.11 Laboratory Accreditation and Validation

Provide laboratories used to develop the Job Mix Formula (JMF), perform acceptance testing, and Contractor Quality Control testing that meet the requirements of ASTM D3666. Provide laboratories with a masonry saw having a diamond blade for trimming pavement cores and samples. Perform all required test methods by an accredited laboratory. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory accreditation is not allowed. Submit a certificate of compliance signed by the manager of the laboratory stating that it meets these requirements to the Government prior to the start of construction. At a minimum, include the following certifications:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not place the asphalt mixture upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 3 Table 1. The temperature requirements may be waived by the Government, if requested; however, meet all other requirements including compaction.

Table 3. Table 1. Surface Temperature Limitations of Underlying Course	
Mat Thickness, inches	Degrees F
3 or greater	40
Less than 3	45

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. Provide asphalt pavement designed and constructed in accordance with this section conforming to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Construct each course to the depth, section, or elevation required by the drawings and rolled, finished, and approved before the placement of the next course. Submit proposed Placement Plan indicating lane widths and longitudinal joints for each course or lift.

2.1.1 Asphalt Mixing Plant

Provide plants used for the preparation of asphalt mixture conforming to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved scales, or on certified public scales at no additional expense to the Government. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Inspection of Plant

Provide access to the Government at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.

2.1.1.3 Storage bins

The asphalt mixture can be stored in non-insulated storage bins for a period of time not exceeding 3 hours. The asphalt mixture can be stored in insulated storage bins for a period of time not exceeding 8 hours. Provide the mix drawn from bins that meets the same requirements as mix loaded directly into trucks.

2.1.2 Hauling Equipment

Provide trucks used for hauling asphalt mixture that have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, lightly coat the truck beds with a minimum amount of paraffin oil, lime solution, or other approved material. Do not use petroleum based products as a release agent. Provide each truck with a suitable cover to protect the mixture from adverse weather, contamination, and loss of material during hauling. When necessary due to long haul distance and cold weather, provide insulated truck beds with covers (tarps) that are securely fastened.

2.1.3 Material Transfer Vehicle (MTV)

Provide Material Transfer Vehicle for placement of the asphalt mixture. Transfer the material from the hauling equipment to the paver using a self-propelled, material transfer vehicle with a swing conveyor that is capable of delivering material to the paver without making contact with the paver. Provide MTV capable to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. Provide Material Transfer Vehicle with remixing and storage capability to prevent physical and thermal segregation.

2.1.4 Asphalt Pavers

Provide mechanical spreading and finishing equipment consisting of a self-powered paver, capable of spreading and finishing the mixture to the specified line, grade, and cross section. Provide paver screed capable of laying a uniform mixture to meet the specified thickness, smoothness, and grade without physical or temperature segregation, the full width of the material being placed. Provide a paver with a vibrating screed to be used during all placement.

2.1.4.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and a distribution system to place the mixture uniformly in front of the screed without segregation. Provide a screed that effectively produces a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.4.2 Automatic Grade Controls

Provide a paver equipped with a control system capable of maintaining the specified screed elevation. One of three methods can be used to control grade: stringline, laser, or computerized elevations along with GPS. For multiple layers it is acceptable to control the grade in the underlying layer and control the grade of the surface layer by applying a constant thickness over the underlying layer which has been placed to the desired grade. Slope control can also be used to control the grade of the surface for roads, but is not acceptable for wide pavements such as parking lots. Provide transverse slope controller capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A ski-type device of not less than 30 ft can be used to provide improved smoothness. Use a shoe on one side of the paver to match an existing paved surface to provide a smooth joint.

2.1.5 Rollers

Provide rollers in good condition and operate at slow speeds to avoid displacement of the asphalt mixture. Provide sufficient number, type, and weight of rollers to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.1.6 Diamond Grinding

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding. In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the asphalt pavement with approved equipment. Perform diamond grinding by sawing with saw blades impregnated with an industrial diamond abrasive. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the asphalt pavement or joint faces. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 feet wide. Diamond grinding equipment that causes raveling, fracturing of aggregate, or disturbance to the underlying material will not be allowed. The maximum area corrected by diamond grinding the surface of the asphalt pavement is 10 percent of the total area of any lot. The maximum depth of diamond grinding is 1/2 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified.

Prior to production diamond grinding operations, perform a test section at the approved location, consisting of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish and transition between adjacent passes. Production diamond grinding operations cannot be performed prior to approval.

2.2 AGGREGATES

Notify the Government at least 7 days before sampling aggregates. Obtain samples in accordance with ASTM D75/D75M that are representative of the materials to be used for the project. Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand, and mineral filler as required. The portion of material retained on the No. 4 sieve is coarse aggregate. The portion of material passing the No. 4 sieve and retained on the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve is defined as mineral filler. Submit sufficient materials to produce 200 pounds of blended mixture for mix design verification. Submit all aggregate test results and samples to the Government at least 14 days prior to start of construction. Perform job aggregate testing no earlier than 6 months before contract award.

2.2.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. Provide coarse aggregate particles meeting the following requirements:

a. The percentage of loss not greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131/C131M.

b. The sodium sulfate soundness loss not exceeding 12 percent, or the magnesium sulfate soundness loss not exceeding 18 percent after five cycles when tested in accordance with ASTM C88.

c. At least 75 percent by weight of coarse aggregate containing two or more fractured faces when tested in accordance with ASTM D5821 with fractured faces produced by crushing.

d. The particle shape essentially cubical and the aggregate containing not more than 10 percent, by weight, of flat and elongated particles (5:1 ratio of length to thickness) when tested in accordance with ASTM D4791, Method B.

e. Slag consisting of air-cooled, blast furnace slag with a compacted weight of not less than 75 lb/cu ft when tested in accordance with ASTM C29/C29M.

f. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.2.2 Fine Aggregate

Provide fine aggregate consisting of clean, sound, tough, durable particles. Provide aggregate particles that are free from coatings of clay, silt, or any objectionable material, contain no clay balls, and meet the following requirements:

a. Quantity of natural sand (noncrushed material) added to the aggregate blend not exceeding 15 percent by weight of total aggregate.

b. Individual fine aggregate sources with a sand equivalent value greater than 45 when tested in accordance with ASTM D2419.

c. Fine aggregate portion of the blended aggregate with an uncompacted void content greater than 45.0 percent when tested in accordance with AASHTO T 304 Method A.

d. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.2.3 Mineral Filler

Provide mineral filler consisting of a nonplastic material meeting the requirements of ASTM D242/D242M.

2.2.4 Aggregate Gradation

Provide a combined aggregate gradation that conforms to gradations specified in Table 4 Table 2, when tested in accordance with ASTM C136/C136M and ASTM C117, and does not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grades uniformly from coarse to fine. Provide a JMF within the specification limits; however, the gradation can exceed the limits when the allowable deviation from the JMF shown in Tables 6 and 7 Tables 4 and 5 are applied.

Table 4. Table 2. Aggregate Gradations

Sieve Size, inch	Gradation 1 Percent Passing by Mass	Gradation 2 Percent Passing by Mass	Gradation 3 Percent Passing by Mass
1	100	---	---
3/4	90-100	100	---
1/2	68-88	90-100	100
3/8	60-82	69-89	90-100
No. 4	45-67	53-73	58-78
No. 8	32-54	38-60	40-60
No. 16	22-44	26-48	28-48
No. 30	15-35	18-38	18-38
No. 50	9-25	11-27	11-27
No. 100	6-18	6-18	6-18
No. 200	3-6	3-6	3-6

2.3 ASPHALT CEMENT BINDER

Provide asphalt cement binder that conforms to ASTM D6373 or ASTM D8239 Performance Grade (PG) .. Provide test data indicating grade certification by the supplier at the time of delivery of each load to the mix plant. When warm-mix asphalt technology involves additives, grade the asphalt binder with the asphalt binder additive included. Submit copies of these certifications to the Government. The supplier is defined as the last source of any modification to the binder. The Government may sample and test the binder at the mix plant at any time before or during mix production.

2.4 WARM-MIX ASPHALT TECHNOLOGIES/PRODUCTS

Provide warm-mix asphalt technologies/products that have a record of good performance and are included on the local state DOT's qualified products list, if the DOT maintains a qualified products list. These qualified products lists can be found at each state DOT's website.

2.5 MIX DESIGN

Develop the mix design. Perform Job Mix formula (JMF) and aggregates testing no earlier than 6 months before contract award. Provide asphalt mixture composed of well-graded aggregate, mineral filler if required, and asphalt material. Provide aggregate fractions sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of Table 4 Table 2. Do not produce asphalt pavement for payment acceptance until a JMF has been approved. Design the asphalt mixture using the Superpave gyratory compactor set at 50 gyrations. Prepare samples at various asphalt contents and compacted in accordance with ASTM D6925. Use laboratory compaction temperatures for Polymer Modified Asphalts as recommended by the asphalt binder manufacturer. Determine the Tensile Strength Ratio (TSR) of the composite mixture in accordance with ASTM D4867/D4867M. Compact the TSR specimens to an air void content of 7 percent plus or minus 1 percent. If the Tensile Strength Ratio (TSR) of the composite mixture is less than 75, reject the aggregates or treat the asphalt mixture with an anti-stripping agent. Add a sufficient amount of anti-stripping agent to produce a TSR of not less than 75. If an antistrip agent is required, provide it at no additional cost to the Government. Provide sufficient materials to produce 200 pound of blended mixture to the Government for verification of mix design at least 14 days prior to construction of test section.

2.5.1 JMF Requirements

Submit the proposed JMF in writing, for approval, at least 14 days prior to the start of the test section including, as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt cement.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt performance grade or penetration grade.

e. Number of Superpave gyratory compactor gyrations.

f. Laboratory mixing temperature.

g. Laboratory compaction temperature.

h. Temperature-viscosity relationship of the asphalt cement

i. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

j. Graphical plots and summary tabulation of air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2. Include summary tabulation that includes individual specimen data for each specimen tested.

k. Specific gravity and absorption of each aggregate.

l. Percent natural sand.

m. Percent particles with two or more fractured faces (in coarse aggregate).

n. Fine aggregate angularity.

o. Percent flat or elongated particles in coarse aggregate.

p. Tensile Strength Ratio and wet/dry specimen test results.

q. Antistrip agent (if required).

r. List of all modifiers.

s. Percentage and properties (asphalt content, aggregate gradation, and aggregate properties) of RAP in accordance with paragraph RECYCLED ASPHALT PAVEMENT, if RAP is used.

t. Warm-mix additive or process.

Table 5. Table 3. Mix Design Criteria

Test Property	Marshall (50 Blows)	Marshall (75 Blows)	Superpave (50 gyrations)
Stability, pounds, minimum (NA for Superpave)	1000 (1)	1800 (1)	NA
Flow, 0.01 inch, (NA for Superpave)	8-18	8-16	NA
Air voids, percent	3-5	3-5	3-5
Minimum Percent Voids in Mineral Aggregate (VMA) (2)			
Gradation 1	13.0	13.0	13.0
Gradation 2	14.0	14.0	14.0
Gradation 3	15.0	15.0	15.0
TSR, minimum percent	75	75	75
(1) This is a minimum requirement. Provide significantly higher average during construction to ensure compliance with the specifications.			
(2) Calculate VMA in accordance with AI MS-2, based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate.			

2.5.2 Adjustments to JMF

The JMF for each mixture is in effect until a new formula is approved in writing by the Government. Should a change in sources of any materials be made, perform a new mix design and a new JMF approved before the new material is used. Make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF are limited to plus or minus 4 percent on the No. 4 and coarser sieves; plus or minus 3 percent on the No. 8 to No. 50 sieves; and plus or minus 1 percent on the No. 100 sieve and No. 200 sieve. Asphalt content adjustments are limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, develop a new mix design.

2.6 RECYCLED HOT MIX ASPHALT

Provide recycled asphalt mixture consisting of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. Provide RAP of a consistent gradation, asphalt content, and properties. Maintain RAP stockpiles free from contamination including coal-tar sealers. Limit the maximum RAP chunk size to 2 inches when feeding RAP into the plant. The individual aggregates in a RAP chunk are not to exceed the maximum size aggregate of the gradation specified in Table 4 Table 2. Design the recycled asphalt mixture using procedures contained in AI MS-2. Provide RAP job mix that meets the requirements of paragraph MIX DESIGN. Limit the amount of RAP so the asphalt binder from the RAP does not exceed 30 percent of the total asphalt content.

2.6.1 RAP Aggregates and Asphalt Cement

Provide a blend of aggregates used in the recycled mix that meet the requirements of paragraph AGGREGATES. Establish the percentage of asphalt binder in the RAP for the mixture design according to ASTM D2172/D2172M or ASTM D6307 using the appropriate dust correction procedure.

2.6.2 RAP Mix

Select the virgin asphalt binder as described below:

a. For 0 to 20 percent recycled binder content - no change in virgin binder selection.

b. For 20+ percent to 30 percent recycled binder content - select virgin binder one grade softer than normal.

PART 3 EXECUTION

3.1 CONTRACTOR QUALITY CONTROL

3.1.1 General Quality Control Requirements

Submit the Quality Control Plan. Do not produce hot-mix warm-mix asphalt for payment acceptance until the quality control plan has been approved. In the quality control plan, address all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design and unique JMF identification code

b. Aggregate Grading

c. Quality of Materials

d. Stockpile Management and procedures to prevent contamination

e. Proportioning including percent of warm-mix additive

f. Mixing and Transportation

g. Mixture Volumetrics

h. Moisture Content of Mixtures

i. Placing and Compaction

j. Joints

k. Surface Smoothness

l. Truck bed release agent

3.1.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site that is equipped with heating and air conditioning units to maintain a temperature of 75 plus or minus 5 degrees F. Provide laboratory facilities that are kept clean and all equipment maintained in proper working condition. Provide the Government with unrestricted access to inspect the laboratory facility, to witness quality control activities, and to perform any check testing desired. The Government will advise in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, immediately suspend the incorporation of the materials into the work. Incorporation of the materials into the work will not be permitted to resume until the deficiencies are corrected.

3.1.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. Use the independent commercial laboratory for acceptance testing in paragraph ACCEPTANCE. Use in-house capabilities or the independent commercial laboratory for quality control testing. Required elements of the testing program include, but are not limited to tests for the control of asphalt content, aggregate gradation, aggregate moisture, moisture in the asphalt mixture, temperatures, VMA, and in-place density. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.1.3.1 Asphalt Content

Determine asphalt content a minimum of twice per lot (a lot is defined in paragraph PAVEMENT LOTS) using the ignition method in accordance with ASTM D6307. Use the extraction method in accordance with ASTM D2172/D2172M if the correction factor for the ignition method in ASTM D6307 is greater than 1.0. The asphalt content for the lot will be determined by averaging the test results.

3.1.3.2 Aggregate Properties

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D5444, ASTM C136/C136M, and ASTM C117. Determine the specific gravity of each aggregate size grouping for each 20,000 tons in accordance with ASTM C127 or ASTM C128. Determine fractured faces for gravel sources for each 20,000 tons in accordance with ASTM D5821. Determine the uncompacted void content of natural sand, manufactured sand, and blended aggregate for each 20,000 tons in accordance with AASHTO T 304 Method A.

3.1.3.3 Moisture Content of Aggregate

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with ASTM C566.

3.1.3.4 Moisture Content of Asphalt Mixture

Determine the moisture content of the asphalt mixture at least once per lot in accordance with AASHTO T 329.

3.1.3.5 Temperatures

Check temperatures at least four times per lot, at necessary locations to determine the temperature at the dryer, the asphalt cement binder in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.1.3.6 VMA

Obtain mixture samples at least four times per lot. Calculate the VMA of each specimen in accordance with AI MS-2 based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate. Provide VMA within the limits of Table 5 Table 3.

3.1.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge or other non-destructive testing device can be used to monitor pavement density.

3.1.3.8 Additional Testing

Perform any additional testing deemed necessary to control the process.

3.1.3.9 QC Monitoring

Submit all QC test results to the Government on a daily basis as the tests are performed. The Government reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.1.4 Sampling

When directed by the Government, sample and test any material which appears to not meet specification requirements unless such material is voluntarily removed and replaced or deficiencies corrected. Perform all sampling in accordance with standard procedures specified.

3.1.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 6 Table 4, as a minimum. Post the control charts as directed by the Government and maintain current at all times. Identify the following on the control charts: the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 6 Table 4 applicable to the test parameter being plotted, and the test results. Also show target values (JMF) on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. When the Suspension Limit is exceeded for individual values or running average values, the Government has the option to require removal and replacement of the material represented by the samples or to leave in place and base acceptance on mixture volumetric properties and in place density. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. In the Quality Control Plan, indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 6. Table 4. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
No. 4 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	6	8	4	5
No. 30 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	4	6	3	4
No. 200 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	1.4	2.0	1.1	1.5
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Stability, pounds (minimum) (NA for Superpave)				
75 Blow JMF	1800	1700	1900	1800
50 Blow JMF	1000	900	1100	1000
Flow, 0.01 inch (NA for Superpave)				
75 Blow JMF	8 min.	7 min.	9 min.	8 min.
	16 max.	17 max.	15 max.	16 max.
50 Blow JMF	8 min.	7 min.	9 min.	8 min.
	18 max.	19 max.	17 max.	18 max.
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used for acceptance			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used for acceptance			
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used for acceptance			
VMA				
Gradation 1	13.5	13.0	13.3	13.0
Gradation 2	14.5	14.0	14.3	14.0
Gradation 3	15.5	15.0	15.3	15.0

3.2 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material while avoiding local overheating. Provide a continuous supply of the asphalt material to the mixer at a uniform temperature. Maintain the temperature of the asphalt delivered to the mixer to provide a suitable viscosity for adequate coating of the aggregate particles. For hot-mix, do not heat unmodified asphalt to a temperature exceeding 325 degrees F when added to the aggregate. Do not heat modified asphalt to a temperature exceeding 350 degrees F when added to the aggregate. For warm-mix, do not heat asphalt binder to a temperature exceeding 270 degrees F when added to the aggregate.

3.3 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate prior to mixing. Provide a rate of heating and a maximum temperature that does not damage the aggregates. Do not heat the aggregate to a temperature exceeding 350 degrees F when the asphalt binder is added. Maintain the temperature no lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.4 PREPARATION OF ASPHALT MIXTURE

Weigh or meter the aggregates and the asphalt cement and introduce into the mixer the amount specified by the JMF. Mix the combined materials until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. The moisture content of all asphalt mixture upon discharge from the plant is not to exceed 0.5 percent by total weight of mixture as measured by AASHTO T 329.

3.5 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the asphalt mixture, clean the underlying course of dust and debris. Apply a prime coat or tack coat in accordance with Section 32 12 13 BITUMINOUS TACK AND PRIME COATS.

3.6 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section 250 to 500 feet long and two paver passes wide with a longitudinal cold joint. Do not place the second lane of test section until the temperature of pavement edge is less than 175 degrees F. Construct the test section with the same depth as the course which it represents. Ensure the underlying grade or pavement structure upon which the test section is to be constructed is the same or very similar to underlying layer for the project. Use the same equipment and procedures in construction of the test section as on the remainder of the course represented by the test section. Construct the test section as part of the project pavement, as approved by the Government.

3.6.1 Sampling and Testing for Test Section

Obtain one sample at the plant from a random truck. Compact three specimens and test for laboratory air voids. Test a portion of the same sample for theoretical maximum density (TMD), aggregate gradation, asphalt content, and TSR. Adjust the compactive effort as required to provide TSR specimens with an air void content of 7 plus or minus 1 percent. Obtain four randomly selected cores from each finished pavement mat (eight total), four from the longitudinal joint, and test for density. Perform random sampling in accordance with procedures contained in ASTM D3665. Construction may continue provided the test results are within the tolerances or exceed the minimum values shown in Table 7 Table 5. If all test results meet the specified requirements, the test section may remain as part of the project pavement. If test results exceed the tolerances shown, remove and replace the test section and construct another test section at no additional cost to the Government.

Table 7. Table 5. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
No. 4 and larger	JMF plus or minus 8
No. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
No. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	See Table 5 Table 3
Tensile Strength Ratio (TSR) (At 7 percent plus/minus 1 percent air void content)	75 percent minimum
Conditioned Strength	60 psi minimum
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0 93.0 minimum
Joint Density, Percent of TMD (Average of 4 Random Cores)	89.5 minimum 90.0 minimum
Stability, pounds (Average of 3 specimens) (for Marshall only)	1000 minimum for 50 blows
Flow, 0.01 inch (Average of 3 specimens) (for Marshall only with non-modified asphalt)	8 - 18 for 50 blows

3.6.2 Additional Test Sections

If the initial test section should prove to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and rolling procedures before beginning construction of a second test section. Construct and evaluate additional test sections, as required, for conformance to the specifications. Full production paving is not allowed until an acceptable section has been constructed and accepted.

3.7 TRANSPORTING AND PLACING

3.7.1 Transporting

Transport asphalt mixture from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to 140 degrees F.

3.7.2 Placing

Place the mix in lifts of adequate thickness and compact at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; strike off in a uniform layer of such depth that, when the work is completed, the required thickness is obtained and the surface conforms to the grade and contour indicated. Do not broadcast waste mixture onto the mat or recycle into the paver hopper. Collect waste mixture and dispose off site. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Begin placement of the mixture along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 10 feet. Offset the longitudinal joint in one course from the longitudinal joint in the course immediately below by at least 1 foot; however, locate the joint in the surface course at the centerline of the pavement. Offset transverse joints in one course by at least 10 feet from transverse joints in the previous course. Offset transverse joints in adjacent lanes a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture can be spread and luted by hand tools.

3.8 COMPACTION OF MIXTURE

3.8.1 General

a. After placing, thoroughly and uniformly compact the mixture by rolling. Compact the surface as soon as possible without causing displacement, cracking, or shoving. Determine the sequence of rolling operations and the type of rollers used with the exception that application of more than three passes with a vibratory roller in the vibrating mode is prohibited. Maintain the speed of the roller, at all times, sufficiently slow to avoid displacement of the asphalt mixture and to be effective in compaction. Correct at once any displacement occurring as a result of reversing the direction of the roller, or from any other cause.

b. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened, but excessive water is not permitted. In areas not accessible to the roller, thoroughly compact the mixture with hand tampers or small compactors. Remove the full depth of any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective. Replace with fresh asphalt mixture and immediately compact to conform to the surrounding area. Perform this work at no expense to the Government. Skin patching is not allowed.

3.8.2 Segregation

The Government can sample and test any material that looks deficient. When the in-place material appears to be segregated, the Government has the option to sample the material and have it tested and compared to the in-place density requirements in Table 2 paragraph ACCEPTANCE. If the material fails to meet these specification requirements, remove and replace the extent of the segregated material the full depth of the layer of asphalt mixture at no additional cost to the Government. When segregation occurs in the mat, take appropriate action to correct the process so that additional segregation does not occur.

3.9 JOINTS

Construct joints to ensure a continuous bond between the courses and to obtain the required density. Provide all joints with the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.9.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, construct by means of placing a bulkhead or by tapering the course. Utilize a dry saw cut on the transverse joint full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. Remove the cutback material from the project. In both methods, provide a light tack coat of asphalt material to all contact surfaces before placing any fresh mixture against the joint.

3.9.2 Longitudinal Joints

Provide a joint that meets density and smoothness requirements for joints and has uniform texture. Cut back longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing adjacent lanes), or otherwise defective, a maximum of 3 inches from the top of the course with a cutting wheel to expose a clean, sound, near vertical surface for the full depth of the course. Remove all cutback material from the project. Provide a light tack coat of asphalt material to all contact surfaces prior to placing any fresh mixture against the joint.

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SECTION 32 12 17.19

FUEL RESISTANT ASPHALT PAVING FOR AIRFIELDS - SURFACE COURSE
11/20

PART 1 GENERAL

1.1 FULL PAYMENT

1.1.1 Method of Measurement

Utilize the quantity of fuel resistant asphalt pavement, per ton placed and accepted, for the purposes of assessing the pay factors stipulated below.

1.1.2 Basis of Payment

The measured quantity of fuel resistant asphalt pavement will be paid for and included in the lump sum Contract price. If less than 100 percent payment is due based on the pay factors stipulated in paragraph PERCENT PAYMENT, a unit price as specified by the Contracting Officer per ton will be used for purposes of calculating the payment reduction.

1.2 PERCENT PAYMENT

The lot pay factor is determined by taking the lowest computed pay factor based on either laboratory air voids, in-place density, smoothness, or grade (each discussed below). Remove and replace lots when the lowest computed pay factor requires rejection. At the end of the project calculate the average pay factor for all lots. If this average lot pay factor exceeds 95.0 percent and no individual lot has a pay factor less than 75.0 percent, then the percent payment for the entire project will be 100 percent of the unit bid price. If the average lot pay factor is less than 95.0 percent, then each lot will be paid for at the unit price multiplied by the lot pay factor. For any lots which are less than 2,000 tons, a weighted lot pay factor will be used to calculate the average lot pay factor. When work on a lot is required to be terminated before all four sublots are completed, the results from the completed sublots will be analyzed to determine the percent payment for the lot following the same procedures and requirements for full lots but with fewer or more test results as determined in paragraph PAVEMENT LOTS.

1.2.1 Payment Adjustment for Laboratory Air Voids

Laboratory air void calculations for each lot will use the average theoretical maximum density values obtained for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). The mean absolute deviation of the laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated as shown in the example below and a pay factor will be determined from Table 1. When 0 percent payment is determined, remove and replace the rejected lot at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint.

Table 1
Pay Factor Based on Laboratory Air Voids

Mean Absolute Deviation of Lab Air Voids from JMF	Pay Factor, percent
0.60 or less	100
0.61 - 0.80	98
0.81 - 1.00	95
1.01 - 1.20	90
Above 1.20	reject (0)

1.2.1.1 Pay Factor Example for Laboratory Air Voids

An example of the computation of mean absolute deviation for laboratory air voids is as follows: Assume that the laboratory air voids are determined from 4 sublots where one set of laboratory compacted specimens is from a single sublot. The laboratory air voids for the 4 sublots are determined to be 2.0, 1.5, 2.5, and 2.2. Assume that the target air voids from the JMF is 2.5. The mean absolute deviation is then:

$$\text{Mean Absolute Deviation} = (|2.0 - 2.5| + |1.5 - 2.5| + |2.5 - 2.5| + |2.2 - 2.5|)/4$$

$$\text{Mean Absolute Deviation} = (0.5 + 1.0 + 0.0 + 0.3)/4 = (1.8)/4 = 0.45$$

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen from Table 1 that the lot pay factor based on laboratory air voids is 100 percent.

1.2.2 Payment Adjustment for In-place Densities

The average in-place mat and joint densities are expressed as a percentage of the average TMD for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). The average in-place mat density and joint density for a lot are determined and compared with Table 2 to calculate a single pay factor per lot. Use the following process to determine the single pay factor for in-place density:

a. Step 1: Determine the pay factors for mat density and joint density using Table 2.

b. Step 2: Determine ratio of joint area to mat area. The area associated with the joint is considered to be 10 feet wide times the length of completed longitudinal construction joint in the lot. This joint area will not exceed the total lot size. The length of joint to be considered will be that length where a new lane has been placed against an adjacent lane of asphalt pavement, either any cold joint against another lot or any other existing asphalt paved previously. The area associated with the joint is expressed as a percentage of the total lot.

c. Step 3: Compute the weighted pay factor for the joint using the formula in the example shown in paragraph PAY FACTOR BASED ON IN-PLACE DENSITY.

d. Step 4: Where freshly placed fuel resistant asphalt pavement abuts old (not in contract) asphalt pavement, determine density at the tie-in longitudinal joint by taking one core per sublot at a random location for each lot of material placed adjacent to the joint. If Step 4 is not applicable, move to Step 5. The size of joint area is 10 feet wide by the length of the joint being paved. Locate the center of each of the four cores 6 inches from the edge of the existing pavement. Take each core at a random location along the length of the joint. The requirements for joint density for this lot, adjacent to the existing asphalt joint, are the same as that for the mat density specified in Table 2. For freshly placed fuel resistant asphalt pavement-old asphalt (not in contract) joints at taxiways abutting runways, aprons, or other taxiways, take two additional randomly located cores along each taxiway intersection.

e. Step 5: Compare weighted pay factor for joint density to pay factor for mat density and select the lowest. This selected pay factor is the pay factor based on density for the lot. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD will be used as the TMD needed to calculate the percent joint density.

When 0 percent payment is determined for mat density, remove and replace the rejected lot at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint. When 0 percent payment is determined for joint density, remove and replace the rejected longitudinal joint with a 10 feet wide paving lane that is centered over the joint.

Table 2
Pay Factor Based on In-place Density

Average Mat Density (4 cores) (Percent of TMD)	Pay Factor, percent	Average Joint Density (4 cores) (Percent of TMD)
95.0 - 98.0	100.0	Above 93.5
94.9	100.0	93.4
94.8 or 98.1	99.9	93.3
94.7	99.8	93.2
94.6 or 98.2	99.6	93.1
94.5	99.4	93.0
94.4 or 98.3	99.1	92.9
94.3	98.7	92.8
94.2 or 98.4	98.3	92.7
94.1	97.8	92.6
94.0 or 98.5	97.3	92.5
93.9	96.3	92.4
93.8 or 98.6	94.1	92.3
93.7	92.2	92.2
93.6 or 98.7	90.3	92.1
93.5	87.9	92.0
93.4 or 98.8	85.7	91.9
93.3	83.3	91.8
93.2 or 98.9	80.6	91.7
93.1	78.0	91.6
93.0 or 99.0	75.0	91.5

Table 2
Pay Factor Based on In-place Density

Average Mat Density (4 cores) (Percent of TMD)	Pay Factor, percent	Average Joint Density (4 cores) (Percent of TMD)
below 93.0, above 99.0	0.0 (reject)	below 91.5

1.2.2.1 Pay Factor Based on In-place Density

An example of the computation of a pay factor (in I-P units only) based on in-place density, is as follows: Assume the following test results for field density made on the lot: (1) Average mat density = 94.2 percent (of lab TMD). (2) Average joint density = 92.5 percent (of lab TMD). (3) Total area of lot = 30,000 square feet. (4) Length of completed longitudinal construction joint = 2,000 feet.

a. Step 1: Determine pay factor based on mat density and on joint density, using Table 2:

Mat density of 94.2 percent = 98.3 pay factor.

Joint density of 92.5 percent = 97.3 pay factor.

b. Step 2: Determine ratio of joint area to mat area. Multiply the length of completed longitudinal construction joint by the specified 10 foot width and divide by the mat area (total paved area in the lot).

Ratio = Ratio of joint area to mat area

Ratio = (2,000 feet x 10 feet)/30,000 square feet

Ratio = 0.6667

c. Step 3: Weighted pay factor (wpf) for joint is determined as indicated below:

wpf = joint pay factor + (100 - joint pay factor) x (1 - ratio)

wpf = 97.3 + (100-97.3) x (1-0.6667) = 98.2 percent

d. Step 4: Compare weighted pay factor for joint density to pay factor for mat density and select the smaller:

Pay factor for mat density: 98.3 percent.

Weighted pay factor for joint density: 98.2 percent

Selected pay factor: 98.2 percent

1.2.3 Payment Adjustment for Smoothness (Final Wearing Surface Only)

1.2.3.1 Profilograph Testing

Test the entire lot in the longitudinal direction per ASTM E1274. Perform the longitudinal testing at the centerline of each paving lot and 1/8th point from each side of the lot. Record the location and data from all profilograph measurements. Compute the profile index for each pass of the profilograph (3 per lot) in each 0.1 mile segment. The profile index for each segment is the average of the profile indices for each pass in each segment. When the average Profile Indices of a lot exceeds the tolerance specified in paragraph SMOOTHNESS REQUIREMENTS determine pay factor using Table 3. Correct any small individual area with surface deviation which exceeds the tolerance specified in paragraph SMOOTHNESS REQUIREMENTS by more than 5.0 inches per mile or more, by grinding to meet the specification requirements in Table 3 or remove and replace at no additional cost to the Government.

Table 3
Pay Factor for Smoothness

Average of Profile Indices Exceeding Tolerance (per lot)	Pay Factor, Percent
less than or equal to 1.0 inch per mile	100.0
greater than 1.0 inch per mile but less than or equal to 32 mm per km2.0 inches per mile	95.0
greater than 2.0 inch per mile but less than 47 mm per km3.0 inches per mile	90.0
greater than 3.0 inch per mile but less than 63 mm per km4.0 inches per mile	75.0
greater than 63 mm per km4.0 inches per mile	Remove and Replace at no cost to the Government

1.2.4 Pay Factor Based on Plan Grade

Within 5 working days after completion of a particular lot incorporating the final wearing course, test the final wearing surface of the pavement for conformance with specified plan grade requirements. Provide a final wearing surface of pavement conforming to the elevations and cross sections shown and not vary more than 0.03 foot for runways and landing zones or 0.05 foot for taxiways, aprons, and shoulders from the plan grade established and approved at site of work. Match finished surfaces at juncture with other pavements with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels at intervals of 25 feet, or less, longitudinally and transversely, to determine the elevation of the completed pavement surface. Maintain detailed notes of the results of the testing and provide a copy to the Government immediately after each day's testing. In areas where the grade exceeds the tolerance by more than 50 percent, remove the surface lift full depth; and replace the lift with fuel resistant asphalt pavement to meet specification requirements, at no additional cost to the Government. Diamond grinding may be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted.

Table 4 Pay Factor for Plan Grade	
Percent of All Measurements Outside Tolerance	Pay Factor, percent
Greater than or equal to 5 but less than 10	90
Greater than or equal to 10 but less than 15	75
Greater than 15	Remove and replace the surface lift at no cost to the Government

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 156 (2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures

AASHTO R 30 (2002; R 2019) Standard Practice for Mixture Conditioning of Hot Mix Asphalt (HMA)

ASPHALT INSTITUTE (AI)

AI MS-2 (2015) Asphalt Mix Design Methods

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M (2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

ASTM C88 (2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C117 (2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing

ASTM C127 (2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate

ASTM C128 (2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C1252	(2017) Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM D36/D36M	(2014; R 2020) Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D242/D242M	(2009; R 2014) Mineral Filler for Bituminous Paving Mixtures
ASTM D979/D979M	(2015) Sampling Bituminous Paving Mixtures
ASTM D1461	(2017) Standard Test Method for Moisture or Volatile Distillates in Asphalt Mixtures
ASTM D2041/D2041M	(2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2419	(2014) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2489/D2489M	(2016) Standard Test Method for Estimating Degree of Particle Coating of Asphalt Mixtures
ASTM D2726/D2726M	(2019) Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D3203/D3203M	(2017) Standard Test Method for Percent Air Voids in Compacted Asphalt Mixtures

ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D3699	(2019) Standard Specification for Kerosene
ASTM D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867/D4867M	(2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5361/D5361M	(2016) Standard Practice for Sampling Compacted Asphalt Mixtures for Laboratory Testing
ASTM D5444	(2015) Mechanical Size Analysis of Extracted Aggregate
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6084/D6084M	(2018) Standard Test Method for Elastic Recovery of Asphalt Materials by Ductilometer
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6373	(2016) Standard Specification for Performance Graded Asphalt Binder
ASTM D6925	(2014) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ASTM D6926	(2020) Standard Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus
ASTM D6927	(2015) Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures
ASTM D7173	(2020) Standard Practice for Determining the Separation Tendency of Polymer from Polymer Modified Asphalt
ASTM E1274	(2018) Standard Test Method for Measuring

Pavement Roughness Using a Profilograph

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Placement Plan; G

SD-03 Product Data

Diamond Grinding Plan; G

Mix Design; G

Contractor Quality Control; G

SD-04 Samples

Aggregates

Asphalt Binder

SD-06 Test Reports

Aggregates; G

QC Monitoring

Resistance to Fuel; G

SD-07 Certificates

Asphalt Binder; G

Testing Laboratory

Airfield Asphalt Pavement QC Manager

Airfield Asphalt Pavement Inspector

Airfield Asphalt Pavement Technician

1.5 CONTRACTOR QUALITY CONTROL STAFF

Reference Section 01 45 00.00 10 QUALITY CONTROL for Contractor personnel qualification requirements along with the information included below. Submit certifications for Contractor Quality Control Staff in the following areas:

a. Airfield Asphalt Pavement QC Manager(1): The QC manager will oversee all QC testing and inspection, review asphalt pavement transmittals prior to submission to the Government, be responsible for making mix design adjustments, and in charge of all other activities related to performance. The QC manager will also ensure that daily reports and necessary transmittals arrive for Government review as specified.

b. Airfield Asphalt Pavement Inspector[(1)]: The Inspector will be available on the project during all paving operations. The Inspector is responsible for identifying observed paving issues and ensuring these issues are addressed by the Contractor Quality Control staff.

c. Airfield Asphalt Pavement Technician[(1)]: The Technician will be responsible for conducting laboratory tests. The Airfield Asphalt Pavement Technician will be present in the laboratory anytime laboratory testing is underway.

[(1)]: Registration for the Airfield Asphalt Pavement Certification Program can be found at www.airfieldasphaltcert.com.

1.6 ACCEPTANCE

1.6.1 Acceptability of Work

Acquire the services of an independent commercial laboratory to perform acceptance testing. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests from split samples to validate the results of the production testing. Testing performed by the Government does not reduce the required testing of the independent commercial laboratory. Split samples will be taken for Government testing to reduce the variability between the independent commercial laboratory and the Government's test results. When the difference between the independent commercial laboratory and the Government's test results for split samples exceed the acceptable range of two results for multi-laboratory precision for the appropriate test method (i.e. ASTM) then at least one of the laboratories is determined to be in error. An evaluation of procedures and equipment in both laboratories will be made to determine the cause(s) for the differences. Develop steps to correct procedures and equipment to bring multi-laboratory precision to within acceptable limits.

1.6.2 Acceptance Requirements

Provide all sampling and testing required for acceptance and payment adjustment. Where appropriate, adjustments in payment for individual lots of asphalt pavement will be made based on laboratory air voids, in-place density, smoothness, and grade in accordance with the following paragraphs. Surface smoothness and grade determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus smoothness and grade measurements for the entire lot cannot be made.

1.6.3 Pavement Lots

A standard lot for all requirements is equal to one day's production or 2,000 short tons, whichever is smaller. Divide each lot into four equal sublots in order to evaluate laboratory air voids and in-place density. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, use the following procedure to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they constitute a lot. Where one or two sublots have been completed, incorporate them into the next lot and the total number of sublots (i.e. 5 or 6 sublots) is used for acceptance criteria. Include partial lots at the end of asphalt production into the previous lot. Complete and report all asphalt testing including but not limited to aggregate gradation, asphalt content, theoretical maximum density, laboratory air voids, and in-place density testing within 24 hours after construction of each lot.

1.6.4 Sublot Sampling

Obtain one random mixture sample from each sublot in accordance with ASTM D979/D979M from a loaded truck or another location for determining laboratory air voids, theoretical maximum density, Contractor Quality Control any additional testing as directed by the Government. Representative samples will be selected from random trucks using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D3203/D3203M. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

1.6.4.1 Additional Sampling and Testing

The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Contractor. Testing in these areas will be treated as a separate lot. Payment will be made for the quantity of fuel resistant asphalt pavement represented by these tests in accordance with the provisions of this section.

1.6.4.2 Theoretical Maximum Density (TMD)

Measure theoretical maximum density one time for each sublot in accordance with ASTM D2041/D2041M for purposes of calculating laboratory air voids and determining in-place density. The average TMD for each lot will be determined as the average TMD of the random sublot samples. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD values will be used as the TMD needed to calculate the percent joint density.

1.6.4.3 Laboratory Air Voids

Prepare one set of laboratory compacted specimens for each sublot in accordance with ASTM D6925 using the Superpave gyratory compactor. Provide three test specimens prepared from the same sample for each set of laboratory compacted specimens. Compact the specimens within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Do not reheat samples prior to compaction. Provide insulated containers as necessary to maintain the sample temperature. Measure the bulk density of laboratory compacted specimens in accordance with ASTM D2726/D2726M. Determine laboratory air voids from one set (three laboratory compacted specimens) for each sublot sample in accordance with ASTM D3203/D3203M.

1.6.5 In-place Density

Obtain one random 4 inch or 6 inch diameter core from the mat and joint of each sublot in accordance with ASTM D5361/D5361M for determining in-place density. Where different job mix formulas are required as part of the same project, and are adjacent to one another, follow the same joint density sampling and joint density testing instructions of this specification. Cut samples neatly with a diamond core drill bit. Obtain random cores that are the full thickness of the layer being placed. Select core locations randomly using the procedures contained in ASTM D3665. Locate cores for mat density no closer than 12 inches from a transverse or longitudinal joint including the pavement edge. Center all cores for joint density on the joint. Discard samples that are clearly defective as a result of sampling and take an additional random core. When the random core is less than 1 inch thick, it will not be included in the analysis. In this case, obtain another random core sample. Clean and tack coat dry core holes before filling with asphalt mixture. Fill all core holes with asphalt mixture and compact using a manual (hand-held) Marshall hammer to the density specified. Provide all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Measure in-place density in accordance with ASTM D2726/D2726M using each core obtained from the mat and joint.

1.6.6 Surface Smoothness

Use a straightedge and profilograph for measuring surface smoothness ofpavements. Use the profilograph method for all longitudinal testing, except for paving lanes less than 0.10 miles in length. Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 0.10 miles, and at the ends of the paving limits for the project. Use the straightedge to also perform smoothness checks for any localized areas that look suspicious, including localized areas that were already tested with the profilograph. Perform all testing in the presence of the Government. Maintain detailed notes of the testing results and provide a copy to the Government immediately after each day's testing. Where drawings show required deviations from a plane surface (for instance crowns, drainage inlets), finish the surface to meet the approval of the Government.

1.6.6.1 Smoothness Requirements

1.6.6.1.1 Straightedge Testing

Provide finished surfaces of the pavements with no abrupt change of 1/8 inch or more, and all pavements within the tolerances specified in Table 5 when checked with an approved 12 foot straightedge.

Table 5
Straightedge Surface Smoothness

Pavement Category	Direction of Testing	Tolerance, inch
Runways, taxiways, and landing zones	Longitudinal	1/8
	Transverse	1/4
Shoulders (outside edge stripe)	Longitudinal	1/4
	Transverse	1/4

Table 5
Straightedge Surface Smoothness

Pavement Category	Direction of Testing	Tolerance, inch
Calibration hardstands and compass swinging bases	Longitudinal	1/8
	Transverse	1/8
All other airfield pavements (including overruns) and helicopter paved areas	Longitudinal	1/4
	Transverse	1/4

1.6.6.1.2 Profilograph Testing

Provide finished surfaces of runways, taxiways and landing zones with a Profile Index not greater than 7 inches per mile when tested with an approved California-type profilograph per ASTM E1274. For pavements other than runways, provide finished surfaces with a Profile Index not greater than 9 inches per mile when tested with an approved California-type profilograph per ASTM E1274.

1.6.6.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in a manner to reveal surface irregularities exceeding the tolerances specified above. If any pavement areas are diamond ground, retest these areas immediately after diamond grinding and submit results to the Government for evaluation. The maximum area allowed to be corrected by diamond grinding is 10 percent of the total area of the lot. Test the entire area of the pavement with a profilograph. Check a number of random locations along with any observed suspicious locations primarily at transverse and longitudinal joints with the straightedge.

1.6.6.2.1 Straightedge Testing

Hold the straightedge in contact with the pavement surface and measure the maximum distance between the straightedge and the pavement surface. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Use the straightedge to measure abrupt changes in surface grade.

1.6.6.2.2 Profilograph Testing

Perform profilograph testing using an approved California profilograph and procedures described in ASTM E1274. Provide equipment that utilizes electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for the pavement. Use a "blanking band" that is 0.2 inch wide and the "bump template" spanning 1 inch with an offset of 0.4 inch. Provide profilograph operated by an approved, factory-trained operator on the alignments specified above. Provide a copy of the reduced tapes to the Government at the end of each day's testing.

1.6.6.2.3 Bumps ("Must Grind" Areas)

Reduce any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height by diamond grinding until they do not exceed 0.3 inch when retested. Taper diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding. The following will not be permitted: (1) skin patching for correcting low areas, (2) planing or milling for correcting high areas. Perform additional profilograph testing in all areas corrected by diamond grinding.

1.6.7 Plan Grade

Within 5 working days after completion of a particular lot incorporating the final wearing course, test the final wearing surface of the pavement for conformance with specified plan grade requirements. Provide a final wearing surface of pavement conforming to the elevations and cross sections shown and not vary more than 0.05 foot from the plan grade established and approved at site of work. Match finished surfaces at juncture with other pavements with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels along the centerline at intervals of 25 feet or less longitudinally to determine the elevation of the completed pavement surface. Measure transverse grades at appropriate intervals. Diamond grinding can be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted. Maintain detailed notes of the results of the testing and provide a copy to the Government immediately after each day's testing.

1.6.8 Laboratory Accreditation and Validation

Provide laboratories used to develop the Job Mix Formula (JMF), perform acceptance testing, and Contractor Quality Control testing that meet the requirements of ASTM D3666. Provide laboratories with a masonry saw having a diamond blade for trimming pavement cores and samples. Perform all required test methods by an accredited laboratory. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory accreditation is not allowed. The Government will inspect the laboratory equipment and test procedures prior to the start of fuel resistant asphalt pavement operations for conformance with ASTM D3666. Submit a certificate of compliance signed by the manager of the laboratory stating that it meets these requirements to the Government prior to the start of construction. At a minimum, include the following certifications:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment, with calibration dates, to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

1.7 ENVIRONMENTAL REQUIREMENTS

Do not place the fuel resistant asphalt pavement upon a wet surface or when the surface temperature of the underlying course is less than specified. The temperature requirements may be waived by the Government, if requested; provided all other requirements, including compaction, are met. The surface temperature limitations of the underlying base course is 45 degrees F for a mat thickness of 2 inches.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of asphalt pavement. However, where the construction covered herein interfaces with other sections, construct each interface to conform to the requirements of both this section and the other section, including tolerance for both.

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. Provide fuel resistant asphalt pavement designed and constructed in accordance with this section conforming to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Construct each course to the depth, section, or elevation required by the drawings and rolled, finished, and approved before the placement of the next course. Submit proposed Placement Plan, indicating lane widths, longitudinal joints, and transverse joints for each course or lift.

2.1.1 Asphalt Mixing Plant

Provide plants used for the preparation of asphalt mixture conforming to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the fuel resistant asphalt mixture on approved scales, or on certified public scales at no additional expense to the Government. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Inspection of Plant

Provide access to the Contracting Officer at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.

2.1.1.3 Storage Silos

The fuel resistant asphalt mixture may be stored in non-insulated storage silos for a period of time not exceeding 3 hours. The fuel resistant asphalt pavement may be stored in insulated storage silos for a period of time not exceeding 8 hours. No differences in the mix removed from silos and the mix loaded into trucks are allowed.

2.1.2 Hauling Equipment

Provide trucks used for hauling fuel resistant asphalt pavement that have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, lightly coat the truck beds with a minimum amount of paraffin oil, lime solution, or other approved material. Do not use petroleum based products as a release agent. Provide each truck with a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture is delivered to the site at the specified temperature, provide insulated or heated truck beds with covers (tarps) that are securely fastened.

2.1.3 Material Transfer Vehicle (MTV)

Provide Material Transfer Vehicles (MTV) for placement of the fuel resistantasphalt pavement. To transfer the material from the hauling equipment to the paver, use a self-propelled, material transfer vehicle with a swing conveyor that delivers material to the paver from outside the paving lane and without making contact with the paver. Provide MTV capable to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. Provide MTV with remixing and storage capability to prevent physical and thermal segregation.

2.1.4 Asphalt Pavers

Provide mechanical spreading and finishing equipment consisting of a self-powered paver, capable of spreading and finishing the mixture to the specified line, grade, and cross section. Provide paver with vibrating screed capable of placing a uniform mixture to meet the specified thickness, smoothness, and grade without physical or temperature segregation, the full width of the material being placed.

2.1.4.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and a distribution system to place the mixture uniformly in front of the screed without segregation. Provide a screed that effectively produces a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.4.2 Automatic Grade Controls

If grade control is required, provide a paver equipped with a control system capable of maintaining the specified screed elevation. One of three methods can be used to control grade: stringline, laser, or computerized elevations along with GPS. For multiple layers it is acceptable to control grade in the underlying layer and control the grade of the surface layer by applying a constant thickness over the underlying layer which has been placed to the desired grade. Provide transverse slope controller capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. Do not use the transverse slope controller to control grade. A ski-type device of not less than 30 ft can be used to provide improved smoothness. Use a shoe on one side of the paver to match an existing paved surface to provide a smooth joint.

2.1.5 Rollers

Provide rollers in good condition and operated at slow speeds to avoid displacement of the fuel resistant asphalt pavement. Provide sufficient number, type, and weight of rollers to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.1.6 Diamond Grinding

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of airfield pavements. In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the fuel resistant asphalt pavement with approved equipment after the fuel resistant asphalt pavement is at a minimum age of 14 days. Perform diamond grinding by sawing with saw blades impregnated with an industrial diamond abrasive. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the asphalt pavement. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 feet wide. Diamond grinding equipment that causes raveling, fracturing of aggregate, or disturbance to the underlying material will not be allowed. The maximum depth of diamond grinding is 1/4 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified.

Prior to production diamond grinding operations, perform a test section at the approved location, consisting of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish and transition between adjacent passes. Production diamond grinding operations cannot be performed prior to approval.

2.2 AGGREGATES

Sample aggregates in the presence of a Government Representative. Obtain samples in accordance with ASTM D75/D75M and be representative of the materials to be used for the project. Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, and mineral filler, as required. Natural sand is not allowed in the fuel resistant asphalt pavement. The portion of material retained on the No. 4 sieve is coarse aggregate. The portion of material passing the No. 4 sieve and retained on the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve is defined as mineral filler. Submit sufficient materials to produce 200 pounds 400 pounds of blended mixture for mix design verification. Submit all aggregate test results and samples to the Government at least 14 days prior to start of construction. Aggregate tests can be no older than 6 months prior to test section.

2.2.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. Provide coarse aggregate particles meeting the following requirements:

a. The percentage of loss not be greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131/C131M.

b. The sodium sulfate soundness loss not exceeding 12 percent, or the magnesium sulfate soundness loss not exceeding 18 percent after five cycles when tested in accordance with ASTM C88.

c. At least 75 percent by weight of coarse aggregate contain at least two or more fractured faces when tested in accordance with ASTM D5821 with fractured faces produced by crushing.

d. The particle shape essentially cubical and the aggregate containing not more than 5 percent, by weight, of flat particles, elongated particles, or flat and elongated particles (5:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791 Method A.

e. Slag consisting of air-cooled, blast furnace slag, with a compacted weight of not less than 75 pounds per cubic foot when tested in accordance with ASTM C29/C29M.

f. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.2.2 Fine Aggregate

Provide fine aggregate consisting of clean, sound, tough, durable particles. Natural Sand is not allowed. Provide aggregate particles that are free from coatings of clay, silt, or any objectionable material, contain no clay balls, and meet the following requirements:

a. Individual fine aggregate sources with a sand equivalent value greater than 45 when tested in accordance with ASTM D2419.

b. Fine aggregate portion of the blended aggregate with an uncompacted void content greater than 45.0 percent when tested in accordance with ASTM C1252 Method A.

c. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.2.3 Mineral Filler

Provide mineral filler consisting of a nonplastic material meeting the requirements of ASTM D242/D242M.

2.2.4 Aggregate Gradation

Provide a combined aggregate gradation that conforms to gradations specified in Table 6, when tested in accordance with ASTM C136/C136M and ASTM C117, and does not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grades uniformly from coarse to fine. Provide a JMF within the specification limits; however, the gradation can exceed the limits when the allowable deviation from the JMF shown in Tables 8 and 9 are applied.

Table 6
Aggregate Gradations

Sieve Size, inch	1/2 mix[(1)] Percent Passing by Mass
1/2	100
3/8	90-100
No. 4	58-78
No. 8	40-60
No. 16	28-48
No. 30	18-38
No. 50	11-27
No. 100	6-18
No. 200	3- 6

(1) This mix is to be used only as a surface course. The allowable lift thickness is 2 inches.

2.3 ASPHALT BINDER

Provide asphalt binder that conforms to ASTM D6373 for Performance Grade (PG) and meeting the requirements annotated below.

a. Test the original binder according to ASTM D6084/D6084M Procedure A – Elastic
Recovery at 77 degrees F with a minimum of 85 percent.

b. Test the original binder according to ASTM D7173 and meeting the maximum temperature difference of7.2 degrees F when using the ASTM D36/D36M Ring-and-Ball apparatus.

c. Prepare the fuel resistant asphalt pavement specimens with the asphalt binder meeting the above requirements and the fuel resistance requirements when tested in accordance with paragraph TESTING REQUIREMENT FOR ASPHALT MIXTURE RESISTANCE TO FUEL. After passing the above requirements and those listed in Table 7, grade the asphalt binder as PG 82-28FR.

Provide test data indicating grade certification by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Government. The supplier is defined as the last source of any modification to the binder. The Government may sample and test the binder at the mix plant at any time before or during mix production.

2.4 MIX DESIGN

Develop the mix design. Provide results of the Job Mix Formula (JMF) and aggregate testing performed no earlier than 6 months prior to Contract award. Provide fuel resistant asphalt mixture composed of well-graded aggregate, mineral filler if required, and asphalt material. Provide aggregate fractions sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of Table 6. Do not produce fuel resistant asphalt pavement for payment until a JMF has been approved. Design the fuel resistant asphalt pavement using hand-held (manual) Marshall Hammer procedures contained in AI MS-2 and the criteria shown in Table 7. Design the fuel resistant asphalt mixture using the Superpave gyratory compactor using the procedures contained in AI MS-2 and the criteria shown in Table 7. Prepare samples at various asphalt contents and compacted in accordance with ASTM D6925 or ASTM D6926 as required by the Government. Use laboratory compaction temperatures for Polymer Modified Asphalts as recommended by the asphalt binder manufacturer. Adjust the compactive effort of the specimens, as required, to provide a Tensile Strength Ratio (TSR) with an air void content of 7 plus or minus 1 percent. . If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867/D4867M is less than 80, reject the aggregates or the asphalt mixture treated with an anti-stripping agent. Add a sufficient amount of anti-stripping agent to produce a TSR of not less than 80. If an antistrip agent is required, provide it at no additional cost to the Government. Provide sufficient materials to produce 200 pound of blended mixture to the Government for verification of mix design at least 14 days prior to construction of test section.

2.4.1 JMF Requirements

Submit the proposed JMF in writing, for approval, at least 14 days prior to the start of the test section, including as a minimum:

a. Percent passing each sieve size.

b. Optimum asphalt binder.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt performance grade and additional test requirements as specified in paragraph ASPHALT BINDER.

e. Number of blows of hammer per side of molded specimen.Number of Superpave gyratory compactor gyrations.

f. Laboratory mixing and compaction temperature.

g. Supplier-recommended field mixing and compaction temperatures.

h. Temperature of mix when discharged from mixer.

i. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

j. Graphical plots and summary tabulation of stability, air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2. Include summary tabulation that includes individual specimen data for each specimen tested.

k. Specific gravity and absorption of each aggregate.

l. Percent manufactured sand.

m. Percent particles with two or more fractured faces (in coarse aggregate).

n. Fine aggregate angularity.

o. Percent flat or elongated particles (in coarse aggregate).

p. Tensile Strength Ratio and wet/dry specimen test results.

q. Type and amount of antistrip agent (if required).

r. Date the JMF was developed. Mix designs that are not dated or which are from a prior construction seasons may not be accepted.

s. Test results for asphalt resistance to fuel in accordance with paragraph TESTING REQUIREMENTS FOR ASPHALT MIXTURE RESISTANCE TO FUEL.

t. List of all modifiers.

Table 7
Marshall Design Criteria

Test Property	50 Blow Mix
Stability, pounds minimum	2150 (1)
Flow, 0.01 inch	Waived (2)
Air voids, percent	2.5 (4)
Percent Voids in mineral aggregate (minimum)	14
Dust Proportion (3)	0.8-1.2
TSR, minimum percent	80
TSR Conditioned Strength (minimum psi)	60
Weight loss by fuel Immersion, maximum percent	1.5 (5)

(1) This is a minimum requirement. Provide significantly higher average during construction to ensure compliance with the specifications

(2) The flow requirement is not applicable for Polymer Modified Asphalts

(3) Dust Proportion is calculated as the aggregate content, expressed as a percent of mass, passing the No. 200 sieve, divided by the effective asphalt content, in percent of total mass of the mixture

(4) Select the JMF asphalt content corresponding to an air void content of 2.5 percent. Verify the other properties of Table 7 meet the specification requirements at this asphalt content.

Table 7 Marshall Design Criteria	
Test Property	50 Blow Mix
(5) Tested in accordance with paragraph TESTING REQUIREMENT FOR ASPHALT MIXTURE RESISTANCE TO FUEL	

Table 7 Superpave Gyratory Compaction Criteria	
Test Property	50 Gyration Mix
Air voids, percent	2.5[1]
Percent Voids in mineral aggregate (minimum)	14
Dust Proportion[2]	0.8-1.2
TSR, minimum percent	80
TSR Conditioned Strength (minimum psi)	60
Weight loss by fuel Immersion, maximum percent	1.5[3]
(1) Select the JMF asphalt content corresponding to an air void content of 2.5 percent. Verify the other properties of Table 7 meet the specification requirements at this asphalt content.	
(2) Dust Proportion is calculated as the aggregate content, expressed as a percent of mass, passing the No. 200 sieve, divided by the effective asphalt content, in percent of total mass of the	
(3) Tested in accordance with paragraph TESTING REQUIREMENT FOR ASPHALT MIXTURE RESISTANCE TO FUEL	

2.4.2 Testing Requirement for Asphalt Mixture Resistance to Fuel

Determine asphalt pavement resistance to fuel by the following procedures:

a. Prepare three test specimens in accordance with the Mix Design requirements at optimum asphalt binder content and 2.5 plus or minus 0.7 percent air voids. Short term age the mix prior to compaction in accordance to AASHTO R 30.

b. Determine the percent air voids in each specimen, if any do not meet the requirements above discard and replace them. Dry the specimens under a fan at room temperature (68F to 80F) for a minimum of 24 hours.

c. Totally immerse the sample in kerosene[1] at room temperature (68F to 80F).

d. After submersing for 2.0 minutes plus or minus 30 seconds, remove the sample and immediately surface dry with a clean paper towel. Then immediately determine the weight in air to the nearest 0.1 grams. Report this as weight 'A' (weight before).

e. Resubmerse the sample in kerosene for 24 hours.

f. After 24 hours plus or minus 10 minutes, carefully remove the sample from the kerosene and suspension container and place it on an absorptive cloth or paper towel. Dry the specimen under a fan at room temperature (68F to 80F) for 24 hours.

g. After drying for 24 hours plus or minus 10 minutes weigh the sample in air to the nearest 0.1 grams. Report this as weight 'B' (weight after immersion).

h. Calculations:

Percent of weight loss by fuel immersion = (A - B) / A x 100

Where: A = Weight before
B = Weight after

(1) Kerosene must meet the requirements of ASTM D3699.

2.4.3 Adjustments to JMF

The JMF for each mixture is in effect until a new formula is approved in writing by the Government. Should a change in sources of any material be made, perform a new mix design and a new JMF approved before the new material is used. Make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF are limited to plus or minus 4 percent on the No. 4 and coarser sieves; plus or minus 3 percent on the No. 8 to No. 50 sieves; and plus or minus 1 percent on the No. 100 sieve. Adjustments to the JMF are limited to plus or minus 1.0 percent on the No. 200 sieve. Asphalt content adjustments are limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, develop a new mix design.

2.5 RECLAIMED ASPHALT PAVEMENT

Reclaimed asphalt pavement (RAP) or recycled asphalt shingles (RAS) is not allowed.

PART 3 EXECUTION

3.1 CONTRACTOR QUALITY CONTROL

3.1.1 General Quality Control Requirements

Submit the Quality Control Plan. The Quality Control Plan is specific to this specification section and supplements the overall Quality Control Plan required by the project. Do not produce asphalt pavement for payment until the quality control plan has been approved. In the quality control plan, address all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design and unique JMF identification code

b. Aggregate Grading

c. Quality of Materials

d. Stockpile Management and procedures to prevent contamination

e. Proportioning

f. Mixing and Transportation

g. Mixture Volumetrics

h. Moisture Content of Mixtures

i. Placing and Finishing

j. Joints

k. Compaction, including Fuel Resistant Asphalt Pavement-Portland Cement Concrete joints

l. Surface Smoothness

m. Truck bed release agent

n. Correlation of mechanical hammer to hand hammer. Determine the number of blows of the mechanical hammer required to provide the same density of the JMF as provided by the hand hammer. Use the average of three specimens per trial blow application.

3.1.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site that is equipped with heating and air conditioning units to maintain a temperature of 75 plus or minus 5 degrees F. Provide laboratory facilities that are kept clean and all equipment maintained in proper working condition. Provide the Government with unrestricted access to inspect the laboratory facility, to witness quality control activities, and to perform any check testing desired. The Government will advise in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, immediately suspend the incorporation of the materials into the work. Incorporation of the materials into the work will not be permitted to resume until the deficiencies are corrected.

3.1.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The quality control (QC) testing is separate and distinct from the acceptance testing in paragraph ACCEPTANCE. Use in-house capabilities or the independent commercial laboratory for quality control testing. Required elements of the testing program include, but are not limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability, in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.1.3.1 Asphalt Content

Determine asphalt content a minimum of twice per lot (a lot is defined in paragraph PAVEMENT LOTS) by one of the following methods: extraction method in accordance with ASTM D2172/D2172M, Method A or B, the ignition method in accordance with the ASTM D6307, or the nuclear method in accordance with ASTM D4125/D4125M, provided each method is calibrated for the specific mix being used. For the extraction method, determine the weight of ash, as described in ASTM D2172/D2172M, as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. Use the last weight of ash value in the calculation of the asphalt content for the mixture. The asphalt content for the lot will be determined by averaging the test results.

3.1.3.2 Aggregate Properties

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with ASTM D5444 or ASTM D6307. For batch plants, test aggregates in accordance with ASTM C136/C136M using actual batch weights to determine the combined aggregate gradation of the mixture. Determine the specific gravity of each aggregate size grouping for each 20,000 tons in accordance with ASTM C127 or ASTM C128. Determine fractured faces for gravel sources for each 20,000 tons in accordance with ASTM D5821. Determine the uncompacted void content of manufactured sand, and blended aggregate for each 20,000 tons in accordance with ASTM C1252 Method A.

3.1.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt binder in the storage tank, the fuel resistant asphalt mixture at the plant, and the fuel resistant asphalt mixture at the job site.

3.1.3.4 Moisture Content of Aggregate

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with ASTM C566.

3.1.3.5 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in accordance with ASTM D1461.

3.1.3.6 Laboratory Air Voids, TMD, and VMAVMA and Marshall Stability

Obtain mixture samples at least four times per lot. Measure theoretical maximum density in accordance with ASTM D2041/D2041M. Compact the remaining portion of the sample into specimens, using 50 blows per side with the Marshall hand-held hammer as described in ASTM D6926. using 50 gyrations of the Superpave gyratory compactor as described in ASTM D6925. After compaction, measure the bulk density of laboratory compacted specimens in accordance with ASTM D2726/D2726M. Determine laboratory air voids from one set (three laboratory compacted specimens) for each sample in accordance with ASTM D3203/D3203M. Also calculate the VMA of each specimen in accordance with AI MS-2 based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate, as well as the Marshall stability, as described in ASTM D6927. Provide VMA within the limits of Table 7.

3.1.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge or other non-destructive testing device may be used to monitor pavement density.

3.1.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraph ACCEPTANCE.

3.1.3.9 Additional Testing

Perform any additional testing, deemed necessary to control the process.

3.1.3.10 QC Monitoring

Submit all QC test results to the Government on a daily basis as the tests are performed. The Government reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.1.4 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 8, as a minimum. Post the control charts as directed by the Government and maintain current at all times. Identify the following on the control charts, the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 8 applicable to the test parameter being plotted, and the test results. Also show target values (JMF) on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. When the Suspension Limit is exceeded for individual values or running average values, the Government Engineer has the option to require removal and replacement of the material represented by the samples or to leave in place and base acceptance on mixture volumetric properties and in place density. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. In the Quality Control Plan, indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 8
Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
No. 4 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	6	8	4	5
No. 30 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	4	6	3	4
No. 200 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	1.4	2.0	1.1	1.5
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
$P_{0.075}/P_{be}$ Ratio, deviation from 1.0; plus or minus values	0.7	0.8	0.3	0.4
VMA of Fuel Resistant Asphalt Pavement, percent deviation from JMF target	-0.5	-1.0	-0.25	-0.5
Table 8 cont'd. Marshall Compaction				
Stability, pounds (minimum)				
50 blow JMF	1760	1640	2150	2030

3.2 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt binder material while avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. Maintain the temperature of unmodified asphalts to no more than 325 degrees F when added to the aggregates. The temperature of modified asphalts is not to exceed 350 degrees F. Performance Graded (PG) asphalts must be within the temperature range of 290 degrees F to 340 degrees F when added to the aggregates and in accordance with the supplier's recommendations.

3.3 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage to the aggregates due to the maximum temperature and rate of heating used is allowed. Maintain the temperature no lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.4 PREPARATION OF ASPHALT MIXTURE

Weigh or meter the aggregates and the asphalt binder and introduce into the mixer in the amount specified by the JMF. Limit the temperature of the asphalt mixture to 350 degrees F when the asphalt binder is added. Mix the combined materials until the aggregate obtains a thorough and uniform coating of asphalt binder (testing in accordance with ASTM D2489/D2489M may be required by the Contracting Officer) and is thoroughly distributed throughout the mixture. The moisture content of all asphalt mixture upon discharge from the plant is not to exceed 0.5 percent by total weight of mixture as measured by ASTM D1461.

3.5 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the fuel resistant asphalt pavement, clean the underlying course of dust and debris. Apply a tack coat in accordance with Section 32 12 13 BITUMINOUS TACK AND PRIME COATS.

3.6 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section 250 to 500 feet long and two paver passes wide with a longitudinal cold joint. Do not place the second lane of test section until the temperature of pavement edge is less than 175 degrees F. Construct the test section with the same depth as the course which it represents. Ensure the underlying grade or pavement structure upon which the test section is to be constructed is the same or very similar to underlying layer for the project. Use the same equipment and procedures in construction of the test section as on the remainder of the course represented by the test section. Construct the test section as part of the project pavement as approved by the Government.

3.6.1 Sampling and Testing for Test Section

Obtain one random sample at the plant, triplicate specimens compacted, and tested for stability, and laboratory air voids. Test a portion of the same sample for TMD, aggregate gradation and asphalt content. Test an additional portion of the sample to determine the TSR. Adjust the compactive effort as required to provide TSR specimens with an air void content of 7 plus or minus 1 percent. Obtain four randomly selected cores from the finished pavement mat, and four from the longitudinal joint, and tested for density. Perform random sampling in accordance with procedures contained in ASTM D3665. Construction may continue provided the test results are within the tolerances or exceed the minimum values shown in Table 7. If all test results meet the specified requirements, the test section may remain as part of the project pavement. If test results exceed the tolerances shown, remove and replace the test section and construct another test section at no additional cost to the Government.

Table 9
Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
No. 4 and larger	JMF plus or minus 8
No. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
No. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	14 minimum
Tensile Strength Ratio (TSR) (At 7 percent plus or minus 1 percent air void content)	80 percent minimum
TSR Conditioned Strength	60 psi minimum
Mat Density, Percent of TMD (Average of 4 Random Cores)	See Table 2
Joint Density, Percent of TMD (Average of 4 Random Cores)	See Table 2

Table 9 cont - Marshall Compaction Requirements

Property	Specification Limit
Stability, (Average of 3 specimens)	2150 pounds minimum

3.6.2 Additional Test Sections

If the initial test section proves to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and rolling procedures before beginning construction of a second test section. Construct and evaluate additional test sections, as required, for conformance to the specifications. Full production paving is not allowed until an acceptable test section has been constructed and accepted.

3.7 TRANSPORTING AND PLACING

3.7.1 Transporting

Transport the fuel resistant asphalt mixture from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material is not permitted until the material has been compacted as specified, and allowed to cool to 140 degrees F.

3.7.2 Placing

Place the mix in lifts of adequate thickness and compacted at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. At daily paving start-up, load the first truck and stage it near the paving operation. Process the second and third truck through the MTV and into the paver. After the third truck has processed through the MTV and paver, the first truck can be deposited into the MTV and paver. If internal temperature of the first truck drops below compaction temperatures, the asphalt mixture will be rejected. The method presented in the previous sentences also applies to when a stoppage or delay exceeds one hour. Upon arrival, place the mixture to the full width by an asphalt paver; strike off in a uniform layer of such depth that, when the work is completed, the required thickness and conform to the grade and contour indicated. Do not broadcast waste mixture onto the mat or recycle it into the paver hopper. Collect waste mixture and dispose off site. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Begin placement of the mixture along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 10 feet. Offset the longitudinal joint in one course from the longitudinal joint in the course immediately below by at least 1 foot; however, locate the joint in the surface course at the centerline of the pavement. Offset transverse joints in one course by at least 10 feet from transverse joints in the previous course. Offset transverse joints in adjacent lanes a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools. Construct the free edge of shoulder pavements following a guide (e.g. plumb-bob, stringline, etc.) to prevent various widths of the asphalt shoulder. Contractor may elect to cut-back the asphalt edge to maintain consistent shoulder dimensions shown on the plans.

3.8 COMPACTION OF MIXTURE

3.8.1 General

After placing, thoroughly and uniformly compact the mixture by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. Determine the sequence of rolling operations and the type of rollers used, except as specified in paragraph FUEL RESISTANT ASPHALT PAVEMENT-PORTLAND CEMENT CONCRETE JOINTS and with the exception that application of more than three passes with a vibratory roller in the vibrating mode is prohibited. Maintain the speed of the roller, at all times, sufficiently slow to avoid displacement of the asphalt mixture and be effective in compaction. Correct at once any displacement occurring as a result of reversing the direction of the roller, or from any other cause.

Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened, but excessive water is not permitted. In areas not accessible to the roller, thoroughly compact the mixture with hand tampers. Remove the full depth of any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective, replace with fresh fuel resistant asphalt mixture and immediately compact to conform to the surrounding area. Perform this work at no expense to the Government. Skin patching is not allowed.

3.8.2 Segregation

Sample and test any material that looks deficient. When the in-place material appears to be segregated, the Government has the option to sample the material and have it tested and compared to the aggregate gradation, asphalt content, and in-place density requirements in Table 7. If the material fails to meet these specification requirements, remove and replace the extent of the segregated material the full depth of the layer of asphalt mixture at no additional cost to the Government. When segregation occurs in the mat, take appropriate action to correct the process so that additional segregation does not occur.

3.9 JOINTS

Construct joints to ensure a continuous bond between the courses and to obtain the required density. Provide all joints with the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.9.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, construct by means of placing a bulkhead or by tapering the course. Utilize a dry saw cut on the transverse joint full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. Cutting equipment that uses water as a cooling or cutting agent nor milling equipment is permitted. Remove the cutback material from the project. In both methods, provide a light tack coat of asphalt material to all contact surfaces before placing any fresh mixture against the joint.

3.9.2 Longitudinal Joints

Cut back longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing the adjacent lane), or otherwise defective, a maximum of 3 inches from the top edge of the lift with a cutting wheel to expose a clean, sound, near vertical surface for the full depth of the course. Remove all cutback material from the project. Attach the cutting wheel to a roller to perform the longitudinal joint cut back. Provide a light tack coat of asphalt material to all contact surfaces prior to placing any fresh mixture against the joint.

3.9.3 Fuel Resistant Asphalt Pavement-Portland Cement Concrete Joints

Joints between fuel resistant asphalt pavement and Portland Cement Concrete (PCC) require specific construction procedures for the fuel resistant asphalt pavement. The following criteria are applicable to the first 10 feet or paver width of fuel resistant asphalt pavement adjacent to the PCC.

a. Place the fuel resistant asphalt pavement side of the joint in a direction parallel to the joint.

b. Place the fuel resistant asphalt pavement side sufficiently high so that when fully compacted the fuel resistant asphalt pavement is greater than 1/8 inch but less than 1/4 inch higher than the PCC side of the joint.

c. Compact with steel wheel rollers and at least one rubber tire roller. Compact with a rubber tire roller that weights at least 20 tons with tires inflated to at least 90 psi. Avoid spalling the PCC during placement and compaction of the fuel resistant asphalt pavement. Operate steel wheel rollers in a way that prevents spalling the PCC. Repair any damage to PCC edges or joints as directed by the Government. If damage to the PCC joint or panel edge exceeds a total of 3 feet, remove and replace the PCC panel at no additional expense to the Government.

d. After compaction is finished, diamond grind a minimum width of 3 feet of the fuel resistant asphalt pavement so that the fuel resistant asphalt pavement side is less than 1/8 inch higher than the PCC side. Perform diamond grinding in accordance with subparagraph DIAMOND GRINDING above. The fuel resistant asphalt pavement immediately adjacent to the joint is not allowed to be lower than the PCC after the grinding operation. Transition the grinding into the fuel resistant asphalt pavement in a way that ensures good smoothness and provides drainage of water. The joint and adjacent materials when completed is required to meet all of the requirements for grade and smoothness. Measure smoothness across the fuel resistant asphalt pavement-PCC joint using a 12 feet straightedge. The acceptable tolerance is 1/8 inch.

e. Consider the fuel resistant asphalt pavement next to the PCC as a separate pay factor associated with the lot being placed for evaluation. Lots are based on individual lifts. Do not comingle cores from different lifts for density evaluation purposes. Take four cores for each lot of material placed adjacent to the joint. The size of lot is 10 feet wide by the length of the joint being paved. Perform the same computation as displayed in paragraph PAY FACTOR BASED ON IN-PLACE DENSITY above to determine the weighted pay factor. Select the lowest computed pay factor for the lot. Locate the center of each of the four cores 6 inches from the edge of the concrete. Take each core at a random location along the length of the joint. The requirements for joint density for this lot, adjacent to the PCC joint, are the same as that for the mat density specified in Table 2. For fuel resistant asphalt pavement-PCC joints at taxiways abutting runways, aprons, or other taxiways, take two additional randomly located cores along each taxiway intersection.

f. All procedures, including repair of damaged PCC, are required to be in accordance with the approved Quality Control Plan.

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SECTION 32 13 14.13

CONCRETE PAVING FOR AIRFIELDS AND OTHER HEAVY DUTY PAVEMENTS
08/19

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurements

The quantity of concrete to be paid for will be the volume of concrete in cubic yards including thickened edges monolithic curb, where required, placed in the completed and accepted pavement. Concrete will be measured in place in the completed and accepted pavement only within the neat line dimensions shown in the plan and cross section. No deductions will be made for rounded or beveled edges or the space occupied by pavement reinforcement, dowel bars, tie bars, or electrical conduits, nor for any void, or other structure extending into or through the pavement slab, measuring 3 cubic feet or less in volume. No other allowance for concrete will be made unless placed in specified locations in accordance with the approved contract modification. The quantity of other materials specified herein, and used in the construction of the work covered by this section, will not be measured for payment, but will be considered a subsidiary obligation, covered under the price per cubic yard for concrete. Joint sealing materials are covered in Section 32 01 19.61 SEALING OF JOINTS IN RIGID PAVEMENT or Section 32 13 73.19 COMPRESSION CONCRETE PAVING JOINT SEALANT.

1.1.2 Payments

1.1.2.1 Unit Price

The quantity of concrete measured as specified above will be paid for at the contract unit price when placed in completed and accepted pavements. Payment will be made at the contract price for cubic yard for the scheduled item, with necessary adjustments as specified below. Payment will constitute full compensation for providing all materials, equipment, plant and tools, and for all labor and other incidentals necessary to complete the concrete pavement, except for other items specified herein for separate payment.

1.1.2.2 Lump Sum

The quantity of concrete will be paid for and included in the lump-sum contract price. If less than 100 percent payment is due based on the pay factors stipulated below, a unit price of as specified by the Contracting Officer per cubic yard will be used for purposes of calculating the payment reduction. Payment will constitute full compensation for all materials, equipment, plant and tools, and for all labor and other incidentals necessary to complete the concrete pavement, except for other items specified herein for separate payment.

1.1.3 Payment of Lots

When a lot of material fails to meet the specification requirements, that lot will be accepted at a reduced price or be removed and replaced. The lowest computed percent payment determined for any pavement characteristic discussed below (for example, thickness, grade, and surface smoothness) becomes the actual percent payment for that lot. The actual percent payment will be applied to the unit price and the measured quantity of concrete in the lot to determine actual payment. Use results of strength tests to control concreting operations. Strength will be evaluated, but will not be considered for payment adjustment. Remove and replace any pavement not meeting the required 'Concrete Strength for Final Acceptance' at no additional cost to the Government.

1.1.4 Payment Adjustment for Smoothness

1.1.4.1 Straightedge Testing

Record location and deviation from straightedge for all measurements. When more than 5.0 and less than or equal to 10.0 percent of all measurements made within a lot exceed the tolerance specified in paragraph SURFACE SMOOTHNESS, after any reduction of high spots or removal and replacement, the computed percent payment based on surface smoothness will be 95 percent. When more than 10.0 percent and less than or equal to 15.0 percent of all measurements exceed the tolerance, the computed percent payment will be 90 percent. When more than 15.0 and less than or equal to 20.0 percent of all measurements exceed the tolerance, the computed percent payment will be 75 percent. Remove and replace the lot when more than 20.0 percent of the measurements exceed the tolerance, at no additional cost to the Government.

1.1.4.2 Profilograph Testing

Record location and data from all profilograph measurements. When the Profile Index of a 0.1 mile segment of a lot exceeds the tolerance specified in paragraph SURFACE SMOOTHNESS by 1.0 inch per mile but less than 2.0 inches per mile, after any reduction of high spots or removal and replacement, the computed percent payment based on surface smoothness will be 95 percent. When the Profile Index exceeds the tolerance by 2.0 inches per mile but less than 3.0 inches per mile, the computed percent payment will be 90 percent. When the Profile Index exceeds the tolerance by 3.0 inches per mile but less than 4.0 inches per mile, the computed percent payment will be 75 percent. Remove and replace the lot when the Profile Index exceeds the tolerance by 4.0 inches per mile or more, at no additional cost to the Government.

1.1.4.3 Aircraft Arresting Systems

The 200 feet of airfield pavement on both the approach and departure sides of the arresting system pendant is a critical area. Consider this area as a separate lot for payment adjustment for smoothness. Protruding objects and undulating surfaces are detrimental to successful tailhook engagements and are not allowable. No exceedance of the tolerances specified in paragraph SURFACE SMOOTHNESS is acceptable. Remove and replace pavements exceeding the tolerances.

1.1.5 Payment Adjustment for Plan Grade

When more than 5.0 and less than or equal to 10.0 percent of all measurements made within a lot are outside the specified tolerance, the computed percent payment for that lot will be 95 percent. When more than 10.0 percent but less than 50 percent are outside the specified tolerances, the computed percent payment for the lot will be 75 percent. Remove and replace the deficient area where the deviation from grade exceeds the specified tolerances by 50 percent or more, at no additional cost to the Government.

1.1.6 Payment Adjustment for Thickness

Using the Average Thickness of the lot, determine the computed percent payment for thickness by entering the following table:

Computed Percent Payment for Thickness		
Deficiency in Thickness Determined by cores inches	Pavements Equal To or Greater Than 8 inches Thick	Pavements Less Than 8 inches Thick
0.00 to 0.24	100	100
0.25 to 0.49	75	65
0.50 to 0.74	50	0
0.75 or greater	0	0

Where 0 percent payment is indicated, remove the entire lot and replace at no additional cost to the Government. Where either of the two cores from a sublot show a thickness deficiency of 0.75 inch or greater, 0.50 inch for pavements 8 inches or less in thickness drill two more cores in the sublot and compute the average thickness of the four cores. If this average shows a thickness deficiency of 0.75 inch or more 0.50 inch for pavements 8 inches or less in thickness remove the entire sublot.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182 (2005; R 2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 201.1R (2008) Guide for Conducting a Visual Inspection of Concrete in Service

ACI 211.1 (1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete

ACI 214R (2011) Evaluation of Strength Test Results of Concrete

ACI 305R	(2020) Guide to Hot Weather Concreting
ACI 306R	(2016) Guide to Cold Weather Concreting
ACI 325.14R	(2017) Guide for Design and Proportioning of Concrete Mixtures for Pavements

ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M	(2019) Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615/A615M	(2020) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A996/A996M	(2016) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM A1064/A1064M	(2017) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A1078/A1078M	(2019) Standard Specification for Epoxy-Coated Steel Dowels in Concrete Pavement
ASTM C31/C31M	(2021a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2021) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C78/C78M	(2022) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2014) Standard Test Method for Lightweight Particles in Aggregate

ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138/C138M	(2017a) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2021) Standard Specification for Portland Cement
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C174/C174M	(2017) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192/C192M	(2019) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C294	(2012; R 2017) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates
ASTM C295/C295M	(2019) Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494/C494M	(2019) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

ASTM C666/C666M	(2015) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C881/C881M	(2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989/C989M	(2018a) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1017/C1017M	(2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1064/C1064M	(2017) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	(2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	(2021) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2018) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1646/C1646M	(2016) Making and Curing Test Specimens for Evaluating Frost Resistance of Coarse Aggregate in Air-Entrained Concrete by Rapid Freezing and Thawing
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors

ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM E1274	(2018) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2015) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

U.S. AIR FORCE (USAF)

AF ETL 97-5	(1997) Proportioning Concrete Mixtures with Graded Aggregates for Rigid Airfield Pavements

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 55	(1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 662	(2009) Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Diamond Grinding Plan; G

Dowels; G

Dowel Bar Assemblies; G

Equipment

Proposed Techniques; G

SD-05 Design Data

Preliminary Proposed Proportioning; G

Proportioning Studies; G

SD-06 Test Reports

Batch Plant Manufacturer's Inspection Report; G

Slipform Paver Manufacturer's Inspection Report; G

Sampling and Testing; G

Diamond Grinding of PCC Surfaces; G

Mixer Performance (Uniformity) Testing; G

Repair Recommendations Plan; G

SD-07 Certificates

Contractor Quality Control Staff; G

Laboratory Accreditation and Validation

Commercial Laboratory; G

NRMCA Certificate of Conformance

1.4 QUALITY CONTROL

1.4.1 Contractor Quality Control Staff

Reference Section 01 45 00.00 10 QUALITY CONTROL for Contractor personnel qualification requirements. Submit American Concrete Institute certification for Contractor Quality Control staff. Qualifications and resumes for petrographer, surveyor, concrete batch plant operator, and profilograph operator. All Contractor Quality Control personnel assigned to concrete construction are required to be American Concrete Institute (ACI) certified in the following grade:

a. The minimum requirements for the CQC System Manager consist of being a graduate engineer or a graduate of construction management, with a minimum of 5 years airfield construction experience and a minimum of 1 year experience as a CQC System Manager on an airfield construction project.

b. CQC personnel responsible for inspection of concrete paving operations: ACI Concrete Transportation Inspector. The ACI Concrete Transportation Inspector is required to be present at the paving site during all paving operations, with the exception of the initial saw cutting operation. The QC manager is required to be present during initial saw cutting operations.

c. CQC staff is required to oversee all aspects of sawing operations (sawing, flushing, vacuuming, checking for random cracking, lighting).

d. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews: ACI Concrete Flatwork Technician/Finisher.

e. Batch Plant Manufacturer's Representative: A representative from the batch plant manufacturer is required to be on-site to inspect and make necessary adjustments to all components of the batch plant including but not limited to aggregate bin weighing operations, water metering, cement and fly ash weighing devices. All necessary inspections and adjustments by the manufacturer representative is required to be performed prior to uniformity testing. Submit a written Batch Plant Manufacturer's Inspection Report signed by the representative noting all inspection items and corrections and stating the batch plant is capable of producing the volume of concrete as required herein.

f. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

g. Slipform Paving Equipment Manufacturer's Representative: A representative of the slipform paving equipment manufacturer is required to be on-site to inspect and make corrections to the paving equipment to ensure proper operations. Perform a complete and full hydraulic flow test of the vibrator system prior to the test section being placed. Submit a written Slipform Paver Manufacturer's Inspection Report signed by the manufacturer's representative noting all inspections, corrections, and flow tests have been performed and the paver is in a condition to perform the required work.

h. Laboratory Testing Technicians: ACI Concrete Strength Testing Technician and Laboratory Testing Technician, Grade I or II.

1.4.2 Other Staff

Submit for approval, the qualifications and resumes for the following staff:

a. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C294 and ASTM C295/C295M and trained in identification of the specific deleterious materials and tests identified in this specification. Detail the education, training and experience related to the project-specific test methods and deleterious materials in the Resume and submit at least 20 days before petrographic and deleterious materials examination is to commence.

b. Licensed Surveyor: Perform all survey work under the supervision of a Licensed Surveyor.

c. Concrete Batch Plant Operator: National Ready Mix Concrete Association (NRMCA) Plant Manager certification.

d. Profilograph Operator: Certification by equipment manufacturer or a state Department of Transportation.

1.4.3 Laboratory Accreditation and Validation

Provide laboratory and testing facilities. Submit accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM C1077, including all applicable test procedures. The laboratories performing the tests are required to be accredited in accordance with ASTM C1077, including ASTM C78/C78M and ASTM C1260. Provide current accreditation and include the required and optional test methods, as specified. In addition, all contractor quality control testing laboratories performing acceptance testing require USACE validation by the Material Testing Center (MTC) for both parent laboratory and on-site laboratory. Validation on all laboratories is required to remain current throughout the duration of the paving project. Contact the MTC manager listed at http://www.erdc.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/9254/Article/ for costs and scheduling. Provide on-site temperature-controlled concrete curing facilities.

1.4.3.1 Aggregate Testing and Mix Proportioning

Aggregate testing and mixture proportioning studies are required to be performed by a commercial laboratory.

1.4.3.2 Acceptance Testing

Provide all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the paving site and in the laboratory. Provide steel molds for molding the beam specimens. Provide and maintain boxes or other facilities suitable for storing and curing the specimens at the paving site while in the mold within the temperature range stipulated by ASTM C31/C31M. Provide flexural loading equipment in accordance with ASTM C78/C78M.

1.4.3.3 Contractor Quality Control

All sampling and testing is required to be performed by an approved, on-site, independent, commercial laboratory, or for cementitious materials and admixtures, the manufacturer's laboratory.

1.4.3.4 Laboratory Inspection

The Government will inspect all laboratories requiring validation for equipment and test procedures prior to the start of any concreting operations for conformance to ASTM C1077. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. The laboratory is to maintain this certification for the duration of the project.

1.4.4 Preconstruction Testing of Materials

All sampling and testing is required to be performed. Use an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. Materials are not allowed to be used until notice of acceptance has been given. Additional payment or extension of time due to failure of any material to meet project requirements, or for any additional sampling or testing required is not allowed. Additional tests may be performed by the Government; such Government testing does not relieve any required testing responsibilities.

1.4.4.1 Aggregates

Sample aggregates in the presence of a Government Representative. Obtain samples in accordance with ASTM D75/D75M and be representative of the materials to be used for the project. Perform all aggregate tests no earlier than 120 days prior to test section.

1.4.4.2 Chemical Admixtures, Curing Compounds and Epoxies

At least 30 days before the material is used, submit certified copies of test results for the specific lots or batches to be used on the project. Provide test results less than 6 months old prior to use in the work. Retest chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing, and rejected if test results do not meet manufacturer requirements.

1.4.4.3 Cementitious Materials

Cement, slag cement, and pozzolan will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the specification under which it is provided. Provide mill test reports no more than 1 month old, prior to use in the work. Do not use cementitious materials until notice of acceptance has been given. Cementitious materials may be subjected to testing by the Government from samples obtained at the mill, at transfer points, or at the project site. If tests prove that a cementitious material that has been delivered is unsatisfactory, promptly remove it from the project site. Retest cementitious material that has not been used within 6 months after testing, and reject if test results do not meet manufacturer requirements.

1.4.5 Testing During Construction

During construction, sample and test aggregates, cementitious materials, and concrete as specified herein. The Government will sample and test concrete and ingredient materials as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Testing by the Government does not relieve the specified testing requirements.

1.4.6 Test Section

Operate and calibrate the mixing plant prior to start of placing the test sections. Do not construct the test sections prior to receiving approval for uniformity testing. Construct the pilot lane and fill-in lane test sections on two separate days using the projects approved mixture proportions. Construct test sections with the same pavement section and placement width proposed for production paving. The underlying grade or pavement structure upon which the test sections are to be constructed is required to be the same as the remainder of the course represented by the test sections. Perform variations in mixture proportions, other than water, if directed. Use the same equipment, materials, and construction techniques on the test sections proposed for use in all subsequent work. Perform base course preparation, concrete production, placing, consolidating, texturing, curing, construction of joints, and all testing in accordance with applicable provisions of this specification. Three days after completion of the test sections, provide and evaluate eight cores with a minimum diameter of 6 inches by full depth cut from points selected in the test sections by the Government. Construct the test sections meeting all specification requirements and being acceptable in all aspects, including plastic and hardened concrete properties, surface texture, thickness, grade, and longitudinal and transverse joint alignment. Failure to construct an acceptable test section necessitates construction of additional test sections at no additional cost to the Government. Do not commence production paving until the results on aggregates and concrete, including evaluation of cores, and all pavement measurements for edge slump, joint face deformation, actual plan grade, surface smoothness and thickness have been submitted and approved. Remove test sections which do not meet specification requirements at no expense to the Government. If slipform paving is performed and is unable to construct an acceptable test section, repair or replace the slipform paving equipment, or paving completed using fixed-forms and equipment compatible with them and allowed by the specification. Use the test sections to develop and demonstrate the proposed techniques of mixing, hauling, placing, consolidating, finishing, texturing, curing, initial saw cutting, start-up procedures, sampling, testing methods, plant operations, and the preparation of the construction joints for production paving.

1.4.6.1 Pilot Lane

Up to 10 days, but not more than 60 days, prior to construction of the concrete pavement, construct a test section as part of the production paving area at an outer edge as indicated on the drawings. Construct the test section consisting of one paving lane at least 400 feet long and to the same thickness as the thickest portion of pavement shown on the Drawings. Construct at the same lane width as that required for use in the project. If keyed or doweled longitudinal construction joints are required in any of the production pavements, install them full length along one side of the test lane throughout the test section. If both keys and dowels are required, install each in half of the test section.

1.4.6.2 Fill-In Lane

A fill-in lane is defined as full width concrete placement using two adjacent existing lanes as forms. Consider the first 400 feet of the initial production fill-in lane as a fill-in lane test section for purposes of testing and evaluation. All requirements for the test section are applicable. Obtain cores from the fill-in lane side of the longitudinal construction joint with the pilot lane.

1.4.7 Acceptability of Work

The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests to validate the results of the production testing. If the results of the production testing vary by less than 2.0 percent of the Government's test results, the results of the production testing will be used. If the results of the Government and production tests vary by 2.0 percent, but less than 4.0 percent, the average of the two will be considered the value to be used. If these vary by 4.0 percent or more, carefully evaluate each sampling and testing procedure and obtain another series of Government and production tests on duplicate samples of material. If these vary by 4.0 percent or more, use the results of the tests made by the Government and the Government will continue check testing of this item on a continuous basis until the two sets of tests agree within less than 4.0 percent on a regular basis. Testing performed by the Government does not relieve the specified testing requirements.

1.4.8 Acceptance Requirements

1.4.8.1 Pavement Lots

A lot is that quantity of construction to be evaluated for acceptance with specification requirements. A lot is equal to one shift of production not to exceed 1000 cubic yards. In order to evaluate thickness, divide each lot into four equal sublots. A sublot is equal to one shift of production not to exceed 250 cubic yards. Grade determinations will be made on the lot as a whole. Surface smoothness determinations will be made on every 0.1 mile segment in each lot. Select sample locations on a random basis in accordance with ASTM D3665. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, use the following procedure to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they constitute a lot. Where one or two sublots have been completed, incorporate them into the next lot (except for the last lot), and the total number of sublots used and acceptance criteria adjusted accordingly.

1.4.8.2 Evaluation

Provide all sampling and testing required for acceptance and payment adjustment, including batch tickets with all required acceptance testing. Individuals performing sampling, testing and inspection duties are required to meet the Qualifications. The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. Testing in these areas are in addition to the sublot or lot testing, and the requirements for these areas are the same as those for a sublot or lot. Provide facilities for and, where directed, personnel to assist in obtaining samples for any Government testing.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Bulk Cementitious Materials

Provide all cementitious materials in bulk at a temperature, as delivered to storage at the site, not exceeding 150 degrees F. Provide sufficient cementitious materials in storage to sustain continuous operation of the concrete mixing plant while the pavement is being placed. Provide separate facilities to prevent any intermixing during unloading, transporting, storing, and handling of each type of cementitious material.

1.5.2 Aggregate Materials

Store aggregate at the site of the batching and mixing plant avoiding breakage, segregation, intermixing or contamination by foreign materials. Store each size of aggregate from each source separately in free-draining stockpiles. Provide a minimum 24 inch thick sacrificial layer left undisturbed for each aggregate stored on ground. Provide free-draining storage for fine aggregate and the smallest size coarse aggregate for at least 24 hours immediately prior to use. Maintain sufficient aggregate at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time concrete pavement is being placed. Do not allow tracked equipment on coarse aggregate stockpiles.

1.5.3 Other Materials

Store reinforcing bars and accessories above the ground on supports. Store all materials to avoid contamination and deterioration.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of concrete pavement. However, where the construction covered herein interfaces with other sections, construct each interface to conform to the requirements of both this section and the other section, including tolerances for both.

2.1.1 Surface Smoothness

Use the profilograph method for all longitudinal testing, except for paving lanes less than 200 feet in length. Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 200 feet, within 200 feet on both the approach and departure sides of an aircraft arresting gear, and at the ends of the paving limits for the project. Smoothness requirements do not apply over crowns, drainage structures, or similar penetration. Maintain detailed notes of the testing results and provide a copy to the Government after each day's testing.

2.1.1.1 Straightedge Testing

Provide the finished surfaces of the pavements with no abrupt change of 1/4 inch or more, and all pavements within the limits specified when checked with an approved 12 foot straightedge. Provide runways and taxiways with a variation from the specified straight edge not greater than 1/8 inch in the longitudinal direction and not greater than 1/4 inch in the transverse direction. Provide runway pavement within 200 feet on both the approach and departure sides of an aircraft arresting gear with a variation in the longitudinal direction from the specified straightedge not more than plus or minus 1/8 inch. Provide all other airfield areas with a variation from a straight edge not greater than 1/4 inch in either the longitudinal or transverse direction. Provide roads, streets, tank hardstands, vehicular parking areas, and open storage areas with a variation from the specified straight edge not greater than 1/4 inch in either the longitudinal or transverse direction.

2.1.1.2 Profilograph Testing

Provide the finished surfaces of the pavements with no abrupt change of 1/4 inch or more, and each 0.1 mile segment of each pavement lot with a Profile Index not greater than specified when tested with an approved California-type profilograph. Provide runways and taxiways with a Profile index not greater than 7 inches per mile in the longitudinal direction. Provide runway and taxiway transverse smoothness measured with the straightedge method and the straightedge requirements apply. Provide all other airfield areas with a Profile Index not greater than 9 inches per mile in the longitudinal direction. Provide roads, streets, tank hardstands, vehicular parking areas and open storage areas with a Profile index not greater than 9 inches per mile in the longitudinal direction.

2.1.1.3 Bumps ("Must Grind" Areas)

Reduce any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height by diamond grinding in accordance with subparagraph DIAMOND GRINDING OF PCC SURFACES below until they do not exceed 0.3 inch when retested. Taper such diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding.

2.1.1.4 Testing Method

After the concrete has hardened sufficiently to permit walking thereon, but not later than 48 hours after placement, test the entire surface of the pavement in each lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. If any pavement areas are diamond ground, retest these areas immediately after diamond grinding. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines 15 feet or less apart, as directed. Perform the longitudinal lines at the centerline of each paving lane shown on the drawings, regardless of whether multiple lanes are allowed to be paved at the same time, and at the 1/8th point in from each side of the lane. Also test other areas having obvious deviations. Perform longitudinal testing lines continuous across all joints. Perform transverse testing lines for pilot lanes carried to construction joint lines and for fill-in lanes carried 24 inches across construction joints, and the readings in this area applied to the fill-in lane. Perform straightedge testing of the longitudinal edges of slipformed pilot lanes before paving fill-in lanes as specified below.

2.1.1.4.1 Straightedge Testing

Hold the straightedge in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Determine measurements along the entire length of the straight edge.

2.1.1.4.2 Profilograph Testing

Perform profilograph testing using approved California profilograph and procedures described in ASTM E1274. Utilize electronic recording and automatic computerized reduction of data equipment to indicate "must-grind" bumps and the Profile Index for each 0.1 mile segment of the pavement lot. Accommodate grade breaks on aprons parking lots by breaking the profile segment into short sections and repositioning the blanking band on each section. Provide the "blanking band" of 0.2 inch wide and the "bump template" span 1 inch with an offset of 0.4 inch. Count the profilograph testing of the last 30 feet of a paving lane in the longitudinal direction from each day's paving operation on the following day's continuation lane. Compute the profile index for each pass of the profilograph (3 per lane) in each 0.1 mile segment. The profile index for each segment is the average of the profile indices for each pass in each segment. Scale and proportion profilographs of unequal lengths to an equivalent 0.1 mile as outlined in the ASTM E1274. Provide a copy of the reduced tapes to the Government at the end of each day's testing.

2.1.2 Edge Slump and Joint Face Deformation

2.1.2.1 Edge Slump

When slip-form paving is used, provide a maximum of 15.0 percent of the total free edge of each pavement panel with a maximum edge slump of 1/4 inch and none of the free edge of the pavement lot with an edge slump exceeding

3/8 inch. (A pavement panel is defined as a lane width by the length between two adjacent transverse contraction joints. The total free edge of the pavement is the cumulative total linear measurement of pavement panel edge originally constructed as non-adjacent to any existing pavement; for example, 100 feet of pilot lane originally constructed as a separate lane, would have 200 feet of free edge; 100 feet of fill-in lane would have no free edge.) The area affected by the downward movement of the concrete along the pavement edge is a maximum of 18 inches back from the edge.

2.1.2.2 Joint Face Deformation

In addition to the edge slump limits specified above, provide a vertical joint face with a surface within the maximum limits shown below:

Offset from Straightedge Applied Longitudinally to Pavement Surface (a)	Offset from Straightedge Applied Longitudinally to Vertical Face (b)	Offset from Straightedge Applied Top to Bottom Against the Joint Face (c)	Abrupt Offset in Any Direction (d)	Offset of Joint Face from True Vertical (e)
Airfield Pavement				
1/8 inch	1/4 inch	3/8 inch	1/8 inch	1 inch per 12 inches
All Other Pavement				
1/4 inch	All other items same as airfield pavement			
(a) Measurement is taken by placing the straightedge longitudinally on the pavement surface 1 inch from the free edge.				
(b) Measurement is taken by applying the straightedge longitudinally along the vertical joint face.				
(c) Measurement places a 3/8 inch spacer attached to a straightedge and spaced approximately equal to the thickness of the concrete being measured. The offset from straightedge with spacers is measured by placing the spacers against the top and bottom of the vertical concrete face.				
(d) An abrupt offset in the joint face occurring along a short distance. Check for abrupt offsets at any location that an abrupt offset appears to be a possible issue.				
(e) Measurement of the offset from the joint face to a level in the true vertical position against the joint face.				

2.1.2.3 Slump Determination

Test the pavement surface to determine edge slump immediately after the concrete has hardened sufficiently to permit walking thereon. Perform testing with a minimum 12 foot straightedge to reveal irregularities exceeding the edge slump tolerance specified above. Determine the vertical edge slump at each free edge of each slipformed paving lane constructed. Place the straightedge transverse to the direction of paving and the end of the straightedge located at the edge of the paving lane. Record measurements at 5 to 10 foot spacings, as directed, commencing at the header where paving was started. Initially record measurements at 5 foot intervals in each lane. When no deficiencies are present after 5 measurements, the interval may be increased. The maximum interval is 10 feet. When any deficiencies exist, return the interval to 5 feet. In addition to the transverse edge slump determination above, at the same time, record the longitudinal surface smoothness of the joint on a continuous line 1 inch back from the joint line using the 12 foot straightedge advanced one-half its length for each reading. Perform other tests of the exposed joint face to ensure that a uniform, true vertical joint face is attained. Properly reference all recorded measurements in accordance with paving lane identification and stationing, and a report submitted within 24 hours after measurement is made. Identify areas requiring replacement within the report.

2.1.2.4 Excessive Edge Slump

When edge slump exceeding the limits specified above is encountered on either side of the paving lane, record additional straightedge measurements to define the linear limits of the excessive slump. Remove and replace concrete slabs having excessive edge slump or joint deformation to the next transverse joint in conformance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Discontinue use of slip-form paving equipment and procedures that fail to consistently provide edges within the specified tolerances on edge slump and joint face deformation construct by means of standard paving procedures using fixed forms.

2.1.3 Plan Grade

Within 5 days after paving of each lot, test the finished surface of the pavement area by running lines of levels at intervals corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. Record the results of this survey and provide a copy to the Government at the completion of the survey of each lot. Provide finished surfaces of all airfield pavements that vary less than 1/2 inch above or below the plan grade line or elevation indicated. The above deviations from the approved grade line and elevation are not permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenant structures. Provide finished surfaces of new abutting pavements that coincide at their juncture. Provide horizontal control of the finished surfaces of all airfield pavements that vary not more than 1/2 inch from the plan alignment indicated.

2.1.4 Flexural Strength

Submit certified copies of laboratory test reports and sources for cement, supplementary cementitious materials (SCM), aggregates, admixtures, curing compound, epoxy, and proprietary patching materials proposed for use on this project. Each lot of pavement will be evaluated for acceptance in accordance with the following procedures.

2.1.4.1 Sampling and Testing

For acceptance, obtain one composite sample of concrete from each sublot in accordance with ASTM C172/C172M from one batch or truckload. Fabricate and cure test cylinders 6 x 12 inches in accordance with ASTM C31/C31M, and tested in accordance with ASTM C39/C39M. Test two test cylinders per sublot (8 per lot) at 14 days.

2.1.4.2 Computations

Average the eight 14-day strength tests for the lot. Use the average strength in accordance with paragraph CONCRETE STRENGTH FOR FINAL ACCEPTANCE in PART 2.

2.1.5 Thickness

Each lot of pavement will be evaluated for acceptance and payment adjustment in accordance with the following procedure. Drill two cores, between 4 and 6 inches in diameter, from the pavement, per sublot (8 per lot). Drill the cores within 3 days after lot placement, filling the core holes with an approved non-shrink concrete, respraying the cored areas with curing compound, and for measuring the cores. Provide the results with the thickness measurement data. Record eight measurements of thickness around the circumference of each core and one in the center, in accordance with ASTM C174/C174M. Average the pavement thickness from the 8 cores for the lot and evaluate as described in paragraph PAYMENT ADJUSTMENT FOR THICKNESS above.

2.1.6 Evaluation of Cores

Record and submit testing, inspection, and evaluation of each core for mortar-rich surface, uniformity of aggregate distribution, segregation, voids, cracks, and depth of reinforcement or dowel (if present). Moisten the core with water to visibly expose the aggregate and take a minimum of three photographs of the sides of the cores entire length, rotating the core approximately 120 degrees between photographs. Include a ruler for scale in the photographs that does not obscure the core. Provide plan view of location for each core.

2.1.7 Diamond Grinding of PCC Surfaces

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of airfield pavements. In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the hardened concrete with an approved equipment after the concrete is at a minimum age of 14 days. Perform diamond grinding by sawing with an industrial diamond abrasive which is impregnated in the saw blades. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the concrete pavement or joint faces. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 55 to 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 ft wide. Diamond grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints is not permitted. The maximum area corrected by diamond grinding the surface of the hardened concrete is 10 percent of the total area of any sublot. The maximum depth of diamond grinding is 1/4 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above in conformance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Retexture pavement areas given a wire comb or tined texture, areas exceeding 25 square feet that have been corrected by diamond grinding by transverse grooving using an approved grooving machine of standard manufacture. Provide grooves that are 1/4 inch deep by 1/4 inch wide on 1-1/2 inch centers and carried into, and tapered to zero depth within the non-corrected surface, or match any existing grooves in the adjacent pavement. All areas in which diamond grinding has been performed are subject to the thickness tolerances specified in paragraph THICKNESS, above.

Prior to production diamond grinding operations, perform a test section at the approved location. Perform a test section that consists of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish, transition between adjacent passes, and the results of crossing a transverse joint. Production diamond grinding operations are not to be performed prior to approval.

2.2 CEMENTITIOUS MATERIALS

Provide cementitious materials consisting of portland cement, or portland cement in combination with supplementary cementitious materials (SCM), that conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.2.1 Portland Cement

Provide portland cement conforming to ASTM C150/C150M, Type , low alkali .

2.2.2 Blended Cements

Provide blended cement conforms to ASTM C595/C595M, Type IP or IS, including the optional requirement for mortar expansion and sulfate soundness. Provide pozzolan added to the Type IP blend consisting of ASTM C618 Class F or Class N and that is interground with the cement clinker. Include in written statement from the manufacturer that the amount of pozzolan in the finished cement does not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of mineral admixture used in the blend are not allowed to change from that submitted for the aggregate evaluation and mixture proportioning. The requirements of Table 2 in paragraph SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM) CONTENT do not apply to the SCM content of blended cement.

2.2.3 Pozzolan

2.2.3.1 Fly Ash

Provide fly ash that conforms to ASTM C618, Class F, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction with a loss on ignition not exceeding 3 percent. Provide Class F fly ash for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 3 percent.

2.2.3.2 Raw or Calcined Natural Pozzolan

Provide natural pozzolan that is raw or calcined and conforms to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction with a loss on ignition not exceeding 3 percent. Provide Class N pozzolan for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 3 percent.

2.2.3.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Provide Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) that conforms to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age of at least 95 percent of the control specimens.

b. The average particle size not exceeding 6 microns.

2.2.4 Slag Cement

Provide slag cement (ground-granulated blast-furnace slag) that conforms to ASTM C989/C989M, Grade 100 or Grade 120.

2.2.5 Supplementary Cementitious Materials (SCM) Content

Use of one of the SCMs listed below is optional, unless the SCM is required to mitigate ASR. The use of SCMs is encouraged in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING.

2.3 AGGREGATES

Provide aggregates meeting the requirements of this specification. If aggregate sources in the project area do not meet the requirements of this specification, provide aggregates from sources outside the project area.

2.3.1 Aggregate Sources

2.3.1.1 Durability of Coarse Aggregate

Provide aggregate with a satisfactory service record in freezing and thawing of at least 5 years successful service in three concrete paving projects. Include a condition survey of the existing concrete and a review of the concrete-making materials, including coarse aggregates, cement, and mineral admixtures in the service record. Consider the previous aggregate source and test results, cement mill certificate data, mineral admixture chemical and physical composition, and the mix design (cement factor and water-cementitious material ratio) in the review. Provide service record performed by an independent third party professional engineer, petrographer, or concrete materials engineer along with their resume. Include photographs and a written report addressing D-cracks and popouts in accordance with ACI 201.1R in the service record. Provide coarse aggregate with a durability factor of 80 or more when subjected to freezing and thawing of specimens prepared in accordance with ASTM C1646/C1646M and tested in accordance with ASTM C666/C666M, Procedure A, when a coarse aggregate size group or source proposed for use does not have a satisfactory demonstrable service record. Test all coarse aggregate size groups and sources proposed for use individually. Evaluate and test all fine and coarse aggregates to be used in all concrete for durability in accordance with ASTM C88. Provide fine and coarse aggregates with a maximum of 18 percent loss when subjected to 5 cycles using Magnesium Sulfate or a maximum of 12 percent loss when subjected to 5 cycles if Sodium Sulfate is used.

2.3.1.2 Alkali-Silica Reactivity

Evaluate and test fine and coarse aggregates to be used in all concrete for alkali-aggregate reactivity. Test all size groups and sources proposed for use.

a. Evaluate the fine and coarse aggregates separately, using ASTM C1260. Reject individual aggregates with test results that indicate an expansion of greater than 0.08 percent after 28 days of immersion in 1N NaOH solution, or perform additional testing as follows: utilize the proposed low alkali portland cement, blended cement, and SCM, or Lithium Nitrate in combination with each individual aggregate. If only SCMs are being evaluated, test in accordance with ASTM C1567. If Lithium Nitrate is being evaluated, with or without SCMs, test in accordance with COE CRD-C 662. Determine the quantity that meets all the requirements of these specifications and that lowers the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Base the mixture proportioning on the highest percentage of SCM required to mitigate ASR-reactivity.

b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing for evaluation and acceptance.

2.3.1.3 Combined Aggregate Gradation

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, provide the combined aggregate grading meeting the following requirements:

a. Provide materials selected and the proportions used such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point and its associated production tolerance thus determined falls within the parallelogram described therein. Refer to AF ETL 97-5 for combined aggregate plot area recommendations for the intended placement technique(s).

b. Determine the Coarseness Factor (CF) from the following equation:

$$CF = \frac{\text{(cumulative percent retained on the 3/8 inch sieve)(100)}}{\text{(cumulative percent retained on the No. 8 sieve)}}$$

c. The Workability Factor (WF) is defined as the percent passing the No. 8 sieve based on the combined aggregate gradation. Adjust the WF, prorated upwards only, by 2.5 percentage points for each 94 pounds per cubic yard of cementitious material greater than 564 pounds per cubic yard.

d. Plot a diagram using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram, plot a parallelogram with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, revise the grading of each size of aggregate used and the proportions selected as necessary.

e. Plot the associated production tolerance limits, identified in Table 6, around the CF and adjusted WF point.

2.3.2 Coarse Aggregate

2.3.2.1 Material Composition

Provide coarse aggregate consisting of crushed or uncrushed gravel, crushed stone, or a combination thereof. Provide aggregate used for paving compass calibration hardstands free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone. Provide aggregates, as delivered to the mixers, consisting of clean, hard, uncoated particles meeting the requirements of ASTM C33/C33M except as specified herein. Provide coarse aggregate that has been washed sufficient to remove dust and other coatings. . Provide coarse aggregate with no more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131/C131M. Provide coarse aggregates with a maximum sodium sulfate soundness loss of 12 percent, or with a magnesium sulfate soundness loss of 18 percent after five cycles when tested in accordance with ASTM C88.

2.3.2.2 Particle Shape Characteristics

Provide particles of the coarse aggregate that are generally spherical or cubical in shape. The quantity of flat particles and elongated particles in any size group coarser than the 3/8 inch sieve are not allowed to exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle Test of ASTM D4791, Method A. A flat particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.

2.3.2.3 Size and Grading

Provide coarse aggregate with a nominal maximum size of 1.5 inches with a minimum of 10 percent retained on the 1.0 inch sieve of the proposed combined aggregate gradation. Grade and provide the coarse aggregates in a minimum of two size groups meeting the individual grading requirements of ASTM C33/C33M, Size No. 4 (1.5 to 0.75 inch) and Size No. 67 (0.75 inch to No. 4) to meet the criteria of paragraph COMBINED AGGREGATE GRADATION. A third coarse aggregate size group may be required to meet the criteria of paragraph COMBINED AGGREGATE GRADATION.

2.3.2.4 Deleterious Materials - Airfield Pavements

The amount of deleterious material in each size group of coarse aggregate is not allowed to exceed the limits shown in Table 5 below, determined in accordance with the test methods shown.

TABLE 5		
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS		
Percentage by Mass		
Materials (h)	Severe Weather	Moderate Weather
Clay lumps and friable particles (ASTM C142/C142M)	0.2	0.2

TABLE 5		
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS		
Percentage by Mass		
Materials (h)	Severe Weather	Moderate Weather
Shale (a) (ASTM C295/C295M)	0.1	0.2
Material finer than No. 200 sieve (b) (ASTM C117)	0.5	0.5
Lightweight particles (c) (ASTM C123/C123M)	0.2	0.2
Clay ironstone (d) (ASTM C295/C295M)	0.1	0.5
Chert, cherty stone, and other aggregates (less than 2.40 Sp. Gr.) (e) (ASTM C123/C123M and ASTM C295/C295M)	0.1	0.5
Claystone, mudstone, and siltstone (f) (ASTM C295/C295M)	0.1	0.1
Shaly and argillaceous limestone (g) (ASTM C295/C295M)	0.2	0.2
Other soft particles (COE CRD-C 130)	1.0	1.0
Total of all deleterious substances exclusive of material finer than No. 200 sieve	1.0	2.0
(a) Shale is defined as a fine-grained, thinly laminated or fissile sedimentary rock. It is commonly composed of clay or silt or both. It has been indurated by compaction or by cementation, but not so much as to have become slate.		
(b) Limit for material finer than No. 200 sieve is allowed to be increased to 1.5 percent for crushed aggregates if the fine material consists of crusher dust that is essentially free from clay or shale. Use XRD or other appropriate techniques as determined by petrographer to quantify amount and justify increase.		
(c) Test with a separation medium with a density of Sp. Gr. of 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.		
(d) Clay ironstone is defined as an impure variety of iron carbonate, iron oxide, hydrous iron oxide, or combinations thereof, commonly mixed with clay, silt, or sand. It commonly occurs as dull, earthy particles, homogeneous concretionary masses, or hard-shell particles with soft interiors. Other names commonly used for clay ironstone are "chocolate bars" and limonite concretions.		

TABLE 5		
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS		
Percentage by Mass		
Materials (h)	Severe Weather	Moderate Weather
(e) Chert is defined as a rock composed of quartz, chalcedony or opal, or any mixture of these forms of silica. It is variable in color. The texture is so fine that the individual mineral grains are too small to be distinguished by the unaided eye. Its hardness is such that it scratches glass but is not scratched by a knife blade. It may contain impurities such as clay, carbonates, iron oxides, and other minerals. Cherty stone is defined as any type of rock (generally limestone) that contains chert as lenses and nodules, or irregular masses partially or completely replacing the original stone. Other aggregates consist of obsidian, ash tuff, and palygorskite.		
(f) Claystone, mudstone, or siltstone, is defined as a massive fine-grained sedimentary rock that consists predominantly of indurated clay or silt without laminations or fissility. It may be indurated either by compaction or by cementation.		
(g) Shaly limestone is defined as limestone in which shale occurs as one or more thin beds or laminae. These laminae may be regular or very irregular and may be spaced from a few inches down to minute fractions of an inch. Argillaceous limestone is defined as a limestone in which clay minerals occur disseminated in the stone in the amount of 10 to 50 percent by weight of the rock; when these make up from 50 to 90 percent, the rock is known as calcareous (or dolomitic) shale (or claystone, mudstone, or siltstone).		
(h) Perform testing in accordance with the referenced test methods, except use the minimum sample size specified below.		

2.3.2.5 Testing Sequence for Deleterious Materials in Coarse Aggregate - Airfields Only

No extension of time or additional payment due to any delays caused by the testing, evaluation, or personnel requirements is allowed. The minimum test sample size of the coarse aggregate is 200 pounds for the 3/4 inch and larger maximum size and 25 pounds for the No. 4 to 3/4 inch coarse aggregate. Provide facilities for the ready procurement of representative test samples. The testing procedure on each sample of coarse aggregate for compliance with limits on deleterious materials is as follows:

Step 1: Wash each full sample of coarse aggregate for material finer than the No. 200 sieve. Discard material finer than the No. 200 sieve.

Step 2: Test remaining full sample for clay lumps and friable particles and remove.

Step 3. Test remaining full sample for chert and cherty stone with SSD density of less than 2.40 specific gravity. Remove lightweight chert and cherty stone. Retain other materials less than 2.40 specific gravity for Step 4.

Step 4: Test the materials less than 2.40 specific gravity from Step 3 for lightweight particles (Sp. GR. 2.0) and remove. Restore other materials less than 2.40 specific gravity to the sample.

Step 5: Test remaining sample for clay-ironstone, shale, claystone, mudstone, siltstone, shaly and argillaceous limestone, and remove.

Step 6: Test a minimum of one-fifth of remaining full sample for other soft particles.

2.3.2.6 Deleterious Material - Road Pavements

The amount of deleterious material in each size group of coarse aggregate is not to exceed the limits in the following table when tested as indicated.

LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR ROAD PAVEMENTS	
Percentage by Mass	
Clay lumps and friable particles (ASTM C142/C142M)	2.0
Material finer than No. 200 sieve (ASTM C117)	1.0
Lightweight particles (ASTM C123/C123M)	1.0
Other soft particles (COE CRD-C 130)	2.0
Total of all deleterious substances, exclusive of material finer than No. 200 sieve	5.0

The limit for material finer than the No. 200 sieve is allowed to be increased to 1.5 percent for crushed aggregates consisting of crusher dust that is essentially free from clay or shale. Use a separation medium for lightweight particles with a density of 2.0 specific gravity. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

2.3.3 Fine Aggregate

2.3.3.1 Composition

Provide fine aggregate consisting of natural sand, manufactured sand, or a combination of the two, and composed of clean, hard, durable particles meeting the requirements of ASTM C33/C33M. Provide aggregate used for paving compass calibration hardstands free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone. Stockpile and batch each type of fine aggregate separately. Provide fine aggregate with particles that are generally spherical or cubical in shape.

2.3.3.2 Grading

Provide fine aggregate, as delivered to the mixer, with a grading that conforms to the requirements of ASTM C33/C33M and having a fineness modulus of not less than 2.50 nor more than 3.40.

2.3.3.3 Deleterious Material

The minimum test sample size for fine aggregate proposed for use in airfield paving is 10 pounds. The amount of deleterious material in the fine aggregate is not to exceed the following limits by mass when performed on the full sample:

Material	Percentage by Mass
Clay lumps and friable particles ASTM C142/C142M	1.0
Material finer than No. 200 sieve ASTM C117	3.0
Lightweight particles ASTM C123/C123M using a medium with a density of Sp. Gr. of 2.0	0.5
Total of all above	3.0

2.4 CHEMICAL ADMIXTURES

2.4.1 General Requirements

Chemical admixtures may only be used when the specific admixture type and manufacturer is the same material used in the mixture proportioning studies. Provide air-entraining admixture conforming to ASTM C260/C260M. An accelerating admixture conforming to ASTM C494/C494M, Type C, may be used only when specified in paragraph MIXTURE PROPORTIONS below provided it is not used to reduce the amount of cementitious material. Calcium chloride and admixtures containing calcium chloride are not allowed. Provide retarding or water-reducing admixture that meet the requirements of ASTM C494/C494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived. ASTM C494/C494M, Type F and G high range water reducing admixtures and Type S specific performance admixtures are not allowed. ASTM C1017/C1017M flowable admixtures are not allowed.

2.4.2 Lithium Nitrate

Provide lithium admixture that consists of a nominal 30 percent aqueous solution of Lithium Nitrate, with a density of 10 pounds per gallon, with the approximate chemical form as shown below:

Constituent	Limit (Percent by Mass)
$LiNo_3$ (Lithium Nitrate)	30 plus or minus 0.5
SO_4^{-2} (Sulfate Ion)	0.1 (max)
Cl^- (Chloride Ion)	0.2 (max)
Na^+ (Sodium Ion)	0.1 (max)
K^+ (Potassium Ion)	0.1 (max)

Provide the services of a manufacturer's technical representative experienced in dispensing, mixing, proportioning, placement procedures and curing of concrete containing lithium nitrate, at no expense to the Government. This representative is required to be present on the project prior to and during at least the first two days of placement using lithium nitrate.

2.4.3 High Range Water Reducing Admixture (HRWRA)

Provide a high-range water-reducing admixture that meets the requirements of ASTM C494/C494M, Type F or G, that is free from chlorides, alkalis, and is of the synthesized, sulfonated complex polymer type. Add the HRWRA to the concrete as a single component at the batch plant. Add the admixture to the concrete mixture only when its use is approved or directed, and only when it has been used in mixture proportioning studies to arrive at approved mixture proportions. Submit certified copies of the independent laboratory test results required for compliance with ASTM C494/C494M.

2.5 MEMBRANE FORMING CURING COMPOUND

Provide membrane forming curing compound that conforms to COE CRD-C 300 and is white pigmented. or conforms to ASTM C309, white-pigmented Type 2, Class B.

2.6 WATER

Provide water for mixing and curing that is fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C1602/C1602M.

2.7 JOINT MATERIALS

2.7.1 Expansion Joint Material

Provide preformed expansion joint filler material conforming to ASTM D1751 or ASTM D1752 Type II III. Provide expansion joint filler that is 3/4 inch thick, unless otherwise indicated, and provided in a single full depth piece.

2.7.2 Slip Joint Material

Provide slip joint material that is 1/4 inch thick expansion joint filler, unless otherwise indicated, conforming to paragraph EXPANSION JOINT MATERIAL.

2.8 REINFORCING

Provide reinforcement that is free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties is not allowed to be used.

2.8.1 Reinforcing Bars and Bar Mats

Provide reinforcing bars conforming to ASTM A615/A615M, billet-steel, Grade

60 . Provide bar mats conforming to ASTM A184/A184M. The bar members may be billet rail or axle steel.

2.8.2 Welded Wire Reinforcement

Provide welded wire reinforcement that is deformed or smooth, conforming to ASTM A1064/A1064M, and is provided in flat sheets.

2.9 DOWELS AND TIE BARS

2.9.1 Dowels

Provide dowels in single piece bars fabricated or cut to length at the shop or mill before delivery to the site. Dowels are to be free of loose, flaky rust and loose scale and be clean and straight. Dowels may be sheared to length provided that the deformation from true shape caused by shearing does not exceed 0.04 inch on the diameter of the dowel and does not extend more than 0.04 inch from the end of the dowel. Dowels are required to be plain (non-deformed) steel bars conforming to ASTM A615/A615M, Grade 40 or 60; ASTM A996/A996M, Grade 50 or 60. Dowels are to be epoxy coated in conformance with Type 1 coating requirements of ASTM A1078/A1078M, to include the ends. Provide grout retention rings that are fully circular metal or plastic devices capable of supporting the dowel until the epoxy hardens. Dowel sleeves or inserts are not permitted.

2.9.2 Dowel Bar Assemblies

Provide dowel bar assemblies that consist of a framework of metal bars or wires arranged to provide rigid support for the dowels throughout the paving operation, with a minimum of four continuous bars or wires extending along the joint line. Provide dowels that are welded to the assembly or held firmly by mechanical locking arrangements that prevent them from rising, sliding out, or becoming distorted during paving operations.

2.10 EPOXY RESIN

Provide epoxy-resin materials that consist of two-component materials conforming to the requirements of ASTM C881/C881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials meet the following requirements:

a. Material for use for embedding dowels and anchor bolts be Type IV, Grade 3.

b. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar be Type III, Grade as approved.

c. Material for use for injecting cracks be Type IV, Grade 1.

d. Material for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete be Type V, Grade as approved.

2.11 EQUIPMENT

All plant, equipment, tools, and machines used in the work are required to be maintained in satisfactory working conditions at all times. Submit the following:

a. Details and data on the batching and mixing plant prior to plant assembly including manufacturer's literature showing that the equipment meets all requirements specified herein.

b. Obtain National Ready Mixed Concrete Association (NRMCA) certification of the concrete plant, at no expense to the Government. Provide inspection report of the concrete plant by an engineer approved by the NRMCA. A list of NRMCA approved engineers is available on the NRMCA website at http://www.nrmca.org. Submit a copy of the NRMCA QC Manual Section 3 Concrete Plant Certification Checklist, NRMCA Certificate of Conformance, and Calibration documentation on all measuring and weighing devices prior to uniformity testing.

c. A description of the equipment proposed for transporting concrete mixture from the central mixing plant to the paving equipment.

d. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture. Manufacturer's literature on the paver and finisher, together with the manufacturer's written instructions on adjustments and operating procedures necessary to assure a tight, smooth surface on the concrete pavement. The literature is required to show that the equipment meets all details of these specifications. Include detailed information on automatic laser controlled systems if proposed for use.

2.11.1 Batching and Mixing Plant

2.11.1.1 Location

Locate the batching and mixing plant . Water and electrical power are available on the project site. Provide operable telephonic or radio communication between the plant and the placing site at all times concreting is taking place.

2.11.1.2 Type and Capacity

Provide a batching and mixing plant consisting of a stationary-type central mix plant, including permanent installations and portable or relocatable plants installed on stable foundations. Provide a plant designed and operated to produce concrete within the specified tolerances, with a minimum capacity of 250 cubic yards per hour, that conforms to the requirements of NRMCA QC 3 including provisions addressing:

1. Material Storage and Handling
2. Batching Equipment
3. Central Mixer
4. Ticketing System
5. Delivery System

2.11.1.3 Tolerances

Materials	Percentage of Required Mass
Cementitious Materials	plus or minus 1
Aggregate	plus or minus 2
Water	plus or minus 1

Materials	Percentage of Required Mass
Admixture	plus or minus 3

For volumetric batching equipment for water and admixtures, the above numeric tolerances apply to the required volume of material being batched. Dilute concentrated admixtures uniformly, if necessary, to provide sufficient volume per batch to ensure that the batchers consistently operate within the above tolerance.

2.11.1.4 Moisture Control

Provide a plant capable of ready adjustment to compensate for the varying moisture contents of the aggregates and to change the quantities of the materials being batched. Provide an electric moisture meter complying with the provisions of COE CRD-C 143 for measuring of moisture in the fine aggregate. Provide a sensing element arranged so that measurement is made near the batcher charging gate of the fine aggregate bin or in the fine aggregate batcher.

2.11.2 Concrete Mixers

Provide stationary or truck mixers that are capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. Do not charge the mixers in excess of the capacity recommended by the manufacturer. Operate the mixers at the drum or mixing blade speed designated by the manufacturer. Maintain the mixers in satisfactory operating condition, with the mixer drums kept free of hardened concrete. Replace mixer blades or paddles when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades or paddles.

2.11.2.1 Stationary

Stationary mixers are required to be drum or pan mixers. Provide mixers with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed.

2.11.2.2 Mixing Time and Uniformity for Stationary Mixers

Use the projects approved mixture proportions for uniformity testing. For stationary mixers, before uniformity data are available, the minimum mixing time for each batch after all solid materials are in the mixer, provided that all of the mixing water is introduced before one-fourth of the mixing time has elapsed, is 1 minute for mixers having a capacity of 1 cubic yard. For mixers of greater capacity, increase this minimum time by 20 seconds for each additional 1.33 cubic yard or fraction thereof. After results of uniformity tests are available, the mixing time may be reduced to the minimum time required to meet uniformity requirements; but if uniformity requirements are not being met, increase the mixing time as directed. Perform mixer performance tests at new mixing times immediately after any change in mixing time or volume. For regular testing perform all six tests on three batches of concrete. The range for regular testing is the average of the ranges of the three batches. Conduct the Regular Test sequence for initial determination of the mixing time or as directed. When regular testing is performed, the concrete is required to meet the limits of any five of the six uniformity requirements listed in Table 1 below.

2.11.2.3 Abbreviated Test

Use the projects approved mixture proportions for uniformity testing. Conduct the Abbreviated Test sequence for production concrete verification at the frequency specified in Table 6. When abbreviated testing is performed, the concrete is required to meet only those requirements listed for abbreviated testing. Abbreviated testing consists of performing the three required tests on a single batch of concrete. The range for abbreviated testing is the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, the results of tests on one of the mixers apply to the others, subject to the approval. Perform all mixer performance (uniformity) testing in accordance with COE CRD-C 55 and with paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION in PART 3.

TABLE 1 UNIFORMITY REQUIREMENTS--STATIONARY MIXERS

Parameter	Regular Tests Allowable Maximum Range for Average of 3 Batches	Abbreviated Tests Allowable Maximum Range for 1 Batch
Unit weight of air-free mortar	2.0 pounds per cubic foot	2.0 pounds per cubic foot
Air content	1.0 percent	--
Slump	1.0 inch	1.0 inch
Coarse aggregate	6.0 percent	6.0 percent
Compressive strength at 7 days	10.0 percent	10.0 percent
Water content	1.5 percent	

2.11.2.4 Truck

Truck mixers are not allowed for mixing or transporting slipformed paving concrete. Provide only truck mixers designed for mixing or transporting paving concrete with extra large blading and rear opening specifically for low-slump paving concrete. Provide truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof that conform to the requirements of ASTM C94/C94M. Determine the number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete by uniformity tests as specified in ASTM C94/C94M and in requirements for mixer performance stated in paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION in PART 3. If requirements for the uniformity of concrete are not met with 100 revolutions of mixing after all ingredients including water are in the truck mixer drum, discontinue use of the mixer until the condition is corrected. Water is not allowed to be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Inject water into the head of the mixer (end opposite the discharge opening) drum under pressure, and turn the drum or blades a minimum of 30 additional revolutions at mixing speed. The addition of water to the batch at any later time is not allowed. Perform mixer performance (uniformity) tests for truck mixers in accordance with ASTM C94/C94M.

2.11.3 Transporting Equipment

Transport slipform concrete to the paving site in non-agitating equipment conforming to ASTM C94/C94M or in approved agitators. Transport fixed form concrete in approved truck mixers designed with extra large blading and rear opening specifically for low slump concrete. Provide transporting equipment designed and operated to deliver and discharge the required concrete mixture completely without segregation.

2.11.4 Transfer and Spreading Equipment

Provide equipment for transferring concrete from the transporting equipment to the paving lane in front of the paver that is specially manufactured, self-propelled transfer equipment which accepts the concrete outside the paving lane, transfers, and spreads it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

2.11.5 Paver-Finisher

Provide paver-finisher consisting of a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement, with a minimum weight of 2200 pounds per foot of lane width, and powered by an engine having a minimum 6.0 horsepower per foot of lane width. The paver-finisher is required to spread, consolidate, and shape the plastic concrete to the desired cross section in one pass. The mechanisms for forming the pavement are required to be easily adjustable in width and thickness. In addition to other spreaders required by paragraph above, the paver-finisher equipped with a full width knock-down auger or paddle mechanism, capable of operating in both directions, which evenly spreads the fresh concrete in front of the screed or extrusion plate.

2.11.5.1 Vibrators

Provide gang mounted immersion vibrators at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete, as required. Provide vibrators that are automatically controlled to immediately stop as forward motion of the paver ceases. Equipped the paver-finisher with an electronic vibrator monitoring device displaying the operating frequency of each individual internal vibrator with a readout display visible to the paver operator that operates continuously while paving, and displays all vibrator frequencies with manual or automatic sequencing among all individual vibrators. Discontinue paving if the vibrator monitoring system fails to operate properly during the paving operation. Provide the spacing of the immersion vibrators across the paving lane as necessary to properly consolidate the concrete, with a maximum clear distance between vibrators of 30 inches and outside vibrators a maximum of 12 inches from the lane edge. Determine vibrator frequency and amplitude per COE CRD-C 521.

2.11.5.2 Screed or Extrusion Plate

Equipped the paver-finisher with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface and finish the surface that no significant amount of hand finishing, except use of cutting straightedges, is required. Provide adjustment for variation in lane width or thickness and to prevent more than 8 inches of the screed or extrusion plate extending over previously placed concrete on either end when paving fill-in lanes. Repair or replace machines that cause displacement of properly installed forms or cause ruts or indentations in the prepared underlying materials and machines that cause frequent delays due to mechanical failures as directed.

2.11.5.3 Longitudinal Mechanical Float

A longitudinal mechanical float may be used. If used, provide a float that is specially designed and manufactured to smooth and finish the pavement surface without working excess paste to the surface that is rigidly attached to the rear of the paver-finisher or to a separate self-propelled frame spanning the paving lane. Provide float plate at least 5 feet long by 8 inches wide and automatically be oscillated in the longitudinal direction while slowly moving from edge to edge of the paving lane, with the float plate in contact with the surface at all times.

2.11.5.4 Other Types of Finishing Equipment

Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to approval. Provide bridge deck finishers with a minimum operating weight of 7500 pounds that have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Only use vibrating screeds or pans for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

2.11.5.5 Fixed Forms

Provide paver-finisher equipped with wheels designed to ride the forms, keep it aligned with the forms, and spread the load so as to prevent deformation of the forms. Provide paver-finishers traveling on guide rails located outside the paving lane that are equipped with wheels when traveling on new or existing concrete to remain. Alternatively, a modified slipform paver that straddles the forms may be used. Provide a modified slipform paver which has the side conforming plates removed or rendered ineffective and travels over or along pre-placed fixed forms.

2.11.5.6 Slipform

The slipform paver-finisher is required to be automatically controlled and crawler mounted with padded tracks so as to be completely stable under all operating conditions and provide a finish to the surface and edges so that no edge slump beyond allowable tolerance occurs. Provide suitable moving side forms that are adjustable and produce smooth, even edges, perpendicular to the top surface and meeting specification requirements for alignment and freedom from edge slump.

2.11.6 Curing Equipment

Provide equipment for applying membrane-forming curing compound mounted on a self-propelled frame that spans the paving lane. Constantly agitate the curing compound reservoir mechanically (not air) during operation and provide a means for completely draining the reservoir. Provide a spraying system that consists of a mechanically powered pump which maintains constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to provide uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a speed correlated with the forward movement of the overall frame. Protect all spray nozzles with wind screens. Calibrate the spraying system in accordance with ASTM D2995, Method A, for the rate of application required in paragraph MEMBRANE CURING. Provide hand-operated sprayers allowed by that paragraph with compressed air supplied by a mechanical air compressor. Immediately replace curing equipment if it fails to apply an even coating of compound at the specified rate.

2.11.7 Texturing Equipment

Provide texturing equipment as specified below. Before use, demonstrate the texturing equipment on a test section, and modify the equipment as necessary to produce the texture directed.

2.11.7.1 Burlap Drag

Securely attach a burlap drag to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Provide length of the material between 24 to 36 inches dragging flat on the pavement surface. Provide burlap drag with a width at least equal to the width of the slab. Provide clean, reasonably new burlap material, completely saturated with water before attachment to the frame, always resaturated before start of use, and kept clean and saturated during use. Provide burlap conforming to AASHTO M 182, Class 3 or 4.

2.11.7.2 Broom

Apply surface texture using an approved mechanical stiff bristle broom drag of a type that provides a uniformly scored surface transverse to the pavement center line. Provide broom capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure that results in scores uniform in appearance and approximately 1/16 inch in depth but not more than 1/8 inch in depth.

2.11.7.3 Artificial Turf

Provide full-width artificial turf drag with the leading transverse edge securely fastened to a lightweight pole on a traveling bridge. Provide a minimum of 2 feet of the artificial turf in contact with the concrete surface during texturing operations that results in corrugations uniform in appearance and approximately 1/16 inch in depth. A variety of different types of artificial turf are available and approval of any one type will be done only after it has been demonstrated to provide a satisfactory texture. One type that has provided satisfactory texture consists of 7,200 approximately 0.85-inch-long polyethylene turf blades per square foot.

2.11.7.4 Deep Texturing Equipment

Provide texturing equipment that consists of a stiff bristled broom a comb with spring wire tines spring strips which produce true, even grooves forming a drag at least 4 feet long. Mount this drag in a wheeled frame spanning the paving lane and so constructed that the drag is mechanically pulled in a straight line across the paving lane perpendicular to the centerline.

2.11.8 Sawing Equipment

Provide equipment for sawing joints and for other similar sawing of concrete consisting of standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Provide diamond tipped blades. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to maintain the required sawing rate. Provide wheel saws used in the removal of concrete with large diameter tungsten carbide tipped blades mounted on a heavy-duty chassis which produce a saw kerf at least 1-1/2 inches wide. Provide saws capable of sawing to the full depth required. Early-entry saws may be used, subject to demonstration and approval. No change to the initial sawcut depth is permitted.

2.11.9 Straightedge

Provide and maintain at the job site, in good condition, a minimum 12 foot straightedge for each paving train for testing the hardened portland cement concrete surfaces. Provide straightedges constructed of aluminum or magnesium alloy and blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Provide straightedges with handles for operation on the pavement.

2.11.10 Work Bridge

Provide a self-propelled working bridge capable of spanning the required paving lane width where workmen can efficiently and adequately reach the pavement surface.

2.12 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

2.12.1 Specified Flexural Strength

Specified flexural strength, R, for concrete is 700 psi at 28 days, as determined by equivalent flexural strength, as specified in paragraph MIXTURE PROPORTIONING FOR FLEXURAL STRENGTH below.

2.12.2 Water-Cementitious Materials Ratio

Maximum allowable water-cementitious material ratio is 0.45. The water-cementitious material ratio is the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus SCM by the mass equivalency method described in ACI 211.1.

2.12.3 Air Content

Provide concrete that is air-entrained with a total air content of 4.0 plus or minus 1.5 percentage points, at the point of placement. Determine air content in accordance with ASTM C231/C231M.

2.12.4 Slump

The maximum allowable slump of the concrete at the point of placement is 2 inches for pavement constructed with fixed forms. For slipformed pavement, at the start of the project, select a slump which produces in-place pavement meeting the specified tolerances for control of edge slump. The selected slump is applicable to both pilot and fill-in lanes.

2.12.5 Concrete Temperature

The temperature of the concrete as delivered is required to conform to the requirements of paragraphs PAVING IN HOT WEATHER and PAVING IN COLD WEATHER, in PART 3. Determine the temperature of concrete in accordance with ASTM C1064/C1064M.

2.12.6 Concrete Strength for Final Acceptance

The strength of the concrete will be considered acceptable when the average equivalent 28-day flexural strengths for each lot are above the 'Specified Flexural Strength' as determined by correlation with 14-day compressive strength tests specified in paragraph MIXTURE PROPORTIONING FOR FLEXURAL STRENGTH below, and no individual set (2 specimens per sublot) in the lot are 25 psi or more below the equivalent 'Specified Flexural Strength'. If any lot or sublot, respectively, fails to meet the above criteria, remove and replace the lot or sublot at no additional cost to the Government. This is in addition to and does not replace the average strength required for day-to-day CQC operations as specified in paragraph AVERAGE CQC FLEXURAL STRENGTH REQUIRED FOR MIXTURES, below.

2.13 MIXTURE PROPORTIONS

2.13.1 Composition

Provide concrete composed of cementitious material, water, fine and coarse aggregates, and admixtures. Include supplementary Cementitious Materials (SCM) choice and usage in accordance with paragraph SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM) CONTENT. Provide a minimum total cementitious materials content of 517 pounds per cubic yard. Acceptable admixtures consist of air entraining admixture and may also include, as approved, water-reducing admixture, retarding admixture, accelerating admixture, water-reducing and retarding admixtures, water reducing and accelerating admixtures.

2.13.2 Proportioning Studies

Perform trial design batches, mixture proportioning studies, and testing, at no expense to the Government. Submit for approval the Preliminary Proposed Proportioning to include items a., b., and i. below a minimum of 7 days prior to beginning a mixture proportioning study. Submit the results of the mixture proportioning studies signed and stamped by the registered professional engineer having technical responsibility for the mix design study, and submitted at least 30 days prior to commencing concrete placing operations. Include a statement summarizing the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard basis. Base aggregate quantities on the mass in a saturated surface dry condition. Provide test results demonstrating that the proposed mixture proportions produce concrete of the qualities indicated. Base methodology for trial mixtures having proportions, slumps, and air content suitable for the work as described in ACI 211.1, modified as necessary to accommodate flexural strength. ACI 211.1 can be supplemented with ACI 325.14R. Submit test results including:

a. Coarse and fine aggregate gradations and plots. Include historic gradation averages and standard deviations on individual sieves for each aggregate size group.

b. Combined aggregate gradation and coarseness vs. workability plots.
c. Coarse aggregate quality test results.
d. Fine aggregate quality test results.
e. Mill certificates for cement and supplemental cementitious materials.
f. Certified test results for air entraining, water reducing, retarding, non-chloride accelerating admixtures.
g. Specified flexural strength, slump, and air content.
h. Documentation of required average CQC flexural strength, Ra.
i. Recommended proportions and volumes for proposed mixture and each of three trial water-cementitious materials ratios.
j. Individual beam and cylinder breaks.
k. Flexural and compressive strength summaries and plots.
l. Correlation ratios for acceptance testing and CQC testing.
m. Historical record of ACI 214R strength test results, documenting production standard deviation (if available).
n. Narrative discussing methodology on how the mix design was developed.
o. Alternative aggregate blending to be used during the test section if necessary to meet the required surface and consolidation requirements.

2.13.2.1 Water-Cementitious Materials Ratio

Perform at least three different water-cementitious materials ratios, which produce a range of strength encompassing that required on the project. The maximum allowable water-cementitious material ratio required in paragraph SPECIFIED FLEXURAL STRENGTH, above is the equivalent water-cementitious materials ratio. The maximum water-cementitious materials ratio of the approved mix design becomes the maximum water-cementitious materials ratio for the project, and in no case exceeds 0.45.

2.13.2.2 Trial Mixture Studies

Perform separate sets of trial mixture studies made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either are to be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerating or retarding admixture may be used without separate trial mixture study. Perform separate trial mixture studies for each placing method (slip form, fixed form, or hand placement) proposed. Report the temperature of concrete in each trial batch. Design each mixture to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding. Proportion laboratory trial mixtures for maximum permitted slump and air content.

2.13.2.3 Mixture Proportioning for Flexural Strength

Follow the step by step procedure below:

a. Fabricate all beams and cylinders for each mixture from the same batch or blend of batches. Fabricate and cure all beams and cylinders in accordance with ASTM C192/C192M, using 6 x 6 inches steel beam molds and 6 x 12 inches single-use cylinder molds.

b. Cure test beams from each mixture for 3, 7, 14, 28 and 90-day flexural tests; 6 beams to be tested per age.

c. Cure test cylinders from each mixture for 3, 7, 14, 28 and 90-day compressive strength tests; 6 cylinders to be tested per age.

d. Test beams in accordance with ASTM C78/C78M, cylinders in accordance with ASTM C39/C39M.

e. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:
   3-day flexural strength
   7-day flexural strength
   14-day flexural strength
   28-day flexural strength

   3-day compressive strength
   7-day compressive strength
   14-day compressive strength
   28-day compressive strength

f. From these graphs select a w/c that produces a mixture giving a 28 -day flexural strength equal to the required strength determined in accordance with the next paragraph.

g. Using the above selected w/c, select from the graphs the expected 3, 7, 14, 28 -day flexural strengths and the expected 3, 7, 14, 28 -day compressive strengths for the mixture.

h. From the above expected strengths for the selected mixture determine the following Correlation Ratios:

   (1) Ratio of the 14-day compressive strength of the selected mixture to the 28 -day flexural strength of the mixture (for acceptance).

   (2) Ratio of the 7-day compressive strength of the selected mixture to the 28 -day flexural strength of the mixture (for CQC control).

i. If there is a change in materials, perform additional mixture design studies using the new materials and new Correlation Ratios determined.

j. No concrete pavement placement is allowed until the mixture proportions are approved. The approved water-cementitious materials ratio is restricted to the maximum value specified in the next paragraph and not be increased without written approval.

2.13.3 Average CQC Flexural Strength Required for Mixtures

In order to ensure meeting the strength requirements specified in paragraph SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES above, during production, the mixture proportions selected during mixture proportioning studies and used during construction requires an average CQC flexural strength exceeding the specified strength, R, by the amount indicated below. This required average CQC flexural strength, Ra, is used only for CQC operations as specified in paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION in PART 3 and as specified in the previous paragraph. During production, adjust the required Ra, as appropriate and as approved, based on the standard deviation of average 28 -day strengths being attained during paving.

2.13.3.1 From Previous Test Records

Where a concrete production facility has previous test records current to within 18 months, establish a standard deviation in accordance with the applicable provisions of ACI 214R. Include test records from which a standard deviation is calculated that represent materials, quality control procedures, and conditions similar to those expected, that represent concrete produced to meet a specified flexural strength or strengths within 150 psi of the 28 -day flexural strength specified for the proposed work, and that consist of at least 30 consecutive tests. Perform verification testing to document the current strength. A strength test is the average of the strengths of two specimens made from the same sample of concrete and tested at 28 days. Required average CQC flexural strength, Ra, used as the basis for selection of concrete proportions is the value from the equation that follows, using the standard deviation as determined above:

Ra = R + 1.34S

Where: S = standard deviation
R = specified flexural strength
Ra = required average flexural strength

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, establish a standard deviation as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

2.13.3.2 Without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, determine the required average strength, Ra, by adding 15 percent to the specified flexural strength, R.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Before commencing paving, perform the following. If used, place cleaned, coated, and adequately supported forms. Have any reinforcing steel needed at the paving site; all transporting and transfer equipment ready for use, clean, and free of hardened concrete and foreign material; equipment for spreading, consolidating, screeding, finishing, and texturing concrete at the paving site, clean and in proper working order; and all equipment and material for curing and for protecting concrete from weather or mechanical damage at the paving site, in proper working condition, and in sufficient amount for the entire placement.

3.1.1 Weather Precaution

When windy conditions during paving appear probable, have equipment and material at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.2 Proposed Techniques

Submit placing and protection methods; paving sequence; jointing pattern; data on curing equipment and profilographs; demolition of existing pavements, as specified; pavement diamond grinding equipment and procedures. Submit for approval the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints; transverse and longitudinal dowel bar spacing; and identifying pilot lanes and hand placement areas. Deviations from the jointing pattern shown on the drawings are not allowed without written approval of the design engineer.

c. Plan and equipment proposed to control alignment of sawn joints within the specified tolerances.

d. Data on the curing equipment, media and methods to be used.

e. Data on profilograph and methods to measure pavement smoothness.

f. Pavement demolition work plan, presenting the proposed methods and equipment to remove existing pavement and protect pavement to remain in place.

3.2 CONDITIONING OF UNDERLYING MATERIAL

3.2.1 General Procedures

Verify the underlying material, upon which concrete is to be placed is clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, verify the underlying material is well drained and have been satisfactorily graded by string-line controlled, automated, trimming machine and uniformly compacted in accordance with the applicable Section of these specifications. Test the surface of the underlying material to crown, elevation, and density in advance of setting forms or of concrete placement using slip-form techniques. Trim high areas to proper elevation. Fill and compact low areas to a condition similar to that of surrounding grade, or filled with concrete monolithically with the pavement. Low areas filled with concrete are not to be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Rework and compact any underlying material disturbed by construction operations to specified density immediately in front of the paver. If a slipform paver is used, continue the same underlying material under the paving lane beyond the edge of the lane a sufficient distance that is thoroughly compacted and true to grade to provide a suitable trackline for the slipform paver and firm support for the edge of the paving lane.

3.2.2 Traffic on Underlying Material

After the underlying material has been prepared for concrete placement, equipment is not permitted thereon with exception of the paver. Subject to specific approval, crossing of the prepared underlying material at specified intervals for construction purposes may be permitted, provided rutting or indentations do not occur. Rework and repair the surface before concrete is placed. Equipment may be allowed to operate on the underlying material only if approved and only if no damage is done to the underlying material and its degree of compaction. Correct any disturbance to the underlying material that occurs, as approved, before the paver-finisher or the deposited concrete reaches the location of the disturbance and replace the equipment or change procedures to prevent any future damage.

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. Immediately cover and protect all unhardened concrete from the rain or other damaging weather.

Remove and replace any slab damaged by rain or other weather full depth, by full slab width, to the nearest original joint as specified in paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS below, at no expense to the Government. Rain damaged pavement is pavement with coarse aggregate exposed at the surface. Cores evaluated by a qualified petrographer to contain carbonation to a depth greater than 1/8 inch or Mohs hardness of less than 2 are also considered rain damaged.

3.3.2 Paving in Hot Weather

When the ambient temperature during paving is expected to exceed 90 degrees F, properly place and finish the concrete in accordance with procedures previously submitted, approved, and as specified herein. Provide concrete that does not exceed the temperature shown in the table below when measured in accordance with ASTM C1064/C1064M at the time of delivery. Cooling of the mixing water or aggregates or placing in the cooler part of the day may be required to obtain an adequate placing temperature. Cool steel forms and reinforcing as needed to maintain steel temperatures below 120 degrees F. Cool or protect transporting and placing equipment if necessary to maintain proper concrete placing temperature. Keep the finished surfaces of the newly laid pavement damp by applying a fog spray (mist) with approved spraying equipment until the pavement is covered by the curing medium.

Maximum Allowable Concrete Placing Temperature	
Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature in Degrees F
Greater than 60	90
40-60	85

Maximum Allowable Concrete Placing Temperature	
Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature in Degrees F
Less than 40	80

3.3.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of ACI 305R. In addition to the protective measures specified in the previous paragraph, the concrete placement may be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. Apply monomolecular films after finishing is complete, do not use in the finishing process. Immediately commence curing procedures when such water treatment is stopped. Repair plastic shrinkage cracks in accordance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Never trowel over or fill plastic shrinkage cracks with slurry.

3.3.4 Paving in Cold Weather

Cold weather paving is required to conform to ACI 306R. Use special protection measures, as specified herein, if freezing temperatures are anticipated or occur before the expiration of the specified curing period. Do not begin placement of concrete unless the ambient temperature is at least 35 degrees F and rising. Thereafter, halt placement of concrete whenever the ambient temperature drops below 40 degrees F. When the ambient temperature is less than 50 degrees F, the temperature of the concrete when placed is required to be not less than 50 degrees F nor more than 75 degrees F. Provide heating of the mixing water or aggregates as required to regulate the concrete placing temperature. Materials entering the mixer are required to be free from ice, snow, or frozen lumps. Do not incorporate salt, chemicals or other materials in the concrete to prevent freezing. If allowed under paragraph MIXTURE PROPORTIONS in PART 2, an accelerating admixture may be used when the ambient temperature is below 50 degrees F. Provide covering and other means for maintaining the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period. Remove pavement slabs, full depth by full width, damaged by freezing or falling below freezing temperature to the nearest planned joint, and replace as specified in paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS, at no expense to the Government.

3.4 CONCRETE PRODUCTION

Provide batching, mixing, and transporting equipment with a capacity sufficient to maintain a continuous, uniform forward movement of the paver of not less than 2.5 feet per minute. Deposit concrete transported in non-agitating equipment in front of the paver within 45 minutes from the time cement has been charged into the mixing drum, except that if the ambient temperature is above 90 degrees F, the time is reduced to 30 minutes. Deposit concrete transported in truck mixers in front of the paver within 90 minutes from the time cement has been charged into the mixer drum of the plant or truck mixer. If the ambient temperature is above 90 degrees F, the time is reduced to 60 minutes. Accompany every load of concrete delivered to the paving site with a batch ticket from the operator of the batching plant. Provide batch ticket information required by ASTM C94/C94M on approved forms. In addition provide design quantities in mass or volume for all materials, batching tolerances of all materials, and design and actual water cementitious materials ratio on each batch delivered, the water meter and revolution meter reading on truck mixers and the time of day. Provide batch tickets for each truck delivered as part of the lot acceptance package to the placing foreman to maintain on file and deliver them to the Government weekly.

3.4.1 Batching and Mixing Concrete

Maintain scale pivots and bearings clean and free of rust. Remove any equipment which fails to perform as specified immediately from use until properly repaired and adjusted, or replaced.

3.4.2 Transporting and Transfer - Spreading Operations

Operate non-agitating equipment only on smooth roads and for haul time less than 15 minutes. Deposit concrete as close as possible to its final position in the paving lane. Operate all equipment to discharge and transfer concrete without segregation. Dumping of concrete in discrete piles is not permitted. No transfer or spreading operation which requires the use of front-end loaders, dozers, or similar equipment to distribute the concrete are permitted.

3.5 PAVING

3.5.1 General Requirements

Construct pavement with paving and finishing equipment utilizing rigid fixed forms or by use of slipform paving equipment. Provide paving and finishing equipment and procedures capable of constructing paving lanes of the required width at a rate of at least 2.5 feet of paving lane per minute on a routine basis. Control paving equipment and its operation, and coordinated with all other operations, such that the paver-finisher has a continuous forward movement at a reasonably uniform speed from beginning to end of each paving lane, except for inadvertent equipment breakdown. Backing the paver and refinishing a lane is not permitted. Remove and replace concrete refinished in this manner. Failure to achieve a continuous forward motion requires halting operations, regrouping, and modifying operations to achieve this requirement. Personnel are not permitted to walk or operate in the plastic concrete at any time. Where an open-graded granular base is required under the concrete, select paving equipment and procedures which operate properly on the base course without causing displacement or other damage.

3.5.2 Consolidation

Consolidate concrete with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. Insert vibrators into the concrete to a depth that provides the best full-depth consolidation but not closer to the underlying material than 2 inches. Excessive vibration is not permitted. Discontinue paving operations if vibrators cause visible tracking in the paving lane, until equipment and operations have been modified to prevent it. Vibrate concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Do not use vibrators to transport or spread the concrete. Do not operate hand-operated vibrators in the concrete at one location for more than 20 seconds. Insert hand-operated vibrators between 6 to 15 inches on centers. For each paving train, provide at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) requires the immediate stopping of the paving operation and approved adjustment of the equipment or procedures.

3.5.3 Operation

When the paver approaches a header at the end of a paving lane, maintain a sufficient amount of concrete ahead of the paver to provide a roll of concrete which spills over the header. Provide a sufficient amount of extra concrete to prevent any slurry that is formed and carried along ahead of the paver from being deposited adjacent to the header. Maintain the spud vibrators in front of the paver at the desired depth as close to the header as possible before they are lifted. Provide additional consolidation adjacent to the headers by hand-manipulated vibrators. When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provide provisions to prevent damage to the previously constructed pavement. Electronically control screeds or extrusion plates from the previously placed pavement so as to prevent them from applying pressure to the existing pavement and to prevent abrasion of the pavement surface. Maintain the overlapping area of existing pavement surface completely free of any loose or bonded foreign material as the paver-finisher operates across it. When the paver travels on existing pavement, maintain approved provisions to prevent damage to the existing pavement. Pavers using transversely oscillating screeds are not allowed to form fill-in lanes that have widths less than a full width for which the paver was designed or adjusted.

3.5.4 Required Results

Adjust and operate the paver-finisher, its gang-mounted vibrators and operating procedures coordinated with the concrete mixture being used, to produce a thoroughly consolidated slab throughout that is true to line and grade within specified tolerances. Provide a paver-finishing operation that produces a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities in a single pass across the pavement; multiple passes are not permitted. Provide equipment and its operation that produce a finished surface requiring no hand finishing other than the use of cutting straightedges, except in very infrequent instances. Stop paving if any equipment or operation fails to produce the above results. Prior to recommencing paving, properly adjust or replace the equipment, modify the operation, or modify the mixture proportions, in order to produce the required results. No water, other than fog sprays (mist) as specified in paragraph PREVENTION OF PLASTIC SHRINKAGE CRACKING above, is allowed to be applied to the concrete or the concrete surface during paving and finishing.

3.5.5 Fixed Form Paving

Provide paving equipment for fixed-form paving and the operation that conforms to the requirements of paragraph EQUIPMENT, and all requirements specified herein.

3.5.5.1 Forms for Fixed-Form Paving

a. Provide straight forms made of steel and in sections not less than 10 feet in length that are clean and free of rust or other contaminants. Seal any holes or perforations in forms prior to paving unless otherwise permitted. Maintain forms in place and passable by all equipment necessary to complete the entire paving operation without need to remove horizontal form supports. Provide flexible or curved forms of proper radius for curves of 100-foot radius or less. Provide wood forms for curves and fillets made of well-seasoned, surfaced plank or plywood, straight, and free from warp or bend that have adequate strength and are rigidly braced. Provide forms with a depth equal to the pavement thickness at the edge. Where the project requires several different slab thicknesses, forms may be built up by bolting or welding a tubular metal section or by bolting wood planks to the bottom of the form to completely cover the underside of the base of the form and provide an increase in depth of not more than 25 percent. Provide forms with the base width of the one-piece or built-up form not less than eight-tenths of the vertical height of the form, except provide forms 8 inches or less in vertical height with a base width not less than the vertical height of the form. Provide forms with maximum vertical deviation of top of any side form, including joints, not varying from a true plane more than 1/8 inch in 10 feet, and the upstanding leg not varying more than 1/4 inch. Where keyway forms are required, rigidly attach the keyway form to the main form so no displacement can take place. Tack-weld metal keyway forms to steel forms. Align keyway forms so that there is no variation over 1/4 inch either vertically or horizontally, when tested with a 12 foot template after forms are set, including tests across form joints.

b. Provide form sections that are tightly locked and free from play or movement in any direction. Provide forms with adequate devices for secure settings so that when in place they withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.

c. Set forms for full bearing on foundation for entire length and width and in alignment with edge of finished pavement. Support forms during entire operation of placing, compaction, and finishing so that forms do not deviate vertically more than 0.01 foot from required grade and elevations indicated. Check conformity to the alignment and grade elevations shown on the drawings and make necessary corrections immediately prior to placing the concrete. Clean and oil the forms each time before concrete is placed. Concrete placement is not allowed until setting of forms has been checked and approved by the CQC team.

d. Do not anchor guide rails for fixed form pavers into new concrete or existing concrete to remain.

e. Securely hold forms for overlay pavements and for other locations where forms set on existing pavements in place with stakes or by other approved methods. Carefully drill holes in existing pavements for form stakes by methods which do not crack or spall the existing pavement. After use, fill the holes flush with the surrounding surface using approved material, prior to overlying materials being placed. Immediately discontinue any method which does not hold the form securely or which damages the existing pavement. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location without proceeding further until the proposed method is approved.

3.5.5.2 Form Removal

Keep forms in place at least 12 hours after the concrete has been placed. When conditions are such that the early strength gain of the concrete is delayed, leave the forms in place for a longer time, as directed. Remove forms by procedures that do not damage the concrete. Do not use bars or heavy metal tools directly against the concrete in removing the forms. Promptly repair any concrete found to be defective after form removal, using procedures specified or as directed.

3.5.6 Slipform Paving

3.5.6.1 General

Provide paving equipment for slipform paving and the operation thereof that conforms to the requirement of paragraph EQUIPMENT, and all requirements specified herein. Provide a slipform paver capable of shaping the concrete to the specified and indicated cross section, meeting all tolerances, with a surface finish and edges that require only a very minimum isolated amount of hand finishing, in one pass. If the paving operation does not meet the above requirements and the specified tolerances, immediately stop the operation, and regroup and replace or modify any equipment as necessary, modify paving procedures or modify the concrete mix, in order to resolve the problem. Provide a slipform paver that is automatically electronically controlled from a taut wire guideline for horizontal alignment and on both sides from a taut wire guideline for vertical alignment, except that electronic control from a ski operating on a previously constructed adjoining lane is required where applicable for either or both sides. Automatic, electronic controls are required for vertical alignment on both sides of the lane. Control from a slope-adjustment control or control operating from the underlying material is not allowed. Properly adjust side forms on slipform pavers so that the finished edge of the paving lane meets all specified tolerances. Install dowels in longitudinal construction joints as specified below. The installation of these dowels by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete is not permitted. If a keyway is required, install a 26 gauge thick metal keyway liner as the keyway is extruded. Provide keyway forms that do not vary more than plus or minus 1/8 inch from the dimensions indicated and do not deviate more than plus or minus 1/4 inch from the mid-depth of the pavement. An abrupt offset either horizontally or vertically in the completed keyway is not allowed. Maintain the keyway liner to remain in place and become part of the joint.

3.5.6.2 Guideline for Slipform Paving

Accurately and securely install guidelines well in advance of concrete placement. Provide supports at necessary intervals to eliminate all sag in the guideline when properly tightened. Provide guideline consisting of high strength wire set with sufficient tension to remove all sag between supports. Provide supports that are securely staked to the underlying material or other provisions made to ensure that the supports are not displaced when the guideline is tightened or when the guideline or supports are accidentally touched by workmen or equipment during construction. Provide appliances for attaching the guideline to the supports that are capable of easy adjustment in both the horizontal and vertical directions. When it is necessary to leave gaps in the guideline to permit equipment to use or cross underlying material, provide provisions for quickly and accurately replacing the guideline without any delay to the forward progress of the paver. Provide supports on either side of the gap that are secured in such a manner as to avoid disturbing the remainder of the guideline when the portion across the gap is positioned and tightened. Check the guideline across the gap and adjacent to the gap for a distance of 200 feet for horizontal and vertical alignment after the guideline across the gap is tightened. Provide vertical and horizontal positioning of the guideline such that the finished pavement conforms to the alignment and grade elevations shown on the drawings within the specified tolerances for grade and smoothness. The specified tolerances are intended to cover only the normal deviations in the finished pavement that may occur under good supervision and do not apply to setting of the guideline. Set the guideline true to line and grade.

3.5.6.3 Stringless Technology

If the use of any type of stringless technology is proposed, submit a detailed description of the system and perform a trial field demonstration at least one week prior to start of paving. Approval of the control system will be based on the results of the demonstration and on continuing satisfactory operation during paving.

3.5.7 Placing Reinforcing Steel

Provide the type and amount of steel reinforcement indicated.

3.5.7.1 Pavement Thickness Greater Than 12 inches

For pavement thickness of 12 inches or more, install the reinforcement steel by the strike-off method wherein a layer of concrete is deposited on the underlying material, consolidated, and struck to the indicated elevation of the steel reinforcement. Place the reinforcement upon the pre-struck surface, followed by placement of the remaining concrete and finishing in the required manner. When placement of the second lift causes the steel to be displaced horizontally from its original position, provide provisions for increasing the thickness of the first lift and depressing the reinforcement into the unhardened concrete to the required elevation. Limit the increase in thickness only as necessary to permit correct horizontal alignment to be maintained. Remove and replace any portions of the bottom layer of concrete that have been placed more than 30 minutes without being covered with the top layer with newly mixed concrete without additional cost to the Government.

3.5.7.2 Pavement Thickness Less Than 12 Inches

For pavements less than 12 inches thick, position the reinforcement on suitable chairs or continuous mesh support devices securely fastened to the subgrade prior to concrete placement. Consolidate concrete after the steel has been placed. Regardless of placement procedure, provide reinforcing steel free from coatings which could impair bond between the steel and concrete, with reinforcement laps as indicated. Regardless of the equipment or procedures used for installing reinforcement, ensure that the entire depth of concrete is adequately consolidated. If reinforcing for Continuously Reinforced Concrete Pavement (CRCP) is required, submit the entire operating procedure and equipment proposed for approval at least 30 days prior to proposed start of paving.

3.5.8 Placing Dowels and Tie Bars

Ensure the method used to install and hold dowels in position result in dowel alignment within the maximum allowed horizontal and vertical tolerance of 1/8 inch per foot after the pavement has been completed. Except as otherwise specified below, maintain the horizontal spacing of dowels within a tolerance of plus or minus 5/8 inch. Locate the dowel vertically on the face of the slab within a tolerance of plus or minus 1/2 inch). Measure the vertical alignment of the dowels parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Measure dowels across crowns and other joints at grade changes to a level surface. Check horizontal alignment perpendicular to the joint edge with a framing square. Do not place longitudinal dowels and tie bars closer than 0.6 times the dowel bar tie bar length to the planned joint line. If the last regularly spaced longitudinal dowel tie bar is closer than that dimension, move it away from the joint to a location 0.6 times the dowel bar tie bar length, but not closer than 6 inches to its nearest neighbor. Resolve dowel (tie bar) interference at a transverse joint-longitudinal joint intersection by deleting the closest transverse dowel (tie bar). Do not position the end of a transverse dowel closer than 12 inches from the end of the nearest longitudinal dowel. Install dowels as specified in the following subparagraphs.

3.5.8.1 Contraction Joints

Securely hold dowels and tie bars in longitudinal and transverse contraction joints within the paving lane in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. Securely hold the basket assemblies in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires.

3.5.8.2 Construction Joints-Fixed Form Paving

Install dowels and tie bars by the bonded-in-place method or the drill-and-dowel method. Installation by removing and replacing in preformed holes is not permitted. Prepare and place dowels and tie bars across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. Provide the spacing of dowels and tie bars in construction joints as indicated, except that, where the planned spacing cannot be maintained because of form length or interference with form braces, provide closer spacing with additional dowels or tie bars.

3.5.8.3 Dowels Installed in Hardened Concrete

Install dowels in hardened concrete by bonding the dowels into holes drilled into the hardened concrete. Before drilling commences, cure the concrete for 7 days or until it has reached a minimum flexural strength of 450 psi. Drill holes 1/8 inch greater in diameter than the dowels into the hardened concrete using rotary-core drills. Rotary-percussion drills are permitted, provided that excessive spalling does not occur to the concrete joint face. Excessive spalling is defined as spalling deeper than 1/4 inch from the joint face or 1/2 inch radially from the outside of the drilled hole. Continuing damage requires modification of the equipment and operation. Drill depth of dowel hole within a tolerance of plus or minus 1/2 inch of the dimension shown on the drawings. Upon completion of the drilling operation, blow out the dowel hole with oil-free, compressed air. Bond dowels in the drilled holes using epoxy resin. Inject epoxy resin at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel is not permitted. Hold the dowels in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Provide dowels required between new and existing concrete in holes drilled in the existing concrete, all as specified above. Where tie bars are required in longitudinal construction joints of slipform pavement, install bent tie bars at the paver, in front of the transverse screed or extrusion plate. Do not install tie bars in preformed holes. Construct a standard keyway, with the bent tie bars inserted into the plastic concrete through a 26 gauge thick metal keyway liner. Protect and maintain the keyway liner to remain in place and become part of the joint. When bending tie bars, provide the radius of bend not be less than the minimum recommended for the particular grade of steel in the appropriate material standard. Before placement of the adjoining paving lane, straighten the tie bars using procedures which do not spall the concrete around the bar.

3.5.8.4 Lubricating Dowel Bars

Wipe the portion of each dowel intended to move within the concrete clean and coat with a thin, even film of lubricating oil or light grease before the concrete is placed.

3.6 FINISHING

Provide finishing operations as a continuing part of placing operations starting immediately behind the strike-off of the paver. Provide initial finishing by the transverse screed or extrusion plate. Provide the sequence of operations consisting of transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Provide finishing by the machine method. Provide a work bridge as necessary for consolidation and hand finishing operations. Use the hand method only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Keep supplemental hand finishing for machine finished pavement to an absolute minimum. Immediately stop any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing. Prior to recommencing machine finishing, properly adjust or replace the equipment. Immediately halt any operations which produce more than 1/8 inch of mortar-rich surface (defined as deficient in plus U.S. No. 4 sieve size aggregate) and the equipment, mixture, or procedures modified as necessary. Compensate for surging behind the screeds or extrusion plate and settlement during hardening and take care to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) is at the required line and grade. Maintain finishing equipment and tools clean and in an approved condition. Water is not allowed to be added to the surface of the slab with the finishing equipment or tools, or in any other way, except for fog (mist) sprays specified to prevent plastic shrinkage cracking.

3.6.1 Machine Finishing With Fixed Forms

Replace machines that cause displacement of the forms. Only one pass of the finishing machine is allowed over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, immediately stop the operation and the equipment, mixture, and procedures adjusted as necessary.

3.6.2 Machine Finishing with Slipform Pavers

Operate the slipform paver so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. Immediately modify or replace any equipment or procedure that fails to meet these specified requirements as necessary. A self-propelled non-rotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. Only one pass of the pipe float is allowed. If there is concrete slurry or fluid paste on the surface that runs over the edge of the pavement, immediately stop the paving operation and the equipment, mixture, or operation modified to prevent formation of such slurry. Immediately remove any slurry which does run down the vertical edges by hand, using stiff brushes or scrapers. Slurry, concrete or concrete mortar is not allowed to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.

3.6.3 Surface Correction and Testing

After all other finishing is completed but while the concrete is still plastic, eliminate minor irregularities and score marks in the pavement surface by means of cutting straightedges. Provide cutting straightedges with a minimum length of 12 feet that are operated from the sides of the pavement or from bridges. Provide cutting straightedges operated from the side of the pavement equipped with a handle 3 feet longer than one-half the width of the pavement. Test the surface for trueness with a straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. Advance the straightedge along the pavement in successive stages of not more than one-half the length of the straightedge. Immediately fill depressions with freshly mixed concrete, strike off, consolidate with an internal vibrator, and refinish. Strike off projections above the required elevation and refinish. Continue the straightedge testing and finishing until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in paragraph SURFACE SMOOTHNESS. This straightedging is not allowed to be used as a replacement for the straightedge testing of paragraph SURFACE SMOOTHNESS in PART 1. Use long-handled, flat bull floats very sparingly and only as necessary to correct minor, scattered surface defects. If frequent use of bull floats is necessary, stop the paving operation and the equipment, mixture or procedures adjusted to eliminate the surface defects. Keep finishing with hand floats and trowels to the absolute minimum necessary. Take extreme care to prevent over finishing joints and edges. Produce the surface finish of the pavement essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations are subject to approval.

3.6.4 Hand Finishing

Use hand finishing operations only as specified below. Provide a work bridge to be used as necessary for consolidation and placement operations to avoid standing in concrete.

3.6.4.1 Equipment and Template

In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping template and a longitudinal float for hand finishing. Provide a template at least 1 foot longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, that is constructed of metal or other suitable material shod with metal. Provide a longitudinal float at least 10 feet long, of approved design, is rigid and substantially braced, and maintain a plane surface on the bottom. Grate tampers (jitterbugs) are not allowed.

3.6.4.2 Finishing and Floating

As soon as placed and vibrated, strike off the concrete and screeded to the cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement is at the required elevation. In addition to previously specified complete coverage with handheld immersion vibrators, tamp the entire surface with the strike-off and tamping template, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, float the pavement longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, place additional concrete, consolidated and screeded, and the float operated until a satisfactory surface has been produced. Do not advance the floating operation more than half the length of the float and then continued over the new and previously floated surfaces.

3.6.5 Texturing

Before the surface sheen has disappeared and before the concrete hardens or curing compound is applied, texture the surface of the pavement as described herein. After curing is complete, thoroughly power broom all textured surfaces to remove all debris.

3.6.5.1 Burlap Drag Surface

Apply surface texture by dragging the surface of the pavement, in the direction of the concrete placement, with an approved burlap drag. Operate the drag with the fabric moist, and the fabric maintained clean or changed as required to keep clean. Perform the dragging so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.5.2 Broom Texturing

Complete brooming before the concrete has hardened to the point where the surface is unduly torn or roughened, but after hardening has progressed enough so that the mortar does not flow and reduce the sharpness of the scores. Overlap successive passes of the broom the minimum necessary to obtain a uniformly textured surface. Wash brooms thoroughly at frequent intervals during use. Remove worn or damaged brooms from the job site. Hand brooming is permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted. For hand brooming, provide brooms with handles longer than half the width of slab to be finished. Transversely draw the hand brooms across the surface from the center line to each edge with slight overlapping strokes.

3.6.5.3 Artificial Turf Drag Surface

Apply artificial turf texture by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf.

3.6.5.4 Wire-Comb Texturing

Apply surface texture using an approved mechanical wire comb drag operated to comb the surface transverse to the pavement centerline. Provide a comb capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Overlap successive passes of the comb the minimum necessary to obtain a continuous and uniformly textured surface. Complete texturing before the concrete has hardened to the point where the surface and edges are unduly torn, but after hardening has progressed to the point where the serrations do not close up. Provide serrations 1/16 to 3/16 inch deep, 1/16 to 1/8 inch wide, and spaced 3/8 inch apart. Produce transverse texturing grooves in straight lines across each lane within a tolerance of plus or minus 1/2 inch of a true line.

3.6.5.5 Surface Grooving

Groove the areas indicated on the drawings as required in 32 01 18.71 GROOVING FOR AIRFIELD PAVEMENTS.

3.6.6 Edging

Before texturing has been completed, carefully finish the edge of the slabs along the forms, along the edges of slipformed lanes, and at the joints with an edging tool to form a smooth rounded surface of 1/8 inch radius. Eliminate tool marks, and provide edges that are smooth and true to line. Water is not allowed to be added to the surface during edging. Take extreme care to prevent overworking the concrete.

3.6.7 Outlets in Pavement

Construct recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement to conform to the details and dimensions shown. Carefully finish the concrete in these areas to provide a surface of the same texture as the surrounding area that is within the requirements for plan grade and surface smoothness.

3.7 CURING

3.7.1 Protection of Concrete

Continuously protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations. Have all equipment needed for adequate curing and protection of the concrete on hand and ready for use before actual concrete placement begins. If any selected method of curing does not afford the proper curing and protection against concrete cracking, remove or replace the damaged pavement, and provide another method of curing as directed. Accomplish curing by one of the following methods .

3.7.2 Membrane Curing

Apply a uniform coating of white-pigmented, membrane-forming, curing compound to the entire exposed surface of the concrete as soon as the free water has disappeared from the surface after finishing. Apply immediately along the formed edge faces after the forms are removed. Do not allow the concrete to dry before the application of the membrane. If any drying has occurred, moisten the surface of the concrete with a fine spray of water, and the curing compound applied as soon as the free water disappears. Apply the curing compound to the finished surfaces by means of an approved automatic spraying machine. Apply the curing compound with an overlapping coverage that provides a two-coat application at a coverage of 400 square feet per gallon, plus or minus 5.0 percent for each coat. A one-coat application is allowed provided it is applied in a uniform application and coverage of 200 square feet per gallon, plus or minus 5.0 percent is obtained. The application of curing compound by hand-operated, mechanical powered pressure sprayers is permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, apply a second coat in a direction approximately at right angles to the direction of the first coat. If pinholes, abrasions, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray curing compound to concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray curing compound to areas where the curing compound is damaged by subsequent construction operations within the curing period immediately. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7.3 Moist Curing

Maintain concrete to be moist-cured continuously wet for the entire curing period, or until curing compound is applied, commencing immediately after finishing. If forms are removed before the end of the curing period, provide curing on unformed surfaces, using suitable materials. Cure surfaces by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Provide burlap and mats that are clean and free from any contamination and completely saturated before being placed on the concrete. Lap sheets to provide full coverage. Provide an approved work system to ensure that moist curing is continuous 24 hours per day and that the entire surface is wet.

3.8 JOINTS

3.8.1 General Requirements for Joints

Construct joints that conform to the locations and details indicated and are perpendicular to the finished grade of the pavement. Provide joints that are straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 1/2 inch. Where any joint fails to meet these tolerances, remove and replace the slabs adjacent to the joint at no additional cost to the Government. Change from the jointing pattern shown on the drawings is not allowed without written approval. Seal joints immediately following curing of the concrete or as soon thereafter as weather conditions permit as specified in Section 32 01 19.61 SEALING OF JOINTS IN RIGID PAVEMENT .

3.8.2 Longitudinal Construction Joints

Install dowels or keys or tie bars in the longitudinal construction joints, or thicken the edges as indicated. Install dowels tie bars as specified above. If any length of completed keyway of 5 feet or more fails to meet the previously specified tolerances, install dowels in that part of the joint by drilling holes in the hardened concrete and grouting the dowels in place with epoxy resin. After the end of the curing period, saw longitudinal construction joints to provide a groove at the top for sealant conforming to the details and dimensions indicated.

3.8.3 Transverse Construction Joints

Install transverse construction joints at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for 30 minutes or longer. Install the transverse construction joint at a planned transverse joint. Provide transverse construction joints by utilizing headers or by paving through the joint, then full-depth sawcutting the excess concrete. Construct pavement with the paver as close to the header as possible, with the paver run out completely past the header. Provide transverse construction joints at a planned transverse joint constructed as shown or, if not shown otherwise, dowelled in accordance with paragraph DOWELS INSTALLED IN HARDENED CONCRETE, or paragraph FIXED FORM PAVING above.

3.8.4 Expansion Joints

Provide expansion joints where indicated, and about any structures and features that project through or into the pavement, using joint filler of the type, thickness, and width indicated, and installed to form a complete, uniform separation between the structure and the pavement or between two pavements. Attach the filler to the original concrete placement with adhesive and mechanical fasteners and extend the full slab depth. After placement and curing of the adjacent slab, sawcut the sealant reservoir depth from the filler. Tightly fit adjacent sections of filler together, with the filler extending across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Finish edges of the concrete at the joint face with an edger with a radius of 1/8 inch.

3.8.5 Slip Joints

Install slip joints where indicated using the specified materials. Attach preformed joint filler material to the face of the original concrete placement with adhesive and mechanical fasteners. Construct a 3/4 inch deep reservoir for joint sealant at the top of the joint. Finish edges of the joint face with an edger with a radius of 1/8 inch.

3.8.6 Contraction Joints

Construct transverse and longitudinal contraction joints by sawing an initial groove in the concrete with a 1/8 inch blade to the indicated depth. During sawing of joints, and again 24 hours later, the CQC team is required to inspect all exposed lane edges for development of cracks below the saw cut, and immediately report results. If there are more than six consecutive uncracked joints after 48 hours, saw succeeding joints 25 percent deeper than originally indicated at no additional cost to the Government. The time of initial sawing varies depending on existing and anticipated weather conditions and be such as to prevent uncontrolled cracking of the pavement. Commence sawing of the joints as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The sawed faces of joints will be inspected for undercutting or washing of the concrete due to the early sawing, and sawing delayed if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. Continue the sawing operation as required during both day and night regardless of weather conditions. Saw the joints at the required spacing consecutively in the sequence of the concrete placement. Provide adequate lighting for night work. Illumination using vehicle headlights is not permitted. Provide a chalk line or other suitable guide to mark the alignment of the joint. Before sawing a joint, examine the concrete closely for cracks, and do not saw the joint if a crack has occurred near the planned joint location. Discontinue sawing if a crack develops ahead of the saw cut. Immediately after the joint is sawed, thoroughly flush the saw cut and adjacent concrete surface with water and vacuumed until all waste from sawing is removed from the joint and adjacent concrete surface. Take necessary precautions to insure that the concrete is properly protected from damage and cured at sawed joints. Tightly seal the top of the joint opening and the joint groove at exposed edges with cord backer rod before the concrete in the region of the joint is resprayed with curing compound, and be maintained until removed immediately before sawing the joint sealant reservoir. Respray the surface with curing compound as soon as free water disappears. Seal the exposed saw cuts on the faces of pilot lanes with bituminous mastic or masking tape. After expiration of the curing period, widen the upper portion of the groove by sawing with ganged diamond saw blades to the width and depth indicated for the joint sealer. Center the reservoir over the initial sawcut.

3.8.7 Thickened Edge Joints

Construct thickened edge joints as indicated on the drawings. Grade the underlying material in the transition area as shown and meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.9 REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

Repair or remove and replace new pavement slabs as specified at no cost to the Government. Removal of partial slabs is not permitted. Prior to any repairs, submit a Repair Recommendations Plan detailing areas exceeding the specified limits as well as repair recommendations required to bring these areas within specified tolerances.

3.9.2 Slabs with Cracks

The Government may require cores to be taken over cracks to determine depth of cracking. Such cores are to be drilled with a minimum diameter of 6 inches, and be backfilled with an approved non-shrink concrete. Perform drilling of cores and filling of holes at no expense to the Government. Clean cracks that do not exceed 2 inches in depth; then pressure injected full depth with epoxy resin, Type IV, Grade 1. Remove and replace slabs containing cracks deeper than 2 inches.

3.9.3 Removal and Replacement of Full Slabs

Remove and replace slabs containing more than 15.0 percent of any longitudinal or transverse joint edge spalled. Where it is necessary to remove full slabs, remove in accordance with paragraph REMOVAL OF EXISTING PAVEMENT SLAB below. Remove and replace full depth, by full width of the slab, and the limit of removal normal to the paving lane and extend to each original joint. Compact and shape the underlying material as specified in the appropriate section of these specifications, and clean the surfaces of all four joint faces of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Install dowels of the size and spacing as specified for other joints in similar pavement by epoxy grouting them into holes drilled into the existing concrete using procedures as specified in paragraph PLACING DOWELS AND TIE BARS, above. Provide dowels for all four edges of the new slab. Cut off original damaged dowels or tie bars flush with the joint face. Lightly oil or grease protruding portions of new dowels. Place concrete as specified for original construction. Take care to prevent any curing compound from contacting dowels or tie bars. Prepare and seal the resulting joints around the new slab as specified for original construction.

3.9.4 Repairing Spalls Along Joints

Repair spalls along joints to be sealed to a depth to restore the full joint-face support prior to placing adjacent pavement. Where directed, repair spalls along joints of new slabs, along edges of adjacent existing concrete, and along parallel cracks by first making a vertical saw cut at least 3 inches outside the spalled area and to a depth of at least 2 inches. Provide saw cuts consisting of straight lines forming rectangular areas without sawing beyond the intersecting saw cut. Chip out the concrete between the saw cut and the joint, or crack, to remove all unsound concrete and into at least 1/2 inch of visually sound concrete. Thoroughly clean the cavity thus formed with high pressure water jets supplemented with oil-free compressed air to remove all loose material. Immediately before filling the cavity, apply a prime coat to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. Apply the prime coat in a thin coating and scrubbed into the surface with a stiff-bristle brush. Provide prime coat for portland cement repairs consisting of a neat cement grout and for epoxy resin repairs consisting of epoxy resin, Type III, Grade 1. Fill the prepared cavity with material identified in the following table based on the cavity volume.

Spall Repairs	
Volume of Prepared Cavity After Removal Operations	Material
less than 0.03 cubic foot	epoxy resin mortar or epoxy resin or latex modified mortar
0.03 cubic foot and 1/3 cubic foot	Portland cement mortar
more than 1/3 cubic foot	Portland cement concrete or latex modified mortar

Provide portland cement concretes and mortars that consist of very low slump mixtures, 1/2 inch slump or less, proportioned, mixed, placed, consolidated by tamping, and cured, all as directed. Provide epoxy resin mortars made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved. Proprietary patching materials may be used, subject to Government approval. Place the epoxy resin materials in the cavity in layers with a maximum thickness of 2 inches. Provide adequate time between placement of additional layers such that the temperature of the epoxy resin material does not exceed 140 degrees F at any time during hardening.

Provide mechanical vibrators and hand tampers to consolidate the concrete or mortar. Remove any repair material on the surrounding surfaces of the existing concrete before it hardens. Where the spalled area abuts a joint, provide an insert or other bond-breaking medium to prevent bond at the joint face. Saw a reservoir for the joint sealant to the dimensions required for other joints. Thoroughly clean the reservoir and then sealed with the sealer specified for the joints.

3.9.5 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Diamond grind slabs containing weak surfaces less than 1/4 inch thick to remove the weak surface. Diamond grind in accordance with paragraph DIAMOND GRINDING OF PCC SURFACES in PART 1. All diamond ground areas are required to meet the thickness, smoothness and grade criteria specified in PART 1 GENERAL. Remove and replace slabs containing weak surfaces greater than 1/4 inch thick.

3.9.6 Repair of Pilot Lane Vertical Faces

Repair excessive edge slump and joint face deformation while concrete is in a plastic state by approved methods.

3.10 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

Removal of existing pavement is not allowed prior to approval of the Proportioning Studies. Remove existing concrete pavement at locations indicated on the drawings. Prior to commencing pavement removal operations, inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain. After pavement removal, survey the remaining edge again to quantify any damage caused by removal operations. Perform both surveys in the presence of the Government. Perform repairs as indicated and as specified herein. Carefully control all operations to prevent damage to the concrete pavement and to the underlying material to remain in place. Perform all saw cuts perpendicular to the slab surface, forming rectangular areas. Perform all existing concrete pavement repairs prior to paving adjacent lanes.

3.10.1 Removal of Existing Pavement Slab

When existing concrete pavement is to be removed and adjacent concrete is to be left in place, perform the first full depth saw cut on the joint between the removal area and adjoining pavement to stay in place with a standard diamond-type concrete saw. Next, perform a full depth saw cut parallel to the joint that is at least 24 inches from the joint and at least 6 inches from the end of any dowels with a diamond saw as specified in paragraph SAWING EQUIPMENT. Remove all pavement beyond this last saw cut in accordance with the approved demolition work plan. Remove all pavement between this last saw cut and the joint line by carefully pulling pieces and blocks away from the joint face with suitable equipment and then picking them up for removal. In lieu of this method, this strip of concrete may be carefully broken up and removed using hand-held jackhammers, 30 lb or less, or other approved light-duty equipment which does not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. In lieu of the above specified removal method, the slab may be sawcut full depth to divide it into several pieces and each piece lifted out and removed. Use suitable equipment to provide a truly vertical lift, and safe lifting devices used for attachment to the slab.

3.10.2 Edge Repair

Protect the edge of existing concrete pavement against which new pavement abuts from damage at all times. Remove and replace slabs which are damaged during construction as directed at no cost to the Government. Repair of previously existing damage areas is considered a subsidiary part of concrete pavement construction. Saw off all exposed keys and keyways full depth.

3.10.2.1 Spall Repair

Repair spalls caused by construction activities if less than 15.0 percent of any slab's edge. Provide repair materials and procedures as previously specified in paragraph, REPAIRING SPALLS ALONG JOINTS. Remove and replace full slabs if spalls exceed 15.0 percent of any slab's edge as specified in paragraph, Removal and Replacement of Full Slabs.

3.10.2.2 Underbreak and Underlying Material

Repair all underbreak by removal and replacement of the damaged slabs in accordance with paragraph REMOVAL AND REPLACEMENT OF FULL SLABS above. Protect the underlying material adjacent to the edge of and under the existing pavement which is to remain in place from damage or disturbance during removal operations and until placement of new concrete, and be shaped as shown on the drawings or as directed. Maintain sufficient underlying material in place outside the joint line to completely prevent disturbance of material under the pavement which is to remain in place. Remove and replace any slab with underlying material that is disturbed or loses its compaction.

3.11 PAVEMENT PROTECTION

Protect the pavement against all damage prior to final acceptance of the work by the Government. Placement of aggregates, rubble, or other similar construction materials on airfield pavements is not allowed. Exclude traffic from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or for a longer period if so directed. As a construction expedient in paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment is permitted on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected, the concrete has attained a minimum field cured flexural strength of 550 psi and approved means are provided to prevent damage to the slab edge. Continuously maintain all new and existing pavement carrying construction traffic or equipment completely clean, and spillage of concrete or other materials cleaned up immediately upon occurrence. Take special care in areas where traffic uses or crosses active airfield pavement. Power broom other existing pavements at least daily when traffic operates. For fill-in lanes, provide equipment that does not damage or spall the edges or joints of the previously constructed pavement.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION

3.12.1 Testing and Inspection by Contractor

During construction, perform sampling and testing of aggregates, cementitious materials (cement, slag cement, and pozzolan), and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary for procurement of representative test samples. Furnish sampling platforms and belt templates to obtain representative samples of aggregates from charging belts at the concrete plant. Obtain samples of concrete at the point of delivery to the paver. Testing by the Government in no way relieves the specified testing requirements. Perform the inspection and tests described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. Perform this testing regardless of any other testing performed by the Government, either for pay adjustment purposes or for any other reason.

3.12.2 Testing and Inspection Requirements

Perform CQC sampling, testing, inspection and reporting in accordance with the following Table.

TABLE 6
TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Fine Aggregate Gradation and Fineness Modulus			
2 per lot	ASTM C136/C136M sample at belt	9 of 10 tests must vary less than 0.15 from average	Retest, resolve, retest
		Outside limits on any sieve	Retest
		2nd gradation failure	Stop, resolve, retest
1 per 10 gradations	ASTM C117	Outside limits on any sieve	Retest
		2nd gradation failure	Stop, repair, retest
Coarse Aggregate Gradation (each aggregate size)			
2 per lot	ASTM C136/C136M sample at belt	Outside limits on any sieve	Retest
		2nd gradation failure	report to COR, correct
		2 consecutive averages of 5 tests outside limits	report to COR, stop ops, repair, retest
1 per 10 gradations	ASTM C117	Outside limits on any sieve	Retest
		2nd gradation failure	report to COR, correct
		2 consecutive averages of 5 tests outside limits	report to COR, stop ops, repair, reverify all operations
Workability Factor and Coarseness Factor Computation			

TABLE 6
TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Same as C.A. and F.A.	see paragraph AGGREGATES	Use individual C.A. and F.A. gradations. Combine using batch ticket percentages. Tolerances: plus or minus 3 points on WF; plus or minus 5 points on CF from approved adjusted mix design values; only the portion of the tolerance box within the parallelogram is available for use	Check batching tolerances, recalibrate scales
		2 consecutive averages of 5 tests outside limits	Stop production paving, report to COR, and revise materials and operations to be in compliance prior to restarting production paving
Aggregate Deleterious, Quality, and ASR Tests			
First test no later than time of uniformity testing and then every 30 days of concrete production	see paragraph AGGREGATES		Stop production, retest, replace aggregate. Increase testing interval to 90 days if previous 2 tests pass
Plant - Scales, Weighing Accuracy			
Monthly	NRMCA QC 3		Stop plant ops, repair, recalibrate
Plant - Batching and Recording Accuracy			
Weekly	Record/Report	Record required/recorded/actu batch mass	Stop plant ops, repair, recalibrate
Plant - Batch Plant Control			
Every lot	Record/Report		Record type and amount of each material per lot

TABLE 6
TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Plant - Mixer Uniformity - Stationary Mixers			
Every 4 months during paving	COE CRD-C 55	After initial approval, use abbreviated method	Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
Plant - Mixer Uniformity - Truck Mixers			
Every 4 months during paving	ASTM C94/C94M	Random selection of truck.	Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
Concrete Mixture - Air Content			
When test specimens prepared plus 2 random	ASTM C231/C231M sample at point of discharge within the paving lane	Individual test control chart: Warning plus or minus 1.0	Adjust AEA, retest
		Individual test control chart: Action plus or minus 1.5	Halt operations, repair, retest
		Range between 2 consecutive tests: Warning plus 2.0	Recalibrate AEA dispenser
		Range between 2 consecutive tests: Action plus 3.0	Halt operations, repair, retest
Concrete Mixture - Unit Weight and Yield			
Same as Air Content	ASTM C138/C138M sample at point of discharge within the paving lane	Individual test basis: Warning Yield minus 0 or plus 1 percent	Check batching tolerances
		Individual test basis: Action Yield minus 0 or plus 5 percent	Halt operations
Concrete Mixture - Slump			

TABLE 6
TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
When test specimens prepared plus 4 random	ASTM C143/C143M sample at point of discharge within the paving lane	Individual test control chart: Upper Warning minus 1/2 inch below max	Adjust batch masses within max W/C ratio
		Individual test control chart: Upper Action at maximum allowable slump	Stop operations, adjust, retest
		Range between each consecutive test: 1-1/2 inches	Stop operations, repair, retest
Concrete Mixture - Temperature			
When test specimens prepared	ASTM C1064/C1064 sample at point of discharge within the paving lane	See paragraph WEATHER LIMITATIONS	
Concrete Mixture - Strength			
8 per lot	ASTM C31/C31M sample at point of discharge within the paving lane	See paragraph CONCRETE STRENGTH TESTING for CQC Perform fabrication of strength specimens and initial cure outside the paving lane and within 1,000 feet of the sampling point.	
Paving - Inspection Before Paving			
Prior to each paving operation	Report	Inspect underlying materials, construction joint faces, forms, reinforcing, dowels, and embedded items	
Paving - Inspection During Paving			
During paving operation		Monitor and control paving operation, including placement, consolidation, finishing, texturing, curing, and joint sawing.	
Paving - Vibrators			

TABLE 6
TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Weekly during paving	COE CRD-C 521	Test frequency (in concrete), and amplitude (in air), average measurement at tip and head.	Repair or replace defective vibrators.
Moist Curing			
2 per lot, min 4 per day	Visual		Repair defects, extend curing by 1 day
Membrane Compound Curing			
Daily	Visual	Calculate coverage based on quantity/area	Respray areas where coverage defective. Recalibrate equipment
Cold Weather Protection			
Once per day	Visual		Repair defects, report conditions to COR

3.12.3 Concrete Strength Testing for CQC

Perform Contractor Quality Control operations for concrete strength consisting of the following steps:

a. Take samples for strength tests at the paving site. Fabricate and cure test cylinders in accordance with ASTM C31/C31M; test them in accordance with ASTM C39/C39M.

b. Fabricate and cure 2 test cylinders per sublot from the same batch or truckload and at the same time acceptance cylinders are fabricated and test them for compressive strength at 7-day age.

c. Average all 8 compressive tests per lot. Convert this average 7-day compressive strength per lot to equivalent 28 -day flexural strength using the Correlation Ratio determined during mixture proportioning studies.

d. Compare the equivalent 28 -day flexural strength from the conversion to the Average Flexural Strength Required for Mixtures from paragraph of same title.

e. If the equivalent average 28-day strength for the lot is below the Average Flexural Strength Required for Mixtures by 20 psiflexural strength or more, at any time, adjust the mixture to increase the strength, as approved.

f. Fabricate and cure two beams for every 2000 cubic yards of concrete placed. Fabricate and cure in accordance with ASTM C31/C31M; test at 14-days of age in accordance with ASTM C78/C78M. Use the flexural strength results to verify the cylinder-beam acceptance correlation ratio.

g. Maintain up-to-date control charts for strength, showing the 7-day CQC compressive strength, the 14-day compressive strength (from acceptance tests) and the 28 -day equivalent flexural strength of each of these for each lot.

3.12.4 Reports

Report all results of tests or inspections conducted informally as they are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, make daily reports of pertinent temperatures. These requirements do not relieve the obligation to report certain failures immediately as required in preceding paragraphs. Confirm such reports of failures and the action taken in writing in the routine reports. The Government has the right to examine all Contractor quality control records.

-- End of Section --

SECTION 32 13 43

PERVIOUS CONCRETE PAVING
05/20

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

Measure the quantity of pervious concrete paving, completed and accepted,in cubic yards. Determine the volume of pervious concrete paving, in place and accepted, by the average job thickness obtained in accordance with paragraph FIELD QUALITY CONTROL and the dimensions indicated.

1.1.2 Payment

The quantity of completed and accepted pervious concrete paving will be paid for at the contract unit price, which will constitute full compensation for the construction and completion of the pervious concrete paving, including the test section, and the furnishing of all other necessary labor and incidentals.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 305.1	(2014) Specification for Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 522.1	(2013) Specification For Pervious Concrete Pavement

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C42/C42M	(2020) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C150/C150M	(2021) Standard Specification for Portland Cement
ASTM C171	(2020) Standard Specification for Sheet

	Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C494/C494M	(2019) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2018a) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	(2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1542/C1542M	(2019) Standard Test Method for Measuring Length of Concrete Cores
ASTM C1549	(2016) Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer
ASTM C1567	(2021) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2018) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1688/C1688M	(2014a) Standard Test Method For Density And Void Content Of Freshly Mixed Pervious Concrete
ASTM C1701/C1701M	(2017a) Standard Test Method for Infiltration Rate of In Place Pervious Concrete
ASTM C1754/C1754M	(2012) Standard Test Method for Density and Void Content of Hardened Pervious Concrete

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2015) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Curing Materials

SD-04 Samples

Test Section

SD-05 Design Data

Mix Design Report; G

SD-06 Test Reports

Concrete Density Tests

Field Infiltration Tests

Surface Smoothness

Core Thickness

Plan Grade

SD-07 Certificates

NRMCA Certificate Of Conformance

1.4 QUALITY CONTROL

1.4.1 NRMCA Certificate of Conformance

Provide a batching and mixing plant consisting of a stationary-type central mix plant, including permanent installations and portable or relocatable plants installed on stable foundations. Provide a plant designed and operated to produce concrete within the specified tolerances, with a minimum capacity of 250 cubic yards per hour. Submit NRMCA Certificate of Conformance that conforms to the requirements of NRMCA QC 3 including provisions addressing:

1. Material Storage and Handling

2. Batching Equipment

3. Central Mixer

4. Ticketing System

5. Delivery System

1.4.2 Qualifications

1.4.2.1 Laboratory Accreditation

Perform sampling and testing using an approved commercial testing laboratory or on-site facility that is accredited in accordance with ASTM C1077. Maintain this certification for the duration of the project.

1.4.2.2 Field Technicians

Provide field technicians meeting one of the following criteria:

a. Provide at least one National Ready Mixed Concrete Association (NRMCA) certified pervious concrete craftsman on site, overseeing each placement crew during all concrete placement.

b. Provide no less than three NRMCA certified pervious concrete installers on site working as members of each placement crew during all concrete placement.

1.5 DELIVERY AND STORAGE

In accordance with ACI 522.1

1.6 ACCEPTANCE

1.6.1 Tolerances

Acceptance of pervious concrete paving is based on compliance with the tolerances presented in Table 1. Remove and replace pervious concrete paving represented by the failing tests or submit repair plan for approval.

TABLE 1	
Attribute	Tolerance
TEST SECTION	
Fresh Density	plus/minus 5 lb/cf of approved mix design value
Core Length (avg 3)	plus 1.5 inches
Core Length (ind)	minus 3/4 inch
FRESH CONCRETE	
Fresh Density	plus/minus 5 lb/cf of approved mix design value
FINISHED PAVEMENT	
Core Length (avg 3)	plus 1.5 inches
Core Length (ind)	minus 3/4 inch
Hardened Density	plus/minus 5 percent of test section value
Grade	plus/minus 0.05 foot from plan
Grade at	plus 1/8 to 1/4 inch above plan
Smoothness	1/4 inch longitudinal and transverse

TABLE 1	
Surface Finish	Free of irregularities, tears, and discontinuities

1.6.2 Test Section

Construct a minimum 400 square feet test section to demonstrate typical joints, surface finish, texture, color, infiltration rate, thickness, density, and standard of workmanship. Place test section using the mixture proportions, materials, and equipment as proposed for the project. Test in accordance with requirements in subpart FIELD QUALITY CONTROL.

When a test section does not meet one or more of the tolerances in Table 1, remove and replace the test section. If the test section is acceptable, it may be incorporated into the project.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Provide cementitious materials consisting of portland cement, or only portland cement in combination with supplementary cementitious materials (SCM), that conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.1.1.1 Portland Cement

ASTM C150/C150M, Type I or II .

2.1.1.2 Blended Cement

Provide blended cement conforming to ASTM C595/C595M, Type IP or IS, including the optional requirement for mortar expansion and sulfate soundness. Provide pozzolan added to the Type IP blend consisting of ASTM C618 Class F or Class N and that is interground with the cement clinker. Include in written statement from the manufacturer that the amount of pozzolan in the finished cement does not vary more than plus or minus 5 percent by mass of the finished cement from lot to lot or within a lot. Do not permit the percentage and type of mineral admixture used in the blend to change from that submitted for the aggregate evaluation and mixture proportioning. The requirements of paragraph SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM) CONTENT do not apply to the SCM content of blended cement.

2.1.1.3 Fly Ash and Pozzolan

ASTM C618, Type F or N, including the optional requirement for uniformity, with a loss on ignition not exceeding 3 percent. Provide Class F fly ash for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 3 percent.

2.1.1.4 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Provide Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) that conforms to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age of at least 95 percent of the control specimens.

b. The average particle size not exceeding 6 microns.

2.1.1.5 Slag

ASTM C989/C989M, Slag Cement (formerly Ground Granulated Blast Furnace Slag) Grade 100 or 120.

2.1.1.6 Supplementary Cementitious Material (SCM) Content

Use of one of the SCMs listed below is optional, unless the SCM is required to mitigate ASR.

TABLE 2
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class N Pozzolan and Class F Fly Ash		
$SiO_2 + Al_2O_3 + Fe_2O_3$ greater than 70 percent	25	35
$SiO_2 + Al_2O_3 + Fe_2O_3$ greater than 80 percent	20	35
$SiO_2 + Al_2O_3 + Fe_2O_3$ greater than 90 percent	15	35
UFFA and UFP	7	16
Slag Cement	40	50

2.1.2 Water

Water conforming to ASTM C1602/C1602M.

2.1.3 Aggregates

2.1.3.1 Durability

Evaluate and test all aggregates to be used in all concrete for durability in accordance with ASTM C88. Provide fine and coarse aggregates with a maximum of 18 percent loss when subjected to 5 cycles using Magnesium Sulfate or a maximum of 12 percent loss when subjected to 5 cycles using Sodium Sulfate.

2.1.3.2 Alkali Reactivity Test

Evaluate the fine and coarse aggregates separately, using ASTM C1260. Reject individual aggregates with test results that indicate an expansion of greater than 0.10 percent at 16 days after casting, or perform additional testing as follows: utilize the proposed low alkali portland cement, blended cement, and SCM in combination with each individual aggregate in accordance with ASTM C1567. Determine the quantity that meets all the requirements of these specifications and that lowers the expansion equal to or less than 0.10 percent at 16 days after casting. Base the mixture proportioning on the highest percentage of SCM required to mitigate ASR-reactivity. If any of the above options does not lower the expansion to less than 0.10 percent at 16 days after casting, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing for evaluation and acceptance.

2.1.3.3 Fine Aggregates

Provide fine aggregate conforming to the quality and grading requirements of ASTM C33/C33M.

2.1.3.4 Coarse Aggregates

Provide coarse aggregate consisting of crushed or uncrushed gravel, crushed stone, or a combination thereof meeting the requirements of ASTM C33/C33M Deliver aggregates to the mixers consisting of clean, hard, uncoated particles. Wash aggregate sufficient to remove dust and other coatings.

a. Gradation: ASTM C33/C33M,#67 .

b. Quality: ASTM C33/C33M, Class 4M or 4S.

2.1.4 Chemical Admixtures

2.1.4.1 Water Reducing and Retarding Admixtures

ASTM C494/C494M: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water reducing and accelerating. Acceptance is based on 28 day physical properties. Do not use calcium chloride admixtures.

2.1.4.2 Air Entraining Admixture

Air entraining admixture conforming to ASTM C260/C260M.

2.1.4.3 Hydration Retarding Admixture

Hydration retarding admixture conforming to ASTM C494/C494M, Type B, retarding, or Type D, water-reducing and retarding.

2.1.5 Curing Materials

2.1.5.1 Polyethylene Sheet

Provide curing materials conforming to ASTM C171, 0.006 inch clear or white opaque polyethylene cut to a minimum of 24 inches wider than full placement width, for curing of pervious concrete.

2.1.6 Edge Restraints

Provide edge restraints consisting of concrete curb sections .

2.1.7 Riser Strips

Provide wood strips of thickness to accommodate the initial strike off and consolidation of the pervious concrete.

2.2 MIX DESIGN

Design pervious concrete mix in accordance with ACI 522.1 to meet the following criteria: the water/cementitious materials ratio within the range of 0.26-0.40 and the air voids of freshly mixed pervious concrete within the range of 18 to 22 percent, as measured in accordance with ASTM C1688/C1688M. Provide air entrainment in freeze-thaw environments. Provide system with a minimum initial Solar Reflectance of at least 0.33 as tested in accordance with ASTM C1549.

2.2.1 Mix Design Report

Perform trial design batches, mixture proportioning studies, testing, and include test results demonstrating that the proposed mixture proportions produce pervious concrete of the qualities indicated. Submit test results in a mix design report to include:

a. Aggregate gradations and plots.

b. Aggregate quality test results, including deleterious materials and ASR tests.

c. Mill certificates for cement and supplemental cementitious materials.

d. Certified test results for all admixtures.

e. Recommended proportions and volumes for proposed mixture.

f. Water/cementitious materials ratio and air voids.

g. Narrative discussing methodology on how the mix design was developed.

2.2.2 Mix Verification

Mix verification tests may be performed by the Government. Provide quantities of cementitious materials, aggregates and admixtures as requested. Verification tests may be conducted on the proposed mix design proportions to confirm the fresh concrete air voids content. An existing mix design may be submitted if developed within the previous 12 months.

2.3 EQUIPMENT

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times.

2.3.1 Compaction Equipment

2.3.1.1 Pipe Roller

A steel pipe roller or a motorized or hydraulically actuated rotating tube screed spanning the width of the section placed.

2.3.1.2 Plate Compactor

Compact small areas using a standard soil plate compactor that has a base area of at least two square feet and exerts a minimum of 10 psi vertical pressure on the pavement surface (through a temporary cover of 19 mm 3/8 inch thick plywood).

2.3.2 Vibratory Screed

Truss mounted vibratory screed, adjustable in length to span the paving lane. Provide capability to adjust the vibration along the screed length and compact the full depth of the pervious concrete thickness.

2.3.3 Jointing Tool

Provide a jointing tool consisting of a "pizza cutter roller" to which a beveled fin with a minimum depth of 1/4 the thickness of the slab has been welded around the circumference of a steel roller.

2.3.4 Concrete Saw

Provide equipment for sawing joints and for other sawing of concrete consisting of standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Provide diamond tipped blades. Provide spares as required to maintain the required sawing rate.

2.3.5 Straightedge

Furnish one 12 foot straightedge constructed of aluminum or magnesium alloy, having blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Provide handles for operation on the pavement.

PART 3 EXECUTION

3.1 PREPARATION FOR PERVIOUS PAVING

Verify the underlying material, upon which pervious concrete is to be placed is clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Correct soft, yielding areas and ruts or other irregularities in the surface. Loosen material in the affected areas and remove unsatisfactory material. Add approved select material where directed. Shape the area to line, grade, and cross section, and compact to the specified density. Conform Subgrade to Section 31 00 00 EARTHWORK. Conform Base course to Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASE SELECT-MATERIAL FOR FLEXIBLE PAVING. Rework and compact any underlying material disturbed by construction operations to specified density immediately in front of the pervious concrete placement.

3.2 WEATHER LIMITATIONS

3.2.1 Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing pervious concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. Immediately cover and protect all unhardened concrete from the rain or other damaging weather. Completely remove and replace any area damaged by rain or other weather full depth.

3.2.2 Cold Weather

Do not place concrete when ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours without approval. If approval is granted, heat concrete materials so that the temperature of the concrete at placement is between 65 and 80 degrees F. Methods of heating materials are subject to approval. Do not use heated mixing water. Follow practices found in ACI 306.1.

3.2.3 Hot Weather

Maintain required concrete temperature in accordance with ACI 305.1 to prevent evaporation rate from exceeding 0.2 pound of water per square foot of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. After placement, use fog spray or other suitable means to reduce the evaporation rate. Start curing within 20 minutes of concrete discharge. Cool underlying material by sprinkling lightly with water before placing concrete.

3.3 CONCRETE PRODUCTION

Batch, mix, and deliver pervious concrete in accordance with ACI 522.1.

3.4 PAVING

3.4.1 Paving Plan

Submit for approval a paving plan identifying the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints.

c. Plan and equipment proposed to control alignment of formed or sawn joints within the specified tolerances.

3.4.2 Placing

Comply with guidelines set in ACI 522.1 for placement of pervious concrete, except as modified herein. Do not exceed a free vertical drop of 5 feet. Deposit concrete either directly from the transporting equipment or by conveyor onto the pre-wetted subgrade or subbase, unless otherwise specified. Do not place concrete on frozen subgrade or subbase. Deposit the concrete between the forms to an approximately uniform height. Do not allow foot traffic on the fresh concrete. Place concrete continuously at a uniform rate, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If this occurs within 10 feet of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected. Spread the concrete using a come-along, square ended shovel, or rake. Strike off the concrete between forms using a vibrating screed. Other strike off devices may be submitted for Government approval. Remove riser strips immediately after strike off operations are complete.

3.4.3 Fixed Form Paving

Use steel forms, except that wood forms may be used for curves having a radius of 150 feet or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. Provide forms with the base width of the form not less than eight-tenths of the vertical height of the form, except that for forms 8 inches or less in vertical height, provide forms with a base width not less than the vertical height of the form. Provide wood forms for curves and fillets that are adequate in strength and rigidly braced. Provide forms and anchors suitable to resist lateral pressures from compaction. Set forms on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Do not set forms on blocks or on built-up spots of underlying material. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location and do not proceed further until the proposed method is approved. Maintain forms in place at least 12 hours after the concrete has been placed. Remove forms without damaging the concrete.

3.4.4 Operation

When paving between or adjacent to previously constructed pavement, make provisions to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of any debris.

3.4.5 Compaction

Automatically control surface vibration so that it stops immediately as forward motion ceases. Do not permit excessive vibration. Tamp concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment. Do not use vibrators to transport or spread the concrete. After initial compaction, further smooth and compact concrete by means of hand-operated longitudinal rollers. Use rollers that are not less than 6 feet long and 8 inches in diameter and stiffened to prevent flexing and warping. Operate the paving equipment to produce a thoroughly compacted concrete layer throughout, requiring no hand finishing, other than the use of jointing tools, except in very infrequent instances.

3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Finish pavement surface on both sides of a joint to the same grade. Provide hand finishing equipment for use at all times.

3.5.1 Fixed Form Finishing

Strike off and screed concrete to the required crown or slope and cross-section. When using a static roller for consolidation, stiffen the roller to prevent flexing and warping. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

3.5.1.1 Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 0.25 in. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

3.5.2 Edging

Immediately after consolidation and jointing, carefully finish slab edges, including edges at formed joints, with an edge having a radius of not less than 0.25 inch. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled.

3.5.3 Jointing

Construct joints at the locations, depths, and width dimensions indicated on the project drawings or the approved shop drawings. Saw cut or use the jointing tool to form contraction joints in fresh concrete immediately after the concrete has been compacted to the specified depth and width. Extend expansion joints through the full depth of the pavement. Cut expansion material flush to grade after concrete has fully hardened and provide joint filler material as indicated or as approved on the shop drawings.

3.6 CURING

Cure pervious concrete for a minimum of 7 days. Protect concrete adequately from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Maintain temperature of air next to concrete above 40 degrees F for the full curing periods.

3.6.1 White-Polyethylene Sheet

Begin curing within 20 minutes of concrete discharge unless longer working time is approved. Lay sheets directly on concrete surface and overlap 12 inches. Make sheeting not less than 24 inches wider than concrete surface to be cured, and weight down on the edges, without using soil or debris, and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure sheets are soundly in place. If moisture evaporates, re-saturate concrete and replace polyethylene on pavement (limit re-saturation and re-placing no longer than 10 minutes per sheet).

3.7 FIELD QUALITY CONTROL

3.7.1 Sampling

Collect samples of fresh concrete in accordance with ASTM C172/C172M during each working day as required to perform tests specified herein.

3.7.2 Consistency Tests

Conduct concrete density tests on the fresh concrete in accordance with ASTM C1688/C1688M. Take samples for density determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every 50 cubic yards (maximum) of concrete to ensure that specification requirements are met.

3.7.3 Sample Cores

After a minimum of seven days following each placement, take three cores at random locations. Core hardened concrete panels in accordance with ASTM C42/C42M. Test thickness and density of the cores in accordance with ASTM C1542/C1542M and ASTM C1754/C1754M Drying Method B, respectively. Compute the tolerance for core thickness and density reported as the average of three cores of each test panel. Fill core holes with regular concrete or pre-mixed grout.

3.7.4 Field Infiltration Tests

After the curing period is complete, determine the infiltration rate of the pervious concrete in accordance with ASTM C1701/C1701M. Locate field infiltration tests at three random locations for each 10000 square feet of pervious concrete surface area. Determine the location of each test using GPS or other methods suitable to repeat testing during the life of the pavement. Submit the test results For Information Only.

3.7.5 Surface Testing

Perform surface testing for surface smoothness and plan grade as indicated below. Reference the measurements in accordance with paving lane identification and stationing, and submit a report within 24 hours after measurement is made. Upon conclusion of surface testing, submit a final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies. Mechanically sweep pavement before testing hardened concrete for compliance tolerances.

3.7.5.1 Surface Smoothness Requirements

Provide the finished surfaces of the pavements with no abrupt change of 1/8 inch or more, and within the tolerances specified in Table 1 when checked with a 12 foot straightedge.

3.7.5.2 Surface Smoothness Testing Method

Test the surface of the pavement with the straightedge to identify all surface irregularities exceeding the tolerances specified above. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines approximately 15 feet apart. Hold the straightedge in contact with the surface and move ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Make the measurement of the gap with a steel spacer bar of rectangular section the same thickness as the allowable gap, and width of four times the nominal maximum aggregate size.

3.7.6 Plan Grade Testing and Conformance

Check each pavement category for conformance with plan grade requirements by running lines of levels to determine the elevation at locations on the pavement surface 15 feet on center.

3.8 Pavement Protection

Protect the pavement against all damage prior to final acceptance of the work. Do not stockpile aggregates, landscaping materials, or other construction materials on pervious concrete pavements. Keep all new and existing pervious pavement carrying construction traffic or equipment completely clean, and clean up spillage of concrete or other materials immediately upon occurrence. Remove dust, leaves and debris with a leaf blower or dry vacuum.

3.9 Open To Traffic

Do not open the pavement to vehicular traffic until the concrete has cured at least 7 uninterrupted days during which the ambient temperature has exceeded 55 deg F or until the pavement is accepted.

-- End of Section --

SECTION 32 16 19

CONCRETE CURBS, GUTTERS AND SIDEWALKS
05/18

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

1.1.1.1 Sidewalks

The quantities of sidewalks to be paid for will be the number of square yards of each depth of sidewalk constructed as indicated.

1.1.1.2 Curbs and Gutters

The quantities of curbs and gutters to be paid for will be the number of linear feet of each cross section constructed as indicated, measured along the face of the curb at the gutter line.

1.1.2 Payment

1.1.2.1 Sidewalks

Payment of the quantities of sidewalks measured as specified will be at the Contract unit price per square yard of the thickness specified.

1.1.2.2 Curbs and Gutters

Payment of the quantities of curbs and gutters measured as specified will be at the Contract unit price per linear foot of each cross section.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M	(2020) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A1064/A1064M	(2017) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM C31/C31M	(2021a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C171	(2020) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete

Biodegradable Form Release Agent

SD-06 Test Reports

Field Quality Control

1.4 EQUIPMENT, TOOLS, AND MACHINES

1.4.1 General Requirements

Plant, equipment, machines, and tools used in the work will be subject to approval and must be maintained in a satisfactory working condition at all times. Use equipment capable of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Discontinue using equipment that produces unsatisfactory results. Allow the Contracting Officer access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.4.2 Slip Form Equipment

Slip form paver or curb forming machines, will be approved based on trial use on the job and must be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass.

1.5 ENVIRONMENTAL REQUIREMENTS

1.5.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 40 degrees F and is falling, or is already below that point. Placement may begin when the air temperature reaches 35 degrees F and is rising, or is already above 40 degrees F. Make provisions to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 35 degrees F, placement and protection must be approved in writing. Approval will be contingent upon full conformance with the following provisions. Prepare and protect the underlying material so that it is entirely free of frost when the concrete is deposited. Heat mixing water and aggregates as necessary to result in the temperature of the in-place concrete being between 50 and 85 degrees F. Methods and equipment for heating must be approved. Use only aggregates that are free of ice, snow, and frozen lumps before entering the mixer. Provide covering or other means as needed to maintain the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.5.2 Placing During Warm Weather

The temperature of the concrete as placed must not exceed 85 degrees F except where an approved retarder is used. Cool the mixing water and aggregates as necessary to maintain a satisfactory placing temperature. The placing temperature must not exceed 95 degrees F at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of Section

03 30 00 CAST-IN-PLACE CONCRETE except as otherwise specified. Concrete must have a minimum compressive strength of 3500 psi at 28 days. Size of aggregate must not exceed 1-1/2 inches. Submit copies of certified delivery tickets for all concrete used in the construction.

2.1.1 Air Content

Use concrete mixtures that have an air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

Use concrete with a slump of 3 inches plus or minus 1 inch for hand placed concrete or 1 inch plus or minus 1/2 inch for slipformed concrete as determined in accordance with ASTM C143/C143M.

2.1.3 Reinforcement Steel

Use reinforcement bars conforming to ASTM A615/A615M. Use wire mesh reinforcement conforming to ASTM A1064/A1064M.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Use impervious sheet materials conforming to ASTM C171, type optional, except that polyethylene film, if used, must be white opaque.

2.2.2 Burlap

Use burlap conforming to AASHTO M 182.

2.2.3 White Pigmented Membrane-Forming Curing Compound

Use white pigmented membrane-forming curing compound conforming to ASTM C309, Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Use concrete protection materials consisting of a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Use hard-pressed fiberboard contraction joint filler for curb and gutter.

2.4.2 Expansion Joint Filler, Premolded

Onless otherwise indicated, use 1/2 inch thick premolded expansion joint filler conforming to ASTM D1751 or ASTM D1752.

2.5 JOINT SEALANTS

Use cold-applied joint sealant conforming to ASTM C920 or ASTM D5893/D5893M.

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Use wood or steel forms that are straight and of sufficient strength to resist springing during depositing and consolidating concrete.

2.6.1 Wood Forms

Use forms that are surfaced plank, 2 inches nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Use forms with a nominal length of 10 feet. Radius bends may be formed with 3/4 inch boards, laminated to the required thickness.

2.6.2 Steel Forms

Use channel-formed sections with a flat top surface and welded braces at each end and at not less than two intermediate points. Use forms with interlocking and self-aligning ends. Provide flexible forms for radius forming, corner forms, form spreaders, and fillers as needed. Use forms with a nominal length of 10 feet and that have a minimum of 3 welded stake pockets per form. Use stake pins consisting of solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.3 Sidewalk Forms

Use sidewalk forms that are of a height equal to the full depth of the finished sidewalk.

2.6.4 Curb and Gutter Forms

Use curb and gutter outside forms that have a height equal to the full depth of the curb or gutter. Use rigid forms for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

2.6.5 Biodegradable Form Release Agent

Use form release agent that is colorless and biodegradableand that is composed of at least 87 percent biobased material. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces. Provide form release agent that does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

2.7 Detectable Warning System

Detectable Warning Systems shown on the Contract plans are to meet requirements of ICC A117.1 - Section 705.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

Construct subgrade to the specified grade and cross section prior to concrete placement.

3.1.1 Sidewalk Subgrade

Place and compact the subgrade in accordance with Section 31 00 00 EARTHWORK . Test the subgrade for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

Place and compact the subgrade in accordance with Section 32 11 23 AGGREGATE BASE COURSE AND/ORGRADED CRUSHED AGGREGATE BASE COURSE FOR FLEXIBLE PAVING . Test the subgrade for grade and cross section by means of a template extending the full width of the curb and gutter. Use subgrade materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

Maintain subgrade in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade must be in a moist condition when concrete is placed. Prepare and protect subgrade so that it is free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet. Use additional stakes and braces at corners, deep sections, and radius bends, as required. Use clamps, spreaders, and braces where required to ensure rigidity in the forms. Remove forms in a manner that will not injure the concrete. Do not use bars or heavy tools against the concrete when removing the forms. Promptly and satisfactorily repair concrete found to be defective after form removal. Clean forms and coat with form oil or biodegradable form release agent each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 1/8 inch in any 10 foot long section. After forms are set, grade and alignment must be checked with a 10 foot straightedge. Sidewalks must have a transverse slope of 1/4 inch per foot Do not remove side forms less than 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

Remove forms used along the front of the curb not less than 2 hours nor more than 6 hours after the concrete has been placed. Do not remove forms used along the back of curb until the face and top of the curb have been finished, as specified for concrete finishing. Do not remove gutter forms while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks must be of the thickness indicated. Use a strike-off guided by side forms after concrete has been placed in the forms to bring the surface to proper section to be compacted. Consolidate concrete by tamping and spading or with an approved vibrator. Finish the surface to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. Produce a scored surface by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

Finish all slab edges, including those at formed joints, with an edger having a radius of 1/8 inch. Edge transverse joints before brooming. Eliminate the flat surface left by the surface face of the edger with brooming. Clean and solidly fill corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing with a properly proportioned mortar mixture and then finish.

3.3.4 Surface and Thickness Tolerances

Finished surfaces must not vary more than 5/16 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Place concrete to the required section in a single lift. Consolidate concrete using approved mechanical vibrators. Curve shaped gutters must be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Float and finish exposed surfaces with a smooth wood float until true to grade and section and uniform in texture. Brush floated surfaces with a fine-hair brush using longitudinal strokes. Round the edges of the gutter and top of the curb with an edging tool to a radius of 1/2 inch. Immediately after removing the front curb form, rub the face of the curb with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Brush the front curb surface, while still wet, in the same manner as the gutter and curb top. Finish the top surface of gutter and entrance to grade with a wood float.

3.4.4 Joint Finishing

Finish curb edges at formed joints as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces must not vary more than 1/4 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.5 SIDEWALK JOINTS

Construct sidewalk joints to divide the surface into rectangular areas. Space transverse contraction joints at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and continuous across the slab. Construct longitudinal contraction joints along the centerline of all sidewalks 10 feet or more in width. Construct transverse expansion joints at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, install transverse expansion joints as indicated. Form expansion joints around structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

Form contraction joints in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness. Unless otherwise approved or indicated, either use a jointer to cut the groove or saw a groove in the hardened concrete with a power-driven saw. Construct sawed joints by sawing a groove in the concrete with a 1/8 inch blade. Provide an ample supply of saw blades on the jobsite before concrete placement is started. Provide at least one standby sawing unit in good working order at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Form expansion joints using 1/2 inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Hold joint filler in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, round joint edges using an edging tool having a radius of 1/8 inch. Remove any concrete over the joint filler. At the end of the curing period, clean the top of expansion joints and fill with cold-applied joint sealant. Use joint sealant that is gray or stone in color. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Apply joint sealing material only when the concrete at the joint is surface dry and atmospheric and concrete temperatures are above 50 degrees F. Immediately remove any excess material on exposed surfaces of the concrete and clean the concrete surfaces.

3.5.3 Reinforcement Steel Placement

Accurately and securely fasten reinforcement steel in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Construct curb and gutter joints at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Construct contraction joints directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length.

a. Construct contraction joints (except for slip forming) by means of 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Remove separators as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

b. When slip forming is used, cut the contraction joints in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. Cut the contraction joint to a depth of at least one-fourth of the gutter/curb depth using a 1/8 inch saw blade.

3.6.2 Expansion Joints

Form expansion joints by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Construct expansion joints in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement using the same type and thickness of joints as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, provide expansion joints at least 1/2 inch in width at intervals not less than 30 feet nor greater than 120 feet. Seal expansion joints immediately following curing of the concrete or as soon thereafter as weather conditions permit. Seal expansion joints and the top 1 inch depth of curb and gutter contraction-joints with joint sealant. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Concrete at the joint must be surface dry and atmospheric and concrete temperatures must be above 50 degrees F at the time of application of joint sealing material. Immediately remove excess material on exposed surfaces of the concrete and clean concrete surfaces.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete must be on hand and ready for use before actual concrete placement begins. Protect concrete as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

Cover the entire exposed surface with two or more layers of burlap. Overlap mats at least 6 inches. Thoroughly wet the mat with water prior to placing on concrete surface and keep the mat continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

Wet the entire exposed surface with a fine spray of water and then cover with impervious sheeting material. Lay sheets directly on the concrete surface with the light-colored side up and overlapped 12 inches when a continuous sheet is not used. Use sheeting that is not less than 18-inches wider than the concrete surface to be cured. Secure sheeting using heavy wood planks or a bank of moist earth placed along edges and laps in the sheets. Satisfactorily repair or replace sheets that are torn or otherwise damaged during curing. Sheeting must remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

Apply a uniform coating of white-pigmented membrane-curing compound to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Coat formed surfaces immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Do not allow concrete surface to dry before application of the membrane. If drying has occurred, moisten the surface of the concrete with a fine spray of water and apply the curing compound as soon as the free water disappears. Apply curing compound in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet/gallon for the total of both coats. Apply the second coat in a direction approximately at right angles to the direction of application of the first coat. The compound must form a uniform, continuous, coherent film that will not check, crack, or peel and must be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray areas where the curing compound is damaged by subsequent construction operations within the curing period. Take precautions necessary to ensure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. Tightly seal the top of the joint opening and the joint groove at exposed edges before the concrete in the region of the joint is resprayed with curing compound. Use a method used for sealing the joint groove that prevents loss of moisture from the joint during the entire specified curing period. Provide approved standby facilities for curing concrete pavement at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, remove debris and backfill, grade, and compact the area adjoining the concrete to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Protect completed concrete from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Remove and reconstruct concrete that is damaged for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Dispose of removed material as directed.

3.7.4 Protective Coating

Apply a protective coating of linseed oil mixture to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Moist cure concrete to receive a protective coating.

3.7.4.1 Application

Complete curing and backfilling operation prior to applying two coats of protective coating. Concrete must be surface dry and clean before each application. Spray apply at a rate of not more than 50 square yards/gallon for first application and not more than 70 square yards/gallon for second application, except that the number of applications and coverage for each application for commercially prepared mixture must be in accordance with the manufacturer's instructions. Protect coated surfaces from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Do not heat protective coating by direct application of flame or electrical heaters and protect the coating from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Do not apply material at ambient or material temperatures lower than 50 degrees F.

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and additional tests to ensure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Take concrete samples in accordance with ASTM C172/C172M not less than once a day nor less than once for every 250 cubic yards of concrete placed. Mold cylinders in accordance with ASTM C31/C31M for strength testing by an approved laboratory. Each strength test result must be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173/C173M or ASTM C231/C231M. Use ASTM C231/C231M with concretes and mortars made with relatively dense natural aggregates. Make two tests for air content on randomly selected batches of each class of concrete placed during each shift. Make additional tests when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. Notify the placing foreman if results are out of tolerance. The placing foreman must take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Perform two slump tests on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Perform additional tests when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

Determine the anticipated thickness of the concrete prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, construct the subgrade true to grade prior to concrete placement. The thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

Provide finished surfaces for each category of the completed work that are uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than 1/4 inch the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, reduce high areas either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete must not exceed 5 percent of the area of any integral slab, and the depth of grinding must not exceed 1/4 inch. Remove and replace pavement areas requiring grade or surface smoothness corrections in excess of the limits specified.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Contracting Officer and deficiencies in appearance will be identified. Remove and replace areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work.

3.10 DETECTABLE WARNING SYSTEM

Install Detectable Warning Systems required by Contract plans in accordance with ICC A117.1, Section 705, and by manufacturers' installation instructions.

-- End of Section --

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SECTION 32 17 23

PAVEMENT MARKINGS
08/16, CHG 5: 11/18

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

1.1.1.1 Surface Preparation

The unit of measurement for surface preparation (cleaning) is the number of square feet of pavement surface prepared for marking and accepted by the Contracting Officer.

1.1.1.2 Pavement Striping and Markings

The unit of measurement for pavement markings is the number of square feet of reflective and/or nonreflective striping or markings actually completed and accepted by the Contracting Officer.

1.1.1.3 Raised Pavement Markers

The unit of measurement for raised pavement markers is the number actually placed as specified and approved by the Contracting Officer.

1.1.1.4 Removal of Pavement Markings on Roads and Automotive Parking Areas

The unit of measurement for removal of pavement markings is the number of square feet of pavement markings removed as specified and accepted by the Contracting Officer.

1.1.2 Payment

The quantities of surface preparation, pavement striping or markings, raised pavement markers, and removal of pavement markings determined as specified in paragraph Measurement, will be paid for at the contract unit price. The payment constitutes full compensation for furnishing all labor, materials, tools, equipment, appliances, and doing all work involved in preparing and marking the pavements as shown on the drawings. Remove and replace any striping or markings which required reflective media, but are placed without it, do not meet the stated minimum retro-reflective requirements, or with other defects, at no cost to the Government. Remove and replace striping or markings which do not conform to the required physical characteristics, alignment or location required at no cost to the Government.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 249 (2012; R2016) Standard Specification for

	White and Yellow Reflective Thermoplastic Striping Material (Solid Form)

ASTM INTERNATIONAL (ASTM)

ASTM D4061	(2013) Standard Test Method for Retroreflectance of Horizontal Coatings
ASTM D6628	(2003; R 2015) Standard Specification for Color of Pavement Marking Materials
ASTM E1710	(2011) Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer
ASTM E2177	(2011) Standard Test Method for Measuring the Coefficient of Retroreflected Luminance (RL) of Pavement Markings in a Standard Condition of Wetness
ASTM E2302	(2003; R 2016) Standard Test Method for Measurement of the Luminance Coefficient Under Diffuse Illumination of Pavement Marking Materials Using a Portable Reflectometer

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 03732	(1997) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS-STD-595A	(2017) Colors used in Government Procurement

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2009; Rev 2012) Manual on Uniform Traffic Control Devices

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-B-1325	(Rev D; Notice 1; Notice 2 2017) Beads (Glass Spheres) Retro-Reflective (Metric)
FS TT-P-1952	(2015; Rev F; Notice 1) Paint, Traffic and Airfield Markings, Waterborne

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Surface Preparation Equipment List; G

Application Equipment List; G

Exterior Surface Preparation

Safety Data Sheets; G

Reflective media for airfields; G

Reflective media for roads; G

Waterborne Paint; G

Solventborne Paint; G

Thermoplastic compound; G

Raised Pavement Markers Primers and Adhesives; G

SD-06 Test Reports

Reflective Media for Airfields; G

Reflective Media for Roads; G

Waterborne Paint; G

Solventborne Paint; G

High Build Acrylic Coating (HBAC); G

Thermoplastic Compound; G

Raised Pavement Markers Primers and Adhesives; G

Test Reports

SD-07 Certificates

Qualifications; G

Reflective Media for Airfields

Reflective Media for Roads

Waterborne Paint

Solventborne Paint

Volatile Organic Compound, (VOC); G

Thermoplastic Compound

SD-08 Manufacturer's Instructions

Waterborne Paint; G

Solventborne Paint; G

Thermoplastic Compound; G

1.4 QUALITY ASSURANCE

1.4.1 Regulatory Requirements

Submit certificate stating that the proposed pavement marking paint meets the Volatile Organic Compound, (VOC) regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located. Submit Safety Data Sheets for each product.

1.4.2 Qualifications

Submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of applicable chemicals. The documentation should include experience on five projects of similar size and scope with references for all personnel.

1.4.3 Qualifications For Airfield Marking Personnel

Submit documentation of qualifications in resume format a minimum of 14 days before pavement marking work is to be performed showing personnel who will be performing the work have experience working on airfields, operating mobile self-powered marking, cleaning, and paint removal equipment and performing these tasks. Include with resume a list of references complete with points of contact and telephone numbers. Provide certification for pavement marking machine operator and Foreman demonstrating experience successfully completing a minimum of two airfield pavement marking projects of similar size and scope. Provide documentation demonstrating personnel have a minimum of three years of experience operating similar equipment and performing the same or similar work in similar environments, similar in size and scope of the planned project. The Contracting Officer reserves the right to require additional proof of competency or to reject proposed personnel.

1.5 DELIVERY AND STORAGE

Deliver paint materials, thermoplastic compound materials, and reflective media in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer.

Provide storage facilities at the job site, only in areas approved by the Contracting Officer, for maintaining materials at temperatures recommended by the manufacturer. All materials shall be delivered and stored in sealed containers that plainly show the designatedname, formula or specification number, batch number, color, date of manufacture, manufacturer'sname, and directions, all of which shall be plainly legible at time of use.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Environmental Requirements

1.6.1.1 Weather Limitations for Application

Apply pavement markings to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 5 degrees F above the dew point and the air and pavement temperatures are within the limits recommended by the pavement marking manufacturer. Allow pavement surfaces to dry after water has been used for cleaning or rainfall has occurred prior to striping or marking. Test the pavement surface for moisture before beginning work each day and after cleaning. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer. Employ the "plastic wrap method" to test the pavement for moisture as specified in paragraph TESTING FOR MOISTURE.

1.6.1.2 Weather Limitations for Removal of Pavement Markings on Roads and Automotive Parking Areas

Pavement surface must be free of snow, ice, or slush; with a surface temperature of at least 40 degrees F and rising at the beginning of operations, except those involving shot or sand blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for waterblasting and removal of previously applied chemicals. Cease waterblasting where surface water accumulation alters the effectiveness of material removal.

1.6.2 Traffic Controls

Place warning signs conforming to MUTCD near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Place small markers along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation.

When traffic must be rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles.

1.6.3 Airfield Traffic Control

Coordinate performance of all work in the controlled zones of the airfield with the Contracting Officer and with the Flight Operations Officer or Airfield Manager . Neither equipment nor personnel can use any portion of the airfield without permission of these officers unless the runway is closed. Runways will be closed during the following times:

Day or Date	Runway Closing Time	Runway Opening Time	Important Notes
[_____]	[_____]	[_____]	[_____]

1.6.4 Airfield Radio Communication

No personnel or equipment will be allowed in the controlled zones of the airfield until radio contact has been made with the control tower and permission is granted by the control tower. A radio for this purpose will be provided by the Government. The Contractor is responsible for the radio and must reimburse the Government for repair or replacement of the radio if it is lost, damaged, or destroyed . Maintain contact with the control tower at all times during work in vicinity of the airfield. Notify the control tower when work is completed and all personnel, equipment and materials have been removed from all aircraft operating surfaces.

1.6.5 Airfield Emergency Landing and Takeoff

Emergencies take precedence over all operations. Upon notification from the control tower of an emergency landing or imminent takeoff, stop all operations immediately and evacuate all personnel and equipment to an area not utilized for aircraft traffic which is at least 250 feet measured perpendicular to and away from the near edge of the runway unless otherwise authorized by the Contracting Officer. Equipment and chemicals or detergents as well as excess water must be able to be removed from the work area within 3 minutes.

1.6.6 Lighting

When night operations are necessary, provide all necessary lighting and equipment. Direct or shade lighting to prevent interference with aircraft, the air traffic control tower, and other base operations. Provide lighting and related equipment capable of being removed from the runway within 15 minutes of notification of an emergency. Night work must be coordinated with the Flight Operations Manager or Airfield Manager and approved in advance by the Contracting Officer. The Government reserves the right to accept or reject night work on the day following night activities by the Contractor.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Surface Preparation and Paint Removal

2.1.1.1 Surface Preparation and Paint Removal Equipment for Airfield Pavements

Prepare all airfield surfaces and remove paint from airfield surfaces in accordance with UFGS 32 01 11.51 Rubber and Paint Removal From Airfield Pavements. Provide submittals in accordance with UFGS 32 01 11.51 Rubber and Paint Removal From Airfield Pavements.

2.1.1.2 Surface Preparation Equipment for Roads and Automotive Parking Areas

Submit a surface preparation equipment list by serial number, type, model, and manufacturer. Include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation. Mobile equipment must allow for removal of markings without damaging the pavement surface or joint sealant. Maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition.

2.1.1.2.1 Sandblasting Equipment

Use mobile sandblasting equipment capable of producing a pressurized stream of sand and air that effectively removes paint from the surface without filling voids with debris in asphalt or tar pavements or removing joint sealants in Portland cement concrete pavements. Include with the equipment and air compressor, hoses, and nozzles of adequate size and capacity for removing paint. Equip the compressor with traps and coalescing filters that maintain the compressed air free of oil and water.

2.1.1.2.2 Waterblasting Equipment

Use mobile waterblasting equipment capable of producing a pressurized stream of water that effectively removes paint from the pavement surface without significantly damaging the pavement. Provide equipment, tools, and machinery which are safe and in good working order at all times.

2.1.1.2.3 Shotblasting Equipment

Use mobile self propelled shotblasting equipment capable of producing an adjustable depth of paint removal and of propelling abrasive particles at high velocities on the paint for effective removal. Ensure each unit is self cleaning and self contained. Use equipment able to confine the abrasive, any dust that is produced, and removed paint and is capable of recycling the abrasive for reuse.

2.1.1.2.4 Grinding or Scarifying Equipment

Use equipment capable of removing surface contaminates, paint build-up, or extraneous markings from the pavement surface without leaving any residue. Clean the surface by hydro blast to remove surface contaminates and ash after a weed torch is used to remove paint.

2.1.1.2.5 Chemical Removal Equipment

Use chemical equipment capable of applying and removing chemicals and paint from the pavement surface, leaving only non-toxic biodegradable residue without scarring or other damage to the pavement or joints and joint seals.

2.1.2 Application Equipment

Submit application equipment list appropriate for the material(s) to be used. Include manufacturer's descriptive data and certification for the planned use that indicates area of coverage per pass, pressure adjustment range, tank and flow capacities, and all safety precautions required for operating and maintaining the equipment. Provide and maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition, or remove them from the work site. Provide mobile and maneuverable application equipment to the extent that straight lines can be followed and normal curves can be made in a true arc.

2.1.2.1 Paint Application Equipment

2.1.2.1.1 Hand-Operated, Push-Type Machines

Provide hand-operated push-type applicator machine of a type commonly used for application of water based paint or two-component, chemically curing paint, thermoplastic, or preformed tape, to pavement surfaces for small marking projects, such as legends and cross-walks, automotive parking areas, or surface painted signs. Provide applicator machine equipped with the necessary tanks and spraying nozzles capable of applying paint uniformly at coverage specified. Hand operated spray guns may be used in areas where push-type machines cannot be used.

2.1.2.1.2 Self-Propelled or Mobile-Drawn Spraying Machines

Provide self-propelled or mobile-drawn spraying machine with suitable arrangements of atomizing nozzles and controls to obtain the specified results. Provide machine having a speed during application capable of applying the stripe widths indicated at the paint coverage rate specified herein and of even uniform thickness with clear-cut edges.

2.1.2.1.2.1 Road Marking

Provide equipment used for marking roads capable of placing the prescribed number of lines at a single pass as solid lines, intermittent lines, or a combination of solid and intermittent lines using a maximum of three different colors of paint as specified.

2.1.2.1.2.2 Airfield Marking

Provide self-propelled or mobile-drawn spraying machine for applying the paint for airfield pavements with an arrangement of atomizing nozzles capable of applying the specified line width in a single pass. Provide paint applicator with paint reservoirs or tanks of sufficient capacity and suitable gages to apply paint in accordance with requirements specified. Equip tanks with suitable mechanical agitators. Equip spray mechanism with quick-action valves conveniently located, and include necessary pressure regulators and gages in full view and reach of the operator. Install paint strainers in paint supply lines to ensure freedom from residue and foreign matter that may cause malfunction of the spray guns. The paint applicator must be readily adaptable for attachment of a dispenser for the reflective media approved for use.

2.1.2.1.2.3 Hand Application

Provide spray guns for hand application of paint in areas where the mobile paint applicator cannot be used.

2.1.2.2 Thermoplastic Application Equipment

2.1.2.2.1 Thermoplastic Material

Apply thermoplastic material with equipment that is capable of providing continuous uniformity in the dimensions and reflectorization of the marking.

2.1.2.2.2 Application Equipment

a. Provide application equipment capable of continuous mixing and agitation of the material, with conveying parts which prevent accumulation and clogging between the main material reservoir and the extrusion shoe or spray gun. All parts of the equipment which come into contact with the material must be easily accessible and exposed for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns must maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat.

b. Provide application equipment constructed to ensure continuous uniformity in the dimensions of the stripe. Provide an applicator with a means for cleanly cutting off stripe ends squarely and providing a method of applying "skiplines." Provide equipment capable of applying varying widths of traffic markings.

c. Provide mobile and maneuverable application equipment allowing straight lines to be followed and normal curves to be made in a true arc.

Provide equipment used for the placement of thermoplastic pavement markings of two general types: mobile applicator and portable applicator.

d. Equip the applicator with a pressurized or drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled rates of flow. The bead dispenser must operate automatically to begin flow prior to the flow of binder to assure that the strip is fully reflectorized.

2.1.2.2.3 Mobile Application Equipment

Provide a truck-mounted, self-contained pavement marking machine that is capable of hot applying thermoplastic by either the extrusion or spray method.

a. Equip the unit to apply the thermoplastic marking material at temperatures according to the manufacturer's instructions, at widths varying from 3 to 12 inches, with an automatic pressurized or drop-on bead dispensing system, capable of operating continuously, and of installing a minimum of 20,000 lineal feet of longitudinal markings in an 8-hour day.

b. Equip the mobile unit with a melting kettle which holds a minimum of 6000 pounds of molten thermoplastic material; capable of heating the thermoplastic composition to temperatures as recommended by the manufacturer. Use a thermostatically controlled heat transfer liquid. Heating of the composition by direct flame is not allowed. Oil and material temperature gauges must be visible at both ends of the kettle.

c. Equip mobile units for application of extruded markings with a minimum of two extrusion shoes; located one on each side of the truck, capable of marking simultaneous edge line and centerline stripes; each being a closed, oil-jacketed unit; holding the molten thermoplastic at a temperature as recommended by the manufacturer; and capable of extruding a line of 3 to 8 inches in width; and at a thickness of not less than 0.120 inch nor more than 0.190 inch, of generally uniform cross section.

d. Equip mobile units for application of spray markings with a spray gun system capable of marking simultaneous edgeline and centerline stripes. Surround (jacket) the spray system with heating oil to maintain the molten thermoplastic at a temperature of 375 to 425 degrees F, capable of spraying a stripe of 3 to 12 inches in width, and in thicknesses varying from 0.060 inch to 0.098 inch, of generally uniform cross section.

e. Equip the mobile unit with an electronic programmable line pattern control system, capable of applying skip or solid lines in any sequence, through any and all of the extrusion shoes, or the spray guns, and in programmable cycle lengths. In addition, equip the mobile unit with an automatic counting mechanism capable of recording the number of lineal feet of thermoplastic markings applied to the pavement surface with an accuracy of 0.5 percent.

2.1.2.2.4 Portable Application Equipment

Provide portable hand-operated equipment, specifically designed for placing special markings such as crosswalks, stop bars, legends, arrows, and short lengths of lane, edge and centerlines; and capable of applying thermoplastic pavement markings by the extrusion method. Equip the portable applicator with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, capable of holding the molten thermoplastic at the temperature recommended by the manufacturer, and of extruding a line of 3 to 12 inches in width, and in thickness of not less than 0.120 inch nor more than 0.190 inch and of generally uniform cross section.

2.1.2.3 Reflective Media Dispenser

Attach the dispenser for applying the reflective media to the paint or thermoplastic dispenser and designed to operate automatically and simultaneously with the applicator through the same control mechanism. The bead applicator must be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION.

2.1.2.4 Preformed Tape Application Equipment

Provide and use mechanical application equipment for the placement of preformed marking tape which is a mobile pavement marking machine specifically designed for use in applying pressure-sensitive pavement marking tape of varying widths. Equip the applicator with rollers, or other suitable compaction device to provide initial adhesion of the material with the pavement surface. Use additional tools and devices as needed to properly seat the applied material as recommended by the manufacturer.

2.2 MATERIALS

Use waterborne or methacrylate paint for airfield markings. Use waterborne paint for roads. Use non-reflectorized waterborne paint for automotive parking areas. The maximum allowable VOC content of pavement markings is 150 grams per liter. Color of markings are indicated on the drawings and must conform to ASTM D6628 for roads and automotive parking areas and SAE AMS-STD-595A for airfields. Provide materials conforming to the requirements specified herein.

2.2.1 Waterborne Paint

FS TT-P-1952, Type I or II .

2.2.2 Thermoplastic Compound

2.2.2.1 Composition Requirements

Thermoplastic compound must conform to AASHTO M 249. Formulate the binder component as an alkyd resin.

2.2.2.2 Primer

a. Asphalt concrete primer: Provide thermosetting adhesive primer with a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved or dispersed in a volatile organic solvent for asphaltic concrete pavements. The solids content must not be less than 10 percent by weight at 70 degrees F and 60 percent relative humidity. A wet film thickness of 0.005 inch, plus or minus 0.001 inch, must dry to a tack-free condition in less than 5 minutes.

b. Portland cement concrete primer: Provide an epoxy resin primer for Portland cement concrete pavements, of the type recommended by the manufacturer of the thermoplastic composition.

2.2.3 Reflective Media

2.2.3.1 Reflective Media for Airfields

FS TT-B-1325, [Type I, [Gradation A,] Type III,] [or] [Type IV, Gradation A or B].

2.2.3.2 Reflective Media for Roads

FS TT-B-1325, Type I, Gradation A or Type IV, Gradation A or B.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Testing for Moisture

Test the pavement surface for moisture before beginning pavement marking after each period of rainfall, fog, high humidity, or cleaning, or when the ambient temperature has fallen below the dew point. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer or authorized representative.

Employ the "plastic wrap method" to test the pavement for moisture as follows: Cover the pavement with a 12 inch by 12 inch section of clear plastic wrap and seal the edges with tape. After 15 minutes, examine the plastic wrap for any visible moisture accumulation inside the plastic. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap. Re-test surfaces when work has been stopped due to rain.

3.1.2 Surface Preparation Demonstration

Prior to surface preparation, demonstrate the proposed procedures and equipment. Prepare areas large enough to determine , adhesion of remaining coating and rate of cleaning. Perform a demonstration removal of pavement marking in an area designated by the Contracting Officer. Approved demonstration area establishes the standard for the remainder of the work.

3.1.3 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. Make the test stripes long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 50 feet long.

3.1.4 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to the Contracting Officer prior to proceeding with the work.

3.1.5 Retroreflective Value Demonstration

After the test stripes have cured to a "no-track" condition, demonstrate compliance with the average retroreflective values specified herein. Take a minimum of ten readings on each test stripe with a Retroreflectometer with a direct readout in millicandelas per square meter per lux (mcd/m2/lx). Perform testing in accordance with ASTM D4061, ASTM E1710, ASTM E2177, and ASTM E2302.

3.1.6 Level of Performance Demonstration

The Contracting Officer will be present at the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the Contracting Officer, the test stripe is the measure of performance required for this project. Do not proceed with the work until the demonstration results are satisfactory to the Contracting Officer.

3.2 EXTERIOR SURFACE PREPARATION

Allow new pavement surfaces to cure for a period of not less than 30 days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required. Remove rubber deposits, existing paint markings, residual curing compounds, and other coatings adhering to the pavement by water blasting or approved chemical removal method.

a. For Portland Cement Concrete pavement, grinding, light shot blasting, or light scarification, to a resulting profile equal to ICRI 03732 CSP 2, CSP 3, and CSP 4, respectively, can be used in addition to water blasting on most pavements, to either remove existing coatings, or for surface preparation.

b. Do not use shot blasting on airfield pavements due to the potential of Foreign Object Damage (FOD) to aircraft. Scrub affected areas, where oil or grease is present on old pavements to be marked, with several applications of trisodium phosphate solution or other approved detergent or degreaser and rinse thoroughly after each application. After cleaning oil-soaked areas, seal with shellac or primer recommended by the manufacturer to prevent bleeding through the new paint. Do not commence painting in any area until pavement surfaces are dry and clean.

3.2.1 Early Painting of Rigid Pavements

Pretreat rigid pavements that require early painting with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride. Apply the solution to the areas to be marked.

3.2.2 Early Painting of Asphalt Pavements

For asphalt pavement systems requiring painting application at less than 30 days, apply the paint and beads at half the normal application rate, followed by a second application at the normal rate after 30 days.

3.3 APPLICATION

Apply pavement markings to dry pavements only.

3.3.1 Paint

Apply paint with approved equipment at rate of coverage specified herein. Provide guidelines and templates as necessary to control paint application. Take special precautions in marking numbers, letters, and symbols. Manually paint numbers, letters, and symbols. Sharply outline all edges of markings. The maximum drying time requirements of the paint specifications will be strictly enforced, to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic. If there is a deficiency in drying of the markings, painting operations must cease until the cause of the slow drying is determined and corrected.

3.3.1.1 Waterborne Paint

3.3.1.1.1 Airfields

For non-reflectorized and reflectorized markings, apply paint conforming to FS TT-P-1952 Type I or II at a rate of 121 plus or minus 6 square feet per gallon .

For reflectorized markings, apply paint and glass spheres at the following rates:

TABLE III

Bead Type	Paint Type	Paint Application Rate	Bead Application Rate
Type I (Gradation A)	Type I, II, III	121 plus or minus 6 Sq Ft/Gallon	8 plus or minus 1 lb/gallon
Type III	Type I, II, III	121 plus or minus 6 Sq Ft/Gallon	10 plus or minus 1 lb/gallon
Type IV (Gradation A)	Type III	76 plus or minus 12 Sq Ft/Gallon	8 plus or minus 1 lb/gallon
Type IV (Gradation B)	Type III	98 plus or minus 9 Sq Ft/Gallon	8 plus or minus 1 lb/gallon

3.3.1.1.2 Roads

Apply paint at a rate of 105 plus or minus 5 square feet per gallon. Apply FS TT-B-1325 Type I (Gradation A) beads at a rate of 7 plus or minus 0.5 pounds of glass spheres per gallon.

3.3.2 Cleanup and Waste Disposal

Keep the worksite clean and free of debris and waste from the removal and application operations. Immediately cleanup following removal operations in areas subject to aircraft traffic. Dispose of debris at approved sites.

3.4 FIELD QUALITY CONTROL

3.4.1 Sampling and Testing

As soon as the paint materials and reflective media are available for sampling, obtain by random selection from the sealed containers, two quart samples of each batch in the presence of the Contracting Officer. Accomplish adequate mixing prior to sampling to ensure a uniform, representative sample. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Clearly identify samples by designated name, specification number, batch number, project contract number, intended use, and quantity involved.

At the discretion of the Contracting Officer, samples provided may be tested by the Government for verification.

3.4.2 Material Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. Provide test results substantiating conformance to the specified requirements with each certificate of compliance.

3.4.3 Dimensional Tolerances

Apply all markings in the standard dimensions provide in the drawings. New markings may deviate a maximum of 10 percent larger than the standard dimension. The maximum deviation allowed when painting over an old marking is up to 20 percent larger than the standard dimensions.

3.4.4 Bond Failure Verification

Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

3.4.5 Reflective Media and Coating Application Verification

Use a wet film thickness gauge to measure the application of wet paint. Use a microscope or magnifying glass to evaluate the embedment of glass beads in the paint. Verify the glass bead embedment with approximately 50 percent of the individual bead spheres embedded and 50 percent of the individual bead spheres exposed.

3.4.6 Retroreflective Markings

Collect and record readings for white and yellow retroreflective markings at the rate of one reading per 1000 linear feet. The minimum acceptable average for white markings is 200 millicandelas per square meter per lux (mcd/m2/lx) (measured with Retroreflectometer). The minimum acceptable average for yellow markings is 175 millicandelas per square meter per lux (mcd/m2/lx). Compute readings by averaging a minimum of 10 readings taken within the area at random locations. Re-mark areas not meeting the retroreflective requirements stated above.

3.4.7 Material Bond Verification and Operations Area Cleanup for Airfields

Vacuum sweep the aircraft operating area before it is opened for aircraft operations to preclude potential foreign object damaged to aircraft engines. Visually inspect the pavement markings and the material captured by the vacuum. Verify that no significant loss of reflective media has occurred to the pavement marking due to the vacuum cleaning.

-- End of Section --

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SECTION 32 18 16.13

PLAYGROUND PROTECTIVE SURFACING
08/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2047	(2017) Standard Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine
ASTM D2261	(2013; R 2017) Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant Rate-of-Extension Tensile Testing Machine)
ASTM D6112	(2013) Compressive and Flexural Creep and Creep-Rupture of Plastic Lumber and Shapes
ASTM F1015	(2003; R 2017) Standard Test Method for Relative Abrasiveness of Synthetic Turf Playing Surfaces
ASTM F1292	(2018; E 2020) Standard Specification for Impact Attenuation of Surfacing Materials Within the Use Zone of Playground Equipment
ASTM F1487	(2021) Standard Consumer Safety Performance Specification for Playground Equipment for Public Use
ASTM F1951	(2014) Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment

CONSUMER PRODUCT SAFETY COMMISSION (CPSC)

CPSC Pub No 325 (2015) Public Playground Safety Handbook

1.2 DEFINITIONS

1.2.1 Critical Height

The fall height at which the protective surfacing meets the requirements of ASTM F1292.

1.2.2 Designated Play Surface

Any elevated surface for standing, walking, sitting, or climbing; or a flat surface a minimum 2 inches wide having up to a maximum 30 degree angle from horizontal. In some play events the platform surface will be the same as the designated play surface. However, the terms should not be interchanged as they do not define the same point of measurement according to ASTM F1487.

1.2.3 Head Injury Criteria (HIC)

A measure of impact severity that considers the duration over which the most critical section of the deceleration pulse persists as well as the peak level of that deceleration. Head impact injuries are not believed to be life threatening if the HIC does not exceed a value of 1,000.

1.2.4 Impact Attenuation

The ability of protective surfacing to reduce and dissipate the energy of an impacting body.

1.2.5 Loose Fill

Consisting of small independent movable components such as sand, gravel, or wood chip. The percent of fine material in the loose fill affects its compression properties from rainfall.

1.2.6 Maximum Equipment Height

The highest point on the equipment (i.e.: roof ridge, top of support pole).

1.2.7 Play Event

A piece of manufactured playground equipment that supports one or more play activities.

1.3 SYSTEM DESCRIPTION

Measure the perimeters of the play event use zone in accordance with the requirements of Section 11 68 13 PLAYGROUND EQUIPMENT.

1.3.1 Child Safety

Meet or exceed the impact attenuating performance requirements of synthetic surfacing and loose-fill surfacing systems, installed in the use zones, as follows. The surfacing critical height value must yield up to both a maximum 200 G's peak deceleration, and a maximum 1,000 Head Injury Criteria (HIC) value for a head-first fall from the play event in accordance with CPSC Pub No 325 and ASTM F1292. The protective surfacing should have a minimum critical height value equal to the height of the highest designated play surface. Measuring fall heights for play events is defined in paragraph FALL HEIGHT. Do not install sand, gravel, and wood products over a concrete or bituminous subsurface in accordance with CPSC Pub No 325.

1.3.2 Child Accessibility

The accessibility requirement in accordance with ASTM F1487 includes the following: When the play event use zone consists of a protective surfacing rated as inaccessible, at least one accessible route must be provided from the use zone perimeter to the play event. When there is more than one of the same play activity provided, only one must meet accessibility requirements (i.e.: one swing seat or one spring rocking play event). When the access and egress points are not the same for a play event, an accessible route must be provided to both. The accessible route must access all accessible play events and elements. The protective surfacing materials that meet accessibility are synthetic surfacing and engineered wood fiber in accordance with ASTM F1951. When the accessible surface is within the use zone, it must meet the requirements of paragraph CHILD SAFETY.

1.3.3 Play Areas at CDC

The technical representative for outdoor play areas at CDC must be the installation Child Development Services (CDS) Coordinator. The design of the CDC outdoor play area must be based on the developmental play program for the age groups accommodated at the CDC. The play area is designed to support the CDC program and to provide a stage set for creative play. Developmental activities are selected which promote the intellectual, social, emotional and physical growth of the children. The developmental play program is developed by the MACOM CDS Director, installation CDS Coordinator and CDC Director. They are responsible for the developmental play program, child safety and accessibility to meet that program.

1.3.4 Sites Other than CDC

The technical representative for outdoor play areas on sites other than CDCs is the Director of Public Works or designated representative. The design of these outdoor play areas must be based on the play program and the age groups to be accommodated as determined by the play area committee.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

- Shop Drawings
- Finished Grade and Underground Utilities

SD-03 Product Data

- Synthetic Surfacing
- Loose Fill Surfacing

Geotextile Fabric

Wood

Temperature Limitation

Wood By-Products

Wood Treatment

Adhesive

Color

SD-04 Samples

Synthetic Surfacing

Loose Fill Surfacing System

SD-06 Test Reports

Percolation Test

Recycled Plastic

Synthetic Surfacing

Sand

Gravel

SD-07 Certificates

Manufacturer's Qualification

Manufacturer's Representative

Installer's Qualification

Substitution

Protective Surfacing Acceptance

SD-10 Operation and Maintenance Data

Maintenance Instructions; G

SD-11 Closeout Submittals

Protective Surfacing Acceptance

Certificate of Insurance

Warranty

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer's Qualification

Submit name of the owner or user; service or preventive maintenance provider; date of the installation; point of contact and telephone number; and address for 10 sites. Protective surfacing should have been installed in a minimum 10 sites and been in successful service for a minimum 5 year calendar period. The manufacturer must provide a Certificate of Insurance AA rated for a minimum one million dollars covering both product and general liability.

1.5.2 Manufacturer's Representative

Submit the individual's name, company name and address, and playground safety training certificate. The manufacturer's certified playground safety inspector or the manufacturer's designated certified playground safety representative must supervise the installation and adjustment of the protective surfacing to verify the installation meets the requirements of the manufacturer, this specification, and paragraphs CHILD SAFETY and CHILD ACCESSIBILITY.

1.5.3 Installer's Qualification

Submit the installer's company name and address, training and experience certification. The installer must be certified by the manufacturer for training and experience installing the protective surfacing.

1.5.4 Shop Drawings

When the use zone perimeter and play event configuration conflict with the requirements and paragraphs CHILD SAFETY and CHILD ACCESSIBILITY, submit scale drawings defining corrective measures to include the following: Adjustment to the play event with the use zone perimeter; use zone perimeter overlaps; fall height and critical height value.

1.6 DELIVERY, STORAGE, AND HANDLING

Provide a delivery schedule at least 10 calendar days prior to the first day of delivery. Deliver, handle, and store protective surfacing material in accordance with the manufacturer's recommendations. The storage area must be as designated. Store the materials in a dry, covered area until installed. Inspect protective surfacing material, upon arrival at the job site, for meeting specified quality. Unacceptable materials must be removed from the job site.

1.7 WARRANTY

Furnish protective surfacing with a minimum 1 year calendar period warranty.

1.8 MAINTENANCE INSTRUCTIONS

Submit 2 bound copies of the manufacturer's operation and maintenance manual describing the recommended preventive maintenance, inspection frequency and techniques, periodic adjustments, lubricants, and cleaning requirements. Furnish protective surfacing spare parts provided by the manufacturer.

PART 2 PRODUCTS

2.1 MATERIALS

Prior to the delivery of materials, submit certificates of compliance attesting that materials meet the specified requirements. Certified copies of the material certificates must include composition and tests to which the material has been subjected. Submit manufacturer's descriptive data; catalogue cuts; and the latest edition of ASTM F1487 and CPSC Pub No 325. Provide materials which are the standard products of a manufacturer regularly engaged in the manufacture of protective surfacing and that are similar to surfacing in satisfactory use a minimum 5 year calendar period. Protective surfacing consists of two systems; synthetic surfacing and loose fill surfacing.

2.2 SYNTHETIC SURFACING

Submit a minimum 2 by 2 inch sample. Submit impact attenuation and critical height performance for each thickness of synthetic surfacing and loose fill surfacing provided. Submit delivery schedule and manufacturer's name for synthetic surfacing and loose fill surfacing plus delivery, storage and handling information. Furnish a list to include part numbers of furnished protective surfacing materials and components for synthetic surfacing and loose fill surfacing and manufacturer's specifications, handling and storage requirements, installation procedures, and safety data sheets to include warnings and critical height performance standards for synthetic surfacing and loose fill surfacing. Synthetic surfacing includes the following: poured-in-place system; tile system; and combination system. The synthetic surfacing consists of either impact attenuating substrate covered by a wear surface bonded to produce a unified system; a shredded rubber or aggregate substrate covered by a polyethylene plastic woven sheet wear surface; or a uniform material manufactured in such a way that the top portion meets the requirements specified for wear surface. Submit chemical composition, color granule percentage, and test results to which material has been subjected, identifying each material and component containing recycled materials and showing the estimated percentage of recovered material content. Furnish freezing temperature life-cycle durability.

2.2.1 Subbase

The subbase for synthetic surfacing may be either concrete, aggregate, or bituminous material.

2.2.1.1 Concrete Subbase

Provide concrete material conforming to Section 32 13 14.13 CONCRETE PAVING FOR AIRFIELDS AND OTHER HEAVY DUTY PAVEMENTS.

2.2.1.2 Bituminous Subbase

Provide bituminous material conforming to Section 32 01 13.62 ASPHALT SURFACE TREATMENT.

2.2.1.3 Aggregate Subbase

Provide aggregate material conforming to Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASE SELECT-MATERIAL FOR FLEXIBLE PAVING.

2.2.2 Impact Attenuating Substrate

Provide a substrate compatible with the wear surface, and consisting of modular units; poured-in-place; or loose fill.

2.2.2.1 Poured-In-Place Substrate

Poured-in-place substrate must consist of a 100 percent recycled, shredded, styrene butadiene rubber (SBR) adhered with a 100 percent solid polyurethane binder to form a resilient, porous material or shredded rubber. Strands of SBR may vary from a minimum 1/50 inch to a maximum 2/25 inch thickness; by a minimum 1/8 inch to a maximum 4/5 inch length. Binder must be between a minimum 12 percent and a maximum 16 percent of the total weight of the mixture of rubber and urethane; and must provide 100 percent coating of the particles. Foam rubber will not be accepted in the substrate.

2.2.2.2 Loose Fill Substrate

The loose fill substrate must consist of 100 percent recycled shredded rubber produced from recycled vehicle tires without non-steel belts. Loose-fill strands may vary from a minimum 1/8 inch to a maximum 1/4 inch thickness; a minimum 1/8 inch to a maximum 1/2 inch width; and a minimum 1/2 inch to a maximum 2 inch length.

2.2.3 Wear Surface

Wear surfaces consist of the following: a poured-in-place durable, weather-resistant, ultraviolet stable, water permeable material top-coat; an integral component of a tile system; synthetic turf wear surface; rubber sheet wear surface; or a polyethylene woven plastic sheet wear surface. The wear surface must meet requirements of ASTM D2047 for a minimum 0.8 coefficient of friction.

2.2.3.1 Poured-in-Place Wear Surface

Poured-in-place wear surface consists of ethylene propylene diene monomer (EPDM) particles adhered with a polyurethane binder formulated to produce an even, uniform surface. Particles of EPDM must meet ASTM D412 for tensile strength and elongation, and contain a minimum 25 percent of rubber hydrocarbons. Particles of EPDM must be peroxide or sulfur cured in accordance with the manufacturer. Size of rubber particles must be between a minimum 1/32 inch, and a maximum 1/8 inch diameter. Binder must be between a minimum 16 percent and a maximum 21 percent total weight of rubber used in the wear surface, and must provide 100 percent coating of the particles. Wear surface must be a minimum 3/8 inch thick. The wear surface must be porous.

2.2.3.2 Synthetic Turf Wear Surface

Synthetic turf wear surface must consist of nylon fibers a minimum 500 denier, or heavy face weight polypropylene fiber a minimum 5,000 denier; and tufted construction conforming to ASTM F1015. Fibers in each roll must be from the same dye lot.

2.2.3.3 Rubber Sheet Wear Surface

Rubber sheet wear surface must consist of a smooth, uniform formulation of EPDM rubber granules bonded under pressure in the factory with polyurethane to form a continuous sheet, and must be a minimum 3/8 inch thick. Up to a maximum 80 percent of the rubber may consist of SBR particles. Particle size must vary from a minimum 1/32 inch to a maximum 3/16 inch diameter.

2.2.3.4 Polyethylene Plastic Woven Sheet Wear Surface

Polyethylene plastic woven sheet wear surface must be lockstitched and meet the tear resistance test, ASTM D2261 and must have an accelerated ultra-violet degradation protection feature.

2.2.4 Synthetic Tile

Synthetic tile must be sized as indicated . Synthetic tile must be a factory-molded unit consisting of the following: combining impact attenuating substrate and wear surface meeting requirements specified for substrate and wear surface; or a dual-density, uniform material, the top portion of which must conform to wear surface requirements specified.

2.2.5 Color

Submit 2 color charts displaying surfacing colors, color granule percentages and finishes. The color must be as shown in Section 09 06 00 SCHEDULES FOR FINISHES . An EPDM wear surface is preferred for color retention. Black or the following dark colored SBR wear surfaces retain heat and are not acceptable: color combinations containing more than 10 percent black; or color combinations averaging more than 10 percent dark colors.

2.2.6 Sealant

Sealant for tile or combined protective surface systems must be compatible with the protective surfacing, and must match the color of the wear surface.

2.2.7 Hardware

Hardware, anchors or fasteners must be corrosion resistant stainless steel or galvanized steel to anchor the surfacing system securely, in accordance with manufacturer's instructions. Hardware must provide or be recessed to provide a flat surface and must be covered by the required depth of protective surfacing.

2.2.8 Binder

Binder for synthetic surfacing must be nontoxic, weather-resistant, ultraviolet stable, non-hardening, and retaining impact-attenuating performance. It must be 100 percent solids containing polyurethane, methylene diphenel isocyanate (MDI), or as recommended by the manufacturer. The use of toluene diphenel isocyanate (TDI) must not exceed 2 percent. Weight of polyurethane must be between a minimum 8.5 lbs/gal and a maximum 9.5 lbs/gal. Coloring pigments must be inorganic oxides.

2.2.9 Adhesive

Provide a two component polyurethane adhesive as recommended by the manufacturer.

2.2.10 Containment Curbs

Containment curbs include the following: treated wood, concrete, recycled plastic, or recycled plastic molded as lumber. Containment curbs must provide a smooth and hazard-free transition from the protective surfacing to the adjacent surface. Curbs must be free of sharp vertical edges, protruding elements and trip hazards. Curbs must be as recommended by the manufacturer. Provide all edges with a minimum 1/2 inch radius.

2.2.11 Transition Edge

The transition edge must be designed to maintain the protective surfacing performance, support the surfacing between changes of material, and must be concrete in accordance with paragraph CONCRETE CURB. The face of the edge to the subgrade must be covered with the impact attenuating surface and meet the requirements of paragraph CHILD SAFETY.

2.2.12 Combination System

Combination systems must consist of combined protective surfacing materials specified. Each component is a part of a manufactured surfacing system. Wear surface must be of the materials specified.

2.3 LOOSE-FILL SURFACING

Loose-fill surfacing installed in the use zone must consist of sand, gravel or wood by-products.

2.3.1 Sand

Submit sieve test results. Sand must be uniformly graded, washed, free of dust, clay, dirt, hazardous substances, or foreign objects. Sand particles must be rounded naturally or by mechanical means and sieved in accordance with ASTM C136/C136M to be in the following gradation range.

SIEVE SIZE	PERCENT PASSING
No. 8	100
No. 16	80-100
No. 30	40-75
No. 50	0-25
No. 100	less than 2

2.3.2 Gravel

Gravel must be washed, free of dust, clay, dirt, hazardous substances or foreign objects. Gravel particles must be rounded naturally or by mechanical means and sieved in accordance with ASTM C136/C136M to be in the following gradation range.

SIEVE SIZE	PERCENT PASSING
1/2 inch	100
3/8 inch	75-85

2.3.3 Wood By-Products

Wood by-products include wood mulch and engineered wood fiber. Wood by-products must be free of sharp or foreign objects or toxic chemicals; poisonous plant material; protrusions; or hazardous material; provide information regarding composition, source, and particle size. Wood by-products manufactured from recycled pallets or lumber containing nails or metal fasteners must be rejected.

2.3.3.1 Wood Mulch

Wood mulch must be untreated chipped bark or untreated chipped tree prunings a maximum 1-1/2 inches long and must be free of twigs, leaves, branches, thorns, dirt, grass, yard clippings, soil, or poisonous plants.

2.3.3.2 Engineered Wood Fiber

Engineered wood fiber manufactured for the purpose of protective surfacing must consist of particles varying from a minimum 1/8 inch wide to a maximum 1/2 inch thick; and a minimum 1 inch wide to a maximum 3 inches long.

2.4 GEOTEXTILE FABRIC

Geotextile fabric consists of the following: nonwoven polypropylene sheet; nonwoven 100 percent polyester sheet; or nonwoven needle punched polyester sheet composed of recycled polyester resins.

2.5 RECYCLED PLASTIC

Provide the estimated percentage of recovered material content in the material and components; and life-cycle durability. Submit individual component and assembled unit structural integrity test; creep tolerance; deflection tolerance; and vertical load test results; and life-cycle durability. Recycled plastic must contain a minimum 85 percent of recycled content.

2.5.1 High Density Polyethylene

The material must be molded of ultraviolet (UV) and color stabilized polyethylene; and consist of a minimum 75 percent plastic profile of high-density polyethylene, low-density polyethylene, and polypropylene raw material. The material must be non-toxic and have no discernible contaminants such as paper, foil, or wood. The material must contain no more than 3 percent air voids. The material must be free of splinters, chips, peels, buckling, and cracks. Material must be resistant to deformation from solar heat gain. Material must have factory-drilled holes. Components with extra holes not filled by hardware or covered by other components must be rejected. The material must not be painted.

2.5.2 Structural Component

Recycled plastic materials will not be used as load bearing structural members.

2.5.3 Recycled Plastic Molded As Lumber

The component deflection must not exceed 1/360 of the span of the frame when exposed to a uniform live load of 40 lbs/ft. The product must meet the structural integrity test requirements set forth in ASTM F1487 and ASTM D6112.

2.6 CURBS

2.6.1 Concrete Curb

Concrete curbs must conform to Section 32 16 19 CONCRETE CURBS, GUTTERS AND SIDEWALKS.

2.6.2 Wood

2.6.2.1 Wood Components

Wood components must be exterior premium grade and free of knots. Wood components must have factory-drilled holes. Components with extra holes not filled by hardware or covered by other components must be rejected.

2.6.2.2 Wood Treatment

Wood components that are not naturally rot and insect resistant must be treated to resist rot and insect attack by using standard treatment procedures. Provide wood treatment chemical content, toxicity level, and life-cycle durability. Any wood placed up to a maximum 6 inches above, or any portion below the top elevation of the protective surfacing, must be treated after fabrication. Creosote, pentachlorophenol, and tributyl tin oxide are prohibited according to ASTM F1487.

PART 3 EXECUTION

3.1 SITE PREPARATION

Prior to installing the protective surfacing, verify the playground equipment and site furnishings are installed in accordance with Section 11 68 13 PLAYGROUND EQUIPMENT, and Section 12 93 00 SITE FURNISHINGS.

3.1.1 Finished Grade and Underground Utilities

Submit finished grade, underground utilities, storm-drainage system and irrigation system status; and location of underground utilities and facilities. Verify that finished grades are as indicated; the smooth grading has been completed in accordance with Section 31 00 00 EARTHWORK; installation of the underground utilities through the area has been completed in accordance with Section 31 00 00 EARTHWORK; installation of the storm-drainage system through the area has been completed in accordance with Section 33 40 00 STORMWATER UTILITIES; and the installation of underground sprinklers through the area has been completed in accordance with Section 32 84 24 UNDERGROUND SPRINKLER SYSTEMS. The location of underground utilities and facilities in the area of the operation must be verified. Damage to underground utilities and facilities must be repaired at the Contractor's expense.

3.1.2 Layout

The layout of the entire use zone perimeter must be staked before excavation begins. The location of all elements must be staked to include the following: All play event configuration access and egress points; and use zone perimeters. The use zone is defined as the area beneath and immediately adjacent to a play structure or equipment that is designated for unrestricted circulation around equipment; and on whose surface it is predicted that a user would land when falling from or exiting the equipment. Also, the use zone is associated with the following terms; "Clear Area," and "Fall Zone". The use zone must be free of hard surfaces, objects or obstacles that a child could run into or fall on top of and be injured. Use zone perimeters must not overlap hard surfaces. The use zone perimeter must meet or exceed the requirements of paragraphs CHILD SAFETY and CHILD ACCESSIBILITY. Use zone perimeters must not overlap except for certain play events as defined in ASTM F1487.

3.1.3 Obstructions Below Ground

When obstructions below ground affect the work, shop drawings showing proposed adjustments must be provided.

3.1.4 Percolation Test

Submit a certified report of inspection, test method used and compliance with recognized test standard must be described. A test for percolation must be done to determine positive drainage, to include the lowest elevation of the subgrade in the areas containing the following: sand; gravel; wood by-products; or synthetic surfacing installed over a pervious base. A positive percolation must consist of a minimum 1 inch per 3 hour period. When a negative percolation test occurs, a shop drawing must be provided to indicate the corrective measures.

3.1.5 Substitution

Under no circumstances are substitutions to be allowed or protective surfacing to be selected without written approval from the technical representative. Evaluate manufacturer substitutions for the critical height value with meeting the site conditions and paragraph FALL HEIGHT.

3.1.6 Subgrade

Correct subgrade irregularities to ensure the required depth of protective surfacing is provided. The subgrade elevation must be as required by the manufacturer.

3.1.7 Subsurface

Install the subsurface in a true, even plane, and sloped to provide positive drainage as indicated.

3.1.8 Subbase

Tolerance of the concrete or bituminous subbase must be within a maximum 1/4 inch in 10 feet. Tolerance of aggregate subbase must be within a maximum similar to 1/4 inch in 10 feet. Compact aggregate subbase to a maximum 95 percent, ASTM D1557. The compaction must be completed in accordance with Section 31 00 00 EARTHWORK. Sand, gravel, and wood products must not be installed over a concrete, aggregate, or bituminous subbase, in accordance with paragraph CHILD SAFETY.

3.1.9 Concrete or Bituminous Curing

Bituminous or concrete subbase must be cured a minimum of 7 days . Curing compounds and other deleterious substances that adversely affect adhesion must be removed. Surface must be clean and dry.

3.1.10 Fall Height

3.1.10.1 General Requirements

The fall height is defined as the vertical distance between the finished elevation of the designated play surface and the finished elevation of the protective surfacing beneath it. For some play events the fall height and platform height are the same, while for other play events the fall height and maximum equipment height are the same, Section 11 68 13 PLAYGROUND EQUIPMENT. When the furnished play event fall height varies from the play event shown, shop drawings must be provided defining the revised depth or type of protective surfacing to meet or exceed the requirements of paragraphs CHILD SAFETY and CHILD ACCESSIBILITY.

3.1.10.2 Measuring Fall Height

EQUIPMENT	MEASURING FALL HEIGHT
Composite Equipment Structure	For a platform surrounded by protective barriers, measure from the platform finished elevation.
	For a platform surrounded by guardrails, measure from the guardrail top elevation.
Infant Crawl Area	A maximum 24 inches height, measured from the crawl wall or barrier finished elevation.
Playhouse, Nonclimbable	Measure from the designated play surface finished elevation.
Spring Rocking Equipment	Measure from the seat top elevation.
Stationary Equipment, Climbable	Measure from the maximum equipment height finished elevation.
Stationary Equipment, Nonclimbable	Measure from the designated play surface finished elevation.
Swing	Measure from the bottom of the pivot point.

3.2 INSTALLING SYNTHETIC SURFACING SYSTEM

Surfacing edges must fully adhere to the subsurface. Fully cover the subsurface to ensure no hard surfaces are exposed through displacement of loose fill. Rolled or beveled containment curb or transition edges must maintain the full thickness required to meet paragraphs CHILD SAFETY and CHILD ACCESSIBILITY. Material must cover foundation and cutouts around elements penetrating the surface. Seams must be the minimum necessary and must be tight.

3.2.1 Temperature Limitation

Provide temperature limitations for applying adhesive.

3.2.2 Poured-in-Place System

Components of the poured-in-place system must be mixed mechanically on site in accordance with manufacturer's recommendations. Hand-mixing is prohibited. Installation of poured-in-place surfacing must be seamless and completely bonded to subsurface. Material must cover foundations and must be tight around elements penetrating the surface. Add a minimum 1/16 inch depth to the required surfacing depth to ensure the full depth of material is installed to meet paragraph CHILD SAFETY.

3.2.2.1 Geotextile Fabric for Poured-In-Place

Install geotextile fabric over a compacted aggregate base as indicated. Fabric must cover the entire area and must be lapped a minimum 4 inch width at the seams. Seams must be adhered in accordance with manufacturer's recommendations. The aggregate base must be free of ruts or protruding objects. The fabric must be installed smooth; and free of tensile stresses, folds, and wrinkles. The fabric must be protected from clogging, tears, or other damage. Damaged fabric must be repaired or replaced as directed.

3.2.2.2 Poured-in-Place Substrate

The substrate layer of the poured-in-place system must be installed in one continuous pour on the same day. When a second pour is required, the edge of the previous work must be fully coated with polyurethane binder to ensure 100 percent bond with new work. Adhesive must be applied in small quantities so that new substrate can be placed before the adhesive dries.

3.2.2.3 Poured-in-Place Wear Surface

Wear surface must be bonded to substrate. Adhesive must be applied to substrate in small quantities so that wear surface can be applied before adhesive dries. Surface must be hand troweled to a smooth, even finish. When wear surface is composed of different color patterns, pour must be continuous and seamless. When seams are required due to color change or field conditions, the adjacent wear surface must be placed as soon as possible, before initial pour has cured. The edge of initial pour must be coated with adhesive and wear surface mixture must be immediately applied.

3.2.3 Tile System

Tile must be laid out to ensure that end cuts are equal. Tile must be installed in accordance with manufacturer's instructions. Hardware must be as recommended by the manufacturer. Tile must be bonded to the subsurface with an adhesive approved by the manufacturer. Cutouts must be filled with sealant according to manufacturer's instructions to eliminate voids at equipment. Sealant must be the minimum amount necessary, must not exceed a maximum 3/8 inch width. Where excessive voids occur at cutouts, tile must be removed and refitted. The tile system must be installed throughout the play equipment use zone with the proper thickness.

3.2.4 Combination System

The combination system must consist of modular impact attenuating substrate units, adhered to form a unified system, shredded rubber tires over a gravel substrate . The substrate must be covered with a wear surface as specified. Cutouts around equipment must be properly filled and sealed according to manufacturer's instructions to eliminate voids. Sealant must be the minimum amount necessary, must not exceed a maximum 3/8 inch width. Where excessive voids occur at cutouts, the modular substrate must be removed and refitted. Construction methods must be employed to ensure full depth installation of specified surfacing material and the finished wear surface.

3.2.4.1 Geotextile Fabric

Geotextile fabric must be installed where a modular or shredded rubber substrate is installed over an aggregate base. It should be installed with poured-in-place wear surface or polyethylene plastic woven sheet wear surface installed over substrate. Fabric must cover the entire area to receive the tile system and must be lapped a minimum 4 inch width at the seams. Seams must be adhered in accordance with manufacturer's recommendations.

3.2.4.2 Modular Substrate

Modular substrate must be laid out to minimize small end pieces. The substrate must be installed in accordance with manufacturer's instructions.

3.2.4.3 Poured-in-Place Substrate

Same as paragraph POURED-IN-PLACE SYSTEM.

3.2.4.4 Synthetic Turf Wear Surface

Wear surface must be bonded to substrate with 100 percent solids polyurethane adhesive. Surface irregularities and wrinkles must be corrected. Seams must be secured in accordance with manufacturer's recommendations. Wear surface roll width must be as wide as practical for the installation.

3.2.4.5 Rubber Sheet Wear Surface

Wear surface must be bonded to substrate with 100 percent solids polyurethane adhesive. Surface irregularities and wrinkles must be corrected. Seams must be secured in accordance with manufacturer's recommendations. Wear surface roll width must be as wide as practical for the installation.

3.2.4.6 Poured-in-Place Wear Surface

Same as paragraph POURED-IN-PLACE SYSTEM.

3.2.4.7 Polyethylene Plastic Woven Sheet Wear Surface

Wear surface must be securely anchored to a perimeter containment material with hardware in accordance with the manufacturer's instructions. Hardware must be appropriate for the type of system and secured to eliminate protrusions.

3.3 LOOSE FILL SURFACING SYSTEM

Submit a minimum 0.125 cubic foot sample.

3.3.1 Sand Surfacing System

Sand must be installed over a compacted subgrade at a minimum 18 inches depth throughout the use zone. The finished elevation of sand must be determined after sand has been settled by saturating with water and percolating. The sand depth in high play activity areas must be as indicated. Sand must meet the requirements of paragraph CHILD SAFETY.

3.3.2 Gravel Surfacing System

Gravel must be installed over a compacted subgrade at a minimum 12 inch depth throughout the use zone. The depth of gravel in high play activity areas must be as indicated. Gravel must meet the requirements of paragraph CHILD SAFETY.

3.3.3 Wood By-Product Surfacing System

Engineered wood fiber protective surfacing must be installed according to manufacturer's instructions. Wood products must meet the requirements of paragraph CHILD SAFETY.

3.3.3.1 Wood Mulch Surfacing System

Wood mulch must be installed over a compacted subgrade covered with geotextile fabric. Wood mulch must meet the requirements of paragraph CHILD SAFETY.

3.3.3.2 Engineered Wood Fiber Surfacing System

Engineered wood fiber protective surfacing must be installed according to manufacturer's instructions. The surfacing must meet the requirements of paragraphs CHILD SAFETY and CHILD ACCESSIBILITY.

3.3.3.3 Geotextile Fabric for Wood By-Product

Geotextile fabric must cover the entire area and must be lapped a minimum 4 inch width at the seams. Seams must be adhered in accordance with manufacturer's recommendations. Folds, wrinkles, or loose fabric must be smoothed. Fabric must be protected from damage during wood product placement.

3.3.3.4 Minimum Depth for Wood By-Product

Wood by-product must be installed at a minimum12 inch depth throughout the use zone. The depth of wood products in high play activity areas must be as indicated.

3.4 RESTORATION AND CLEAN UP

When the operation has been completed, clean up and protect the site. Existing areas that have been damaged from the operation must be restored to original condition at the Contractor's expense.

3.4.1 Clean Up

The site and play events must be cleaned of all materials associated with the operation. Play events and surfaces must be cleaned of dirt, stains, filings, and other blemishes occurring from shipment and installation. Cleaning methods and agents must be as recommended by the manufacturer.

3.4.2 Protection

The area must be protected as required or directed by providing barricades and signage. Signage must be in accordance with Section 10 14 00.10 EXTERIOR SIGNAGE.

3.4.3 Disposal of Materials

Excess and waste material must be removed and disposed of off Government property.

3.5 PROTECTIVE SURFACING ACCEPTANCE

Submit record of measurements and findings by the certified playground safety inspector. When the protective surfacing is installed, the play events and protective surfacing must be thoroughly inspected and measured to verify the playground meets manufacturer's recommendations, paragraphs CHILD SAFETY and CHILD ACCESSIBILITY, and paragraph FALL HEIGHT as follows: 1) secure anchoring; 2) all hardware and connectors are tight and below the wear surface; 3) sharp points, edges, and protrusions; 4) entanglement; and 5) pinch, crush, and shear points.

a. Measure use zone distances to determine the area is free of hard surfaces, objects or obstacles. Determine exceptions to use zone overlaps occur in accordance with ASTM F1487. Measure play event fall height and compare to critical height value for the thickness of installed synthetic surfacing. Measure play event fall height and depth of loose fill protective surfacing.

b. Ensure installed chopped tire material is free from steel belts. Ensure the slide exit region has the required clear zone. Swing seat clearances are measured while occupied by a maximum user for the age group using the equipment.

c. The finished installation must have the appearance of a single covering. Protective surfacing that does not comply must be reinstalled. Hardware that does not comply must be replaced. Ensure positive drainage for the area and the lowest elevation of protective surfacing subgrade has been provided.

d. A written report describing the results of the evaluation must be provided.

3.6 RE-INSTALLATION

When re-installation is required, the following must be accomplished at no additional cost to the Government re-install the product as specified; provide new replacement materials supplied by the manufacturer; repair any damage caused by the failed installation.

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SECTION 32 31 13

CHAIN LINK FENCES AND GATES
11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A392	(2011a; R 2017) Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A824	(2001; R 2017) Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use With Chain Link Fence
ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM F567	(2014a; R 2019) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2014; R 2019) Standard Specification for Fence Fittings
ASTM F668	(2017) Standard Specification for Polyvinyl Chloride (PVC) and Other Polymer-Coated Steel Chain Link Fence Fabric
ASTM F883	(2013; R 2022) Standard Performance Specification for Padlocks
ASTM F934	(1996; R 2017) Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials
ASTM F1043	(2018) Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-F-191/1	(Rev F) Fencing, Wire and Post, Metal (Chain-Link Fence Fabric)
FS RR-F-191/2	(Rev E) Fencing, Wire and Post, Metal (Chain-Link Fence Gates)

FS RR-F-191/3	(Rev E; Am 1) Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)
FS RR-F-191/4	(Rev F) Fencing, Wire and Post, Metal (Chain-Link Fence Accessories)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fence Assembly; G

Location of Gate, Corner, End, and Pull Posts; G

Gate Assembly; G

Gate Hardware and Accessories; G

Erection/Installation Drawings; G

SD-03 Product Data

Fence Assembly; G

Gate Assembly; G

Gate Hardware and Accessories; G

Zinc Coating; G

PVC Coating; G

Aluminum Alloy Coating; G

Fabric; G

Stretcher Bars; G

Concrete; G

SD-04 Samples

Fabric; G

Posts; G

Braces; G

Line Posts; G

Sleeves; G

Top Rail; G

Bottom Rail; G

Tension Wire; G

Stretcher Bars; G

Gate Posts; G

Gate Hardware and Accessories; G

Wire Ties; G

SD-07 Certificates

Certificates of Compliance

SD-08 Manufacturer's Instructions

Fence Assembly

Gate Assembly

Hardware Assembly

Accessories

SD-11 Closeout Submittals

Recycled Material Content

1.3 QUALITY CONTROL

1.3.1 Certificates of Compliance

Submit certificates of compliance in accordance with the applicable reference standards and descriptions of this section for the following:

a. Zinc coating

b. PVC coating

c. Aluminum alloy coating

d. Fabric

e. Stretcher bars

f. Gate hardware and accessories

g. Concrete

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit reports of listing chain-link fencing and accessories regarding weight in ounces for zinc coating, thickness of PVC coating, and chemical composition and thickness of aluminum alloy coating.

Submit manufacturer's catalog data for complete fence assembly, gate assembly, hardware assembly and accessories.

2.2 FENCES

2.2.1 Fabric

FS RR-F-191/1; Type IV, Class 2b polyvinyl chloride (PVC) coated over zinc- or aluminum-coated steel, 9-gauge core wire size, conforming to ASTM F668. Color to be black complying with ASTM F934.I, zinc-coated steel, 9 gauge conforming to ASTM A392, with 1.20 ounces per square foot of coated surface . Provide selvage knuckled at one selvage and twisted and barbed at the other . Height of fabric, as indicated.

Provide fabric consisting of wires woven into a 2 inch diamond mesh. Provide one-piece fabric widths for fence heights up to 12 feet.

2.2.1.1 Top and Bottom Selvages

Provide knuckled selvages at top and bottom for fabric with 2 inch mesh and up to 60 inches high, and if over 60 inches high, provide twisted and barbed top selvage and knuckled bottom selvage.

Knuckle top and bottom selvages for 1-3/4 inch and 1 inch mesh fabric.

2.2.2 Posts

2.2.2.1 Metal

2.2.2.1.1 Line Posts

Provide line posts complying with FS RR-F-191/3. Provide Class 1, steel pipe, Grade A High Strength or , in minimum sizes listed in FS RR-F-191/3 for each class and grade .

2.2.2.1.2 End, Corner and Pull Posts

Provide end, corner, and pull posts in minimum sizes listed in FS RR-F-191/3 for each class and grade . Provide Class 1, steel pipe, Grade A High Strength , , .

2.2.2.1.3 Steel Pipe, Class 1, Grade B Test Requirements

Steel pipe, Class 1, Grade B meeting the following performance criteria when subjected to salt spray testing in accordance with ASTM B117:

a. Exterior: 1,000 hours with maximum 5 percent red rust.

b. Interior: 650 hours with maximum 5 percent red rust.

2.2.2.1.4 PVC Coating on Posts and Rails

Provide PVC color coating, minimum thickness, 0.01 inch fused and adhered to the exterior coating of the posts and rails in accordance with ASTM F1043; color to match fabric in accordance with ASTM F934.

2.2.2.2 Post Tops

Provide steel, wrought iron, or malleable iron tops and designed as a weathertight closure cap. Post top to have finish and coating matching rails and posts. Steel type to be pressed steel galvanized after fabrication having a minimum zinc coating of 1.20 ounces per square foot. Provide one cap for each post, unless equal protection is provided by a combination post-cap and wire supporting arm. Provide caps with an opening to permit through passage of the top rail.

2.2.3 Braces and Rails

Class 1, steel pipe, Grade A High Strength or , in minimum sizes listed in FS RR-F-191/3 for each class and grade . Provide PVC color coating, minimum thickness, 0.01 inch in accordance with ASTM F1043; color to match fabric in accordance with ASTM F934.

2.2.3.1 Top Rail

Provide top rail conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade unless members are to be oversized. Provide expansion couplings 6 inches long at each joint in top rails.

2.2.3.2 Center Rails Between Line Posts

Provide center rail conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade unless members are to be oversized.

2.2.3.3 Bottom Rail

Provide bottom rail conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade unless members are to be oversized.

2.2.3.4 Post-Brace Assembly

Provide bracing conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade, and 3/8 inch adjustable truss rods and turnbuckles.

2.2.4 Wire Ties

Provide 9-gauge wire for tying fabric to line posts,spaced 12 inches on center. For tying fabric to rails and braces, space wire ties 24 inches on center. For tying fabric to tension wire, space 0.105-inch hog rings 24 inches on center. Manufacturer's standard procedure will be accepted if of equal strength and durability.

FS RR-F-191/4. Provide wire ties constructed of the same material and coating as the fencing fabric.

2.2.5 Sleeves

Provide sleeves for setting into concrete construction of the same material as post sections, sized 1 inch greater than the diameter or dimension of the post. Weld flat plates to each sleeve base to provide anchorage and prevent intrusion of concrete.

2.2.6 Stretcher Bars

Provide bars that have one-piece lengths equal to the full height of the fabric with a minimum cross section of 3/16 by 3/4 inch, in accordance with ASTM F626.

2.2.7 Stretcher Bar Bands

Provide bar bands for securing stretcher bars to posts that are steel, wrought iron, or malleable iron spaced not over 15 inches on center. Bands may also be used in conjunction with special fittings for securing rails to posts. Provide bands with projecting edges chamfered or eased.

2.2.8 Tension Wire

Provide metallic coated steel marcelled tension wire,(No. 7-gauge) complying with ASTM A824. Provide zinc-coated steel wire with zinc coating that weighs not less than 1.2 ounces per square foot.

2.2.9 Miscellaneous Hardware

Provide miscellaneous hot-dip galvanized hardware as required.

2.3 GATES

FS RR-F-191/2; Type I, single swing II, double swing III, single cantilever sliding, wheel sliding gate IV, double cantilever sliding V, single overhead sliding VI, double overhead sliding VII, vertical lift VIII, special. Shape and size of gate frame, as indicated . Framing and bracing members, round or square of steel alloy. Steel member finish, zinc-coated or PVC-coated over zinc- or aluminum-coated steel. Provide gate frames and braces of minimum sizes listed in FS RR-F-191/3 for each Class and Grade, except that steel pipe frames are a minimum of 1.90 inches o.d., 0.120 inches minimum wall thickness and aluminum pipe frames and intermediate braces are 1.869 inches o.d. minimum, 0.940 lb/ft of length. Provide intermediate members as necessary for gate leaves more than 8 feet wide, to provide rigid construction, free from sag or twist. Provide truss rods or intermediate braces for gate leaves less than 8 feet wide.

2.3.1 Gate Posts

Provide gate posts for supporting each gate leaf in minimum sizes listed in FS RR-F-191/3 for each material class and grade . Gate post material class, grade and finish to match other fence posts.

2.3.2 Gate Fabric

Gate fabric, is as specified for fencing fabric. Attach gate fabric to gate frame in accordance with manufacturer's standards, except that welding is not permitted.

2.3.3 Gate Frame

Provide gate frame assembly that is welded or assembled with special malleable or pressed-steel fittings and rivets to provide rigid connections. Install fabric with stretcher bars at vertical edges;

stretcher bars may also be used at top and bottom edges. Attach stretcher bars and fabric to gate frames on all sides at intervals not exceeding 15 inches. Attach hardware with rivets or by other means which provides equal security against breakage or removal.

Provide special gate frames, as indicated.

2.3.4 Gate Bracing

Provide diagonal cross-bracing, consisting of 3/8 inch diameter adjustable-length truss rods on welded gate frames, where necessary to obtain frame rigidity without sag or twist. Provide nonwelded gate frames with diagonal bracing.

2.3.5 Padlocks

Provide padlocks conforming to ASTM F883, with chain.

2.3.6 Gate Hardware and Accessories

Provide gate hardware and accessories that conforms to ASTM A392 and ASTM F626, and as specified. Coating for steel latches, stops, hinges, keepers, and accessories, is galvanized

a. Provide malleable iron forged steel pressed steel hinges to suit gate size, non-lift-off type, offset to permit 180-degree opening. Provide hinge with stainless steel pin.

b. Provide latch that permits accessibility and operation from either side of the gate regardless of the latching arrangement, and with a padlock eye provided as an integral part of the latch. Provide fork and plunger bar type gate latches.

c. Provide stops and holders of malleable iron for vehicular gates. Provide stops that automatically engage the gate and hold it in the open position until manually released.

d. Provide accessories with polyvinyl (PVC) coatings matching that specified for chain-link fabric or framework.

e. Provide double gates with a cane bolt and ground-set keeper, with latch or locking device and padlock eye designed as an integral part.

f. Provide manufacturer's standard heavy-duty track ball bearing hanger sheaves, overhead framing and supports, guides, stays, bracing, and accessories as required for easy operation of manual sliding gates.

2.4 MATERIALS

2.4.1 Zinc Coating

Provide zinc-coated ferrous metal components and accessories that are factory coated after fabrication, except as otherwise specified.

For galvanizing field repairs, provide material that is cold-applied zinc-rich coating conforming to ASTM A780/A780M.

2.4.2 Concrete

Provide concrete conforming to ASTM C94/C94M, and obtaining a minimum 28-day compressive strength of 3,000 psi.

2.4.3 Grout

Provide grout of proportions one part portland cement to three parts clean, well-graded sand and a minimum amount of water to produce a workable mix.

PART 3 EXECUTION

Submit manufacturer's erection/installation drawings and instructions that detail proper assembly and materials in the design for fence, gate, hardware and accessories.

Provide complete installation conforming to ASTM F567.

3.1 PREPARATION

Ensure final grading and established elevations are complete prior to commencing fence installation.

3.1.1 Clearing and Grading

Clear fence line of trees, brush, and other obstacles to install fencing for a distance of 8 feet inside; and 8 feet outside the fence. Establish a graded, compacted fence line prior to fencing installation.

3.2 INSTALLATION

3.2.1 Security

Install new chain link fencing, remove existing fencing, and perform related work to provide continuous security for facility. Schedule and fully coordinate work with Contracting Officer and cognizant Security Officer.

3.2.2 Fence Installation

Install fence on prepared surfaces to line and grade indicated. Secure fastening and hinge hardware in place to fence framework by peening or welding. Allow for proper operation of components. Coat peened or welded areas with a repair coating matching original coating. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

3.2.2.1 Post Spacing

Provide line posts spaced equidistantly apart, not exceeding 10 feet on center. Provide gate posts spaced as necessary for size of gate openings. Do not exceed 500 feet on straight runs between braced posts. Provide corner or pull posts, with bracing in both directions, for changes in direction of 15 degrees or more, or for abrupt changes in grade. Submit drawings showing location of gate, corner, end, and pull posts.

3.2.2.2 Top and Bottom Tension Wire

Install top and bottom tension wires before installing chain-link fabric, and pull wires taut. Place top and bottom tension wires within 8 inches of respective fabric line.

3.2.3 Excavation

Provide excavations for post footings which are drilled holes in virgin or compacted soil, of minimum sizes as indicated. Space footings for line posts 10 feet on center maximum and at closer intervals when indicated, with bottoms of the holes approximately 3 inches below the bottoms of the posts. Set bottom of each post not less than 36 inches below finished grade when in firm, undisturbed soil. Set posts deeper, as required, in soft and problem soils and for heavy, lateral loads. Remove excavated soil from Government property.

When solid rock is encountered near the surface, drill into the rock at least 12 inches for line posts and at least 18 inches for end, pull, corner, and gate posts. Drill holes at least 1 inch greater in diameter than the largest dimension of the placed post. If solid rock is below the soil overburden, drill to the full depth required except that penetration into rock need not exceed the minimum depths specified above.

3.2.4 Setting Posts

Remove loose and foreign materials from holes and moisten the soil prior to placing concrete. Provide tops of footings that are trowel finished and sloped or domed to shed water away from posts. Set hold-open devices, sleeves, and other accessories in concrete.

Keep exposed concrete moist for at least 7 calendar days after placement or cured with a membrane curing material, as approved. Grout all posts set into sleeved holes in concrete with an approved grouting material. Maintain vertical alignment of posts in concrete construction until concrete has set.

3.2.4.1 Earth and Bedrock

Provide concrete bases of dimensions indicated on the manufactures installation drawings. Compact concrete to eliminate voids, and finish to a dome shape.

3.2.4.2 Bracing

Brace gate, corner, end, and pull posts to nearest post with a horizontal brace used as a compression member, placed at least 12 inches below top of fence, and two diagonal tension rods.

3.2.4.3 Tolerances

Provide posts that are straight and plumb within a vertical tolerance of 1/4 inch after the fabric has been stretched. Provide fencing and gates that are true to line with no more than 1/2 inch deviation from the established centerline between line posts. Repair defects as directed.

3.2.5 Concrete Strength

Provide concrete that has attained at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than 7 calendar days after placement, before rails, tension wire, or fabric are installed. Do not stretch fabric and wires or hang gates until the concrete has attained its full design strength.

Sample and test concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.6 Top Rails

Provide top rails that run continuously through post caps or extension arms, bending to radius for curved runs. Provide expansion couplings as recommended by the fencing manufacturer.

3.2.7 Center Rails

Provide single piece center rails between posts set flush with posts on the fabric side, using special offset fittings where necessary.

3.2.8 Brace Assembly

Provide bracing assemblies at end and gate posts and at both sides of corner and pull posts, with the horizontal brace located at midheight of the fabric.

Install brace assemblies so posts are plumb when the diagonal rod is under proper tension. Provide two complete brace assemblies at corner and pull posts where required for stiffness and as indicated.

3.2.9 Tension Wire Installation

Install tension wire by weaving them through the fabric and tying them to each post with not less than 7-gauge galvanized wire or by securing the wire to the fabric with 10-gauge ties or clips spaced 24 inches on center.

3.2.10 Fabric Installation

Provide fabric in single lengths between stretch bars with bottom barbs placed approximately 1-1/2 inches above the ground line. Pull fabric taut and tied to posts, rails, and tension wire with wire ties and bands.

Install fabric on the security side of fence, unless otherwise directed. Ensure fabric remains under tension after the pulling force is released.

3.2.11 Stretcher Bar Installation

Thread stretcher bars through or clamped to fabric 4 inches on center and secured to posts with metal bands spaced 15 inches on center.

3.2.12 Gate Installation

Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.

3.2.13 Tie Wires

Provide tie wires that are U-shaped to the pipe diameters to which attached. Twist ends of tie wires not less than two full turns and bent so as not to present a hazard.

3.2.14 Fasteners

Install nuts for tension bands and hardware on the side of the fence opposite the fabric side. Peen ends of bolts to prevent removal of nuts.

3.2.15 Zinc-Coating Repair

Clean and repair galvanized surfaces damaged by welding or abrasion, and cut ends of fabric, or other cut sections with specified galvanizing repair material applied in strict conformance with the manufacturer's printed instructions.

3.2.16 Accessories Installation

3.2.16.1 Post Caps

Design post caps to accommodate top rail. Install post caps as recommended by the manufacturer.

3.2.16.2 Padlocks

Provide padlocks for gate openings and provide chains that are securely attached to gate or gate posts. Provide padlocks keyed alike, and provide two keys for each padlock.

3.2.17 Grounding

Ground fencing as and specified.

Ground all fences crossed by overhead power lines in excess of 600 volts, and all electrical equipment attached to the fence. Ground fences on each side of all gates, at each corner, at the closest approach to each building located within 50 feet of the fence, and where the fence alignment changes more than 15 degrees. Grounding locations can not exceed 650 feet. Bond each gate panel with a flexible bond strap to its gate post. Ground fences crossed by power lines of 600 volts or more at or near the point of crossing and at distances not exceeding 150 feet on each side of crossing. Provide ground conductor consisting of No. 6 AWG solid copper wire. Provide copper-clad steel rod grounding electrodes3/4 inch by 10 foot long. Drive electrodes into the earth so that the top of the electrode is at least 6 inches below the grade. Where driving is impracticable, bury electrodes a minimum of 12 inches deep and radially from the fence, with top of the electrode not less than 2 feet or more than 8 feet from the fence. Clamp ground conductor to the fence and electrodes with bronze grounding clamps to create electrical continuity between fence posts, fence fabric, and ground rods. Total resistance of the fence to ground cannot exceed 25 ohms.

3.3 CLOSEOUT ACTIVITIES

Remove waste fencing materials and other debris from the work site.

Submit manufacturer's data indicating percentage of recycled material content in protective fence materials, including chain link fence, fabric, and gates to verify affirmative procurement compliance.

-- End of Section --

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SECTION 32 31 13.53

HIGH-SECURITY FENCES (CHAIN LINK AND ORNAMENTAL) AND GATES
11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A392	(2011a; R 2017) Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A478	(1997; R 2019) Standard Specification for Chromium-Nickel Stainless Steel Weaving and Knitting Wire
ASTM A666	(2015) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A824	(2001; R 2017) Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use With Chain Link Fence
ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM F567	(2014a; R 2019) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2014; R 2019) Standard Specification for Fence Fittings
ASTM F883	(2013; R 2022) Standard Performance Specification for Padlocks
ASTM F900	(2011; R 2017) Standard Specification for Industrial and Commercial Swing Gates

ASTM F1043	(2018) Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework
ASTM F1083	(2018) Standard Specification for Pipe, Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures
ASTM F1184	(2016) Standard Specification for Industrial and Commercial Horizontal Slide Gates
ASTM F1910	(1998; R 2018) Standard Specification for Long Barbed Tape Obstacles
ASTM F1911	(2005; R 2019) Standard Practice for Installation of Barbed Tape
ASTM F2408	(2016) Standard Specification for Ornamental Fences Employing Galvanized Steel Tubular Pickets
ASTM F2814	(2009; R 2015) Standard Guide for Design and Construction of Ornamental Steel Picket Fence Systems for Security Purposes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fence Installation Drawings; G

SD-03 Product Data

Fabric

Posts

Post Caps

Chain Link Braces

Line Posts

Sleeves

Rails

Tension Wire

Barbed Wire

Barbed Wire Supporting Arms

Barbed Tape

Latches

Hinges

Stops

Keepers

Rollers

Turnstiles

Padlocks

Wire Ties

Ornamental Fence Systems

Swing Gates

Slide Gates

Fence Fabric Reinforcement

SD-07 Certificates

Chain Link Fence

Fabric

Barbed Wire

Gate Hardware and Accessories

Concrete

Gate Operator

SD-10 Operation and Maintenance Data

Electro-Mechanical Locks

Gate Operator

Operating and maintenance instructions

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials elevated off of the ground to protect against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 COMPONENTS

2.1.1 Chain Link Fence Fabric

2.1.1.1 General

Provide ASTM A392, Class 2, zinc-coated steel wire with minimum coating weight of 2.0 ounces of zinc per square foot of coated surface. Fabricate fence fabric of 9 gauge wire woven in 2 inch diamond mesh. Provide twisted and barbed fabric on the top selvage and knuckled on the bottom selvage.

2.1.1.2 Approval Of Polyvinyl Chloride-Coated Fence Materials

Inspect polyvinyl chloride-coated fence materials for cracking, peeling, and conformance with the specifications prior to installation. Replace any fence materials rejected by the Contracting Officer with approved materials at no additional cost to the Government.

2.1.2 Ornamental Fence Systems

Submit manufacturer's catalog data. Provide ASTM F2814 structural components consisting of tubular steel ornamental pickets and rails. Provide ASTM F2408 industrial class pickets with a minimum cross-sectional area of 1 sq in and a minimum wall thickness of 14 gauge. Provide pickets with spear-pointed tips extending a minimum of 6 in above the top rail of the fence. Mount pickets to a top and bottom rail spaced a maximum of 80 inches apart. Space pickets along rails with a maximum gap not to exceed 2.25 inches. Secure pickets to rails by welding . Provide all items and accessories finished by PVC powder-coating or painting in dark bronze.

Add the following accessories to further harden the Ornamental Fence System: spiked railing along the top rail . Accessories are specified separately in this section.

2.1.3 Posts

2.1.3.1 Metal Posts for Chain Link Fence

Provide posts conforming to ASTM F1083, zinc-coated. Group IAHigh Strength steel pipe. Group IC steel pipe. Provide sizes as shown on the drawings. Use line posts and terminal (corner, gate, and pull) posts of the same designation throughout the fence. Provide gate post for the gate type specified subject to the limitation specified in ASTM F900 or ASTM F1184.

2.1.3.2 Accessories

a. Provide accessories conforming to ASTM F626. Coat ferrous accessories with `

b. Provide truss rods (with turnbuckles or other means of adjustment)for each terminal post.

c. Provide barbed wire supporting arms of the 45 degree outward angle 3-strand arm type and of the design required for the post furnished. Secure arms by top railboltingriveting.

d. Furnish post caps in accordance with manufacturer's standard accessories with coating matching that of fence posts.

e. Provide 9 gauge tie wire for attaching fabric to rails, braces, and posts and match the material and coating of the fence fabric. Use tie wires for attaching fabric to tension wire on high security fences made from 16 gauge stainless steel. Provide double loop tie wires 6.5 inches in length. Provide miscellaneous hardware coatings which conform to ASTM A153/A153M unless modified.

2.1.4 Chain Link Braces and Rails

ASTM F1083, zinc-coated, Group IA High Strength, steel pipe, size NPS 1-1/4. Provide Group IC steel pipe, zinc-coated, with PVC polymer overcoat that meets the strength and coating requirements of ASTM F1043. Use braces and rails that are Group IA High Strength Group IC, steel pipe, size NPS 1-1/4 or Group II, formed steel sections, size 1-21/32 inch and be zinc coated and polyvinyl chloride-coated, minimum thickness, 0.01 inch conforming to the requirements of ASTM F1043. Group II, formed steel sections, size 1-21/32 inch, conforming to ASTM F1043, may be used as braces and rails if Group II line posts are furnished. Provide rails and braces with polyvinyl chloride coating, minimum thickness, 0.01 inch conforming to ASTM F1043; color of PVC coating to match that of fabric.

2.1.5 Chain Link Gates

2.1.5.1 Gate Assembly

Provide gate assembly conforming to ASTM F900 and/or ASTM F1184 of the type and swing shown. Provide gate frames conforming to strength and coating requirements of ASTM F1083 for Group IA High Strength, steel pipe, nominal pipe size (NPS) 1-1/2. Use gate fabric that matches the specified chain link fabric.

2.1.5.2 Gate Leaves

For gate leaves, more than 8 feet wide, provide either intermediate members and diagonal truss rods or tubular members as necessary to provide rigid construction, free from sag or twist. For gate leaves less than 8 feet wide, provide truss rods or intermediate braces. Provide intermediate braces on all gate frames with an electro-mechanical lock. Attach fabric to the gate frame by method standard with the manufacturer. Welding is not an acceptable method for attaching fabric to gate frames.

2.1.5.3 Gate Hardware and Accessories

Submit manufacturer's catalog data. Furnish and install latches, hinges, stops, keepers, rollers, and other hardware items as required for the operation of the gate. All items are required to match the material characteristics of the fence system being installed. Provide hinge with stainless steel pin. Arrange latches for padlocking so that the padlock will be accessible from both sides of the gate. Provide stops for holding the gates in the open position. For high security applications, extend each end member of gate frames sufficiently above the top member to carry three strands of barbed wire in horizontal alignment with barbed wire strands on the fence. Coating for steel latches, stops, hinges, keepers, and accessories, must be galvanized

2.1.6 Ornamental Fence Gates

2.1.6.1 Swing Gates

Submit manufacturer's catalog data. Fabricate swing gates by welding 2 sq in tubular steel ends and rails. Use pickets that match the adjacent fence construction. Reinforce gates to ensure assembly sags no more than 1% of the gate leaf width or 2 in, whichever is less. Size gate posts to accommodate the weight and width of each gate leaf. Mount gates to posts with weldable steel plates or blocks, pressed steel, or malleable iron hinges. Hot-dip galvanize all hinges with a minimum zinc weight of 1.20 oz/sq ft. Provide hinge with stainless steel pin. Secure all tamper points by welding or peening the threads. Use swing gate latches and drop bar guides manufactured of pressed steel, hot-dipped galvanized with a minimum zinc weight of 1.20 oz/sq ft. Finish all gate hardware in the same color/coating as the fence system.

2.1.6.2 Slide Gates

Submit manufacturer's catalog data. Fabricate slide gates by welding 2 sq in tubular steel ends and rails. Use pickets that match the adjacent fence construction. Select the type and class of slide gate to comply with ASTM F1184. Size gate posts to accommodate the weight and width of each gate leaf in accordance with ASTM F1184, or per manufacturer's recommendations. Specify Type II, Class 2, interior roller design for cantilever slide gates.

2.1.7 Turnstiles

Provide galvanized steel, three wing turnstile consisting of a rotor, cage, ceiling plate, and bottom bearing plate. Provide electronic opening and closing by card key. Provide one way continuous turn or one-third turn and stop motion.

2.1.8 Padlocks

Provide padlocks conforming to ASTM F883, Type PO1, Options A, B, and G, Grade 6. Size 1-3/4 inch. . Key all padlocks into master key system as specified in Section 08 71 00 DOOR HARDWARE.

2.1.9 Gate Operator

Provide electric gate operators for sliding gates as follows: Provide electric gate operators with a right angle gearhead instantly reversing motor with magnetic drum-type brake, friction disc clutch, reversing starter with thermal overload protection, and a chain-driven geared rotary-type automatic limit switch. Use only hardened steel machine cut worm and mating bronze gears that operate in a bath of oil. Gate operators with V-belt pulleys are not allowed. Equip gate operators with an emergency release to allow the gate to be operated manually that is also capable of being locked in the engaged or disengaged position. Provide positive stops on the gate tracks as a backup to the limit switches.

2.1.10 Electro-Mechanical Locks

Provide electro-mechanical locking devices for sliding gates and personnel gates that are solenoid actuated such that the deadbolt retracts when the solenoid is energized and remains electrically retracted until the gate is closed. Provide continuous duty type solenoid, rated for 120V ac, 60Hz operation. Ensure the locking device is unlockable by key and keyed on both sides. Monitor status of the electro-mechanical lock by two limit switches (integral to the locking device) wired in series. Ensure one switch monitors the deadlock lever and the other monitors the locking tongue.

2.2 MATERIALS

2.2.1 Wire

2.2.1.1 Wire Ties

Submit samples as specified. Provide wire ties constructed of the same material and finish as the fencing fabric.

2.2.1.2 Barbed Wire

Provide barbed wire conforming to ASTM A121 zinc-coated, Type Z, Class 3, with 12.5 gauge wire with 14 gauge, round, 4-point barbs spaced no more than 5 inches apart.

2.2.1.3 Tension Wire

Provide metallic coated steel marcelled tension wire (No. 7-gauge), complying with ASTM A824. Provide zinc-coated steel wire with coating that weighs not less than 2.0 ounces per square foot.

2.2.2 Barbed Tape

Provide reinforced barbed tape, double coil or single coil, for fence toppings fabricated from 430 series stainless steel with a hardness range of Rockwell (30N) 37-45 conforming to the requirements of ASTM A240/A240M. Provide stainless steel strip 0.025 inch thick by 1 inch wide before fabrication. Provide barbs that are a minimum of 1.2 inch in length, in groups of 4, spaced on 4 inch centers. Use stainless steel core wire with a 0.098 inch diameter and a minimum tensile strength of 140 psi and conforming to ASTM A478. The above requirements also apply to reinforced barbed tape, single coil, for ground application. Fabricate non-reinforced barbed tape, single coil, for ground applications from 301 series stainless steel, with a hardness range of Rockwell (30N) 50-55, in accordance with ASTM A666. Provide stainless steel strips 0.025 inch thick by 1.21 inches wide before fabrication. Use barbs with a minimum of 1.2 inch in length, in groups of 4, spaced on 4 inch centers. Use No. 16 AWG stainless steel twistable wire ties for attaching the barbed tape to the barbed wire and to the fence for ground application.

Ensure long barbed tape obstacles conform to ASTM F1910.

2.2.3 Concrete

ASTM C94/C94M, using 3/4 inch maximum size aggregate, and having minimum compressive strength of 3000 psi at 28 days. Use grout consisting of one part portland cement to three parts clean, well-graded sand and the minimum amount of water to produce a workable mix.

PART 3 EXECUTION

3.1 PREPARATION

Perform complete installation conforming to ASTM F567.

3.1.1 Line and Grade

Install fence to the lines and grades indicated. Clear the area on either side of the fence line to the extent indicated. Space line posts equidistant at intervals not exceeding 10 feet. Set terminal (corner, gate, and pull) posts whenever abrupt changes in vertical and horizontal alignment are encountered. Provide continuous fabric between terminal posts; however, ensure runs between terminal posts do not exceed 500 feet. Repair any damage to galvanized surfaces, including welding, with paint containing zinc dust in accordance with ASTM A780/A780M.

3.1.2 Excavation

Excavate holes to depths indicated. Clear all post holes of loose material and spread waste material where directed. Eliminate ground surface irregularities along the fence line to the extent necessary to maintain a 1 -2 inch clearance between the bottom of the fabric and finish grade.

3.2 INSTALLATION

3.2.1 Installation Drawings

Submit complete Fence Installation Drawings for review and approval by the Contracting Officer prior to shipment. Submit drawing details that include, but are not limited to the following information: Fence Installation Drawings, Location of gate, corner, end, and pull posts, Gate Assembly, Turnstiles, and Gate Hardware and Accessories. Install fence system per approved drawings.

3.2.2 Security Fencing

Install new security fencing, remove existing security fencing, and perform related work to provide continuous security for facility. Schedule and fully coordinate work with Contracting Officer.

3.2.3 Posts

3.2.3.1 Earth and Bedrock

a. Set posts plumb and in alignment. Except where solid rock is encountered, set posts in concrete to the depth indicated on the drawings. Where solid rock is encountered with no overburden, set posts to a minimum depth of 18 inches in rock. Where solid rock is covered with an overburden of soil or loose rock, set posts to the minimum depth indicated on the drawing unless a penetration of 18 inches in solid rock is achieved before reaching the indicated depth, in which case terminate depth of penetration. Grout all portions of posts set in rock.

b. Set portions of posts not set in rock in concrete from the rock to ground level. Set posts in holes not less than the diameter shown on the drawings. Make diameters of holes in solid rock at least 1 inch greater than the largest cross section of the post. Thoroughly consolidate concrete and grout around each post, free of voids and finished to form a dome. Allow concrete and grout to cure for 72 hours prior to attachment of any item to the posts. Group II line posts may be mechanically driven, for temporary fence construction only, if rock is not encountered. Set driven posts to a minimum depth of 3 feet and protect with drive caps when setting.

c. Test fence post rigidity by applying a 50 pound force on the post, perpendicular to the fabric, at 5 feet above ground. Ensure post movement measured at the point where the force is applied is less than or equal to 3/4 inch from the relaxed position. Test every tenth post for rigidity. When a post fails this test, make further tests on the next four posts on either side of the failed post. Remove, replace, and retest all failed parts at the Contractor's expense.

3.2.3.2 Concrete Slabs and Walls

When installed in concrete slabs or walls, set posts in zinc-coated sleeves, to a minimum depth of 12 inches. Fill sleeve joint with lead, nonshrink grout, or other approved material. Set posts for support of removable fence sections in sleeves that provide a tight sliding joint and hold posts aligned and plumb without use of lead or setting material.

3.2.4 Rails

Bolt bottom rail to double rail ends and securely fasten double rail ends to the posts. Peen bolts to prevent easy removal. Install bottom rail before chain link fabric. Provide 3/8" diameter eye hook anchored into concrete footing at midpoint.

3.2.5 Fabric

a. Set fabric height at 7 feet.

b. Install chain link fabric on the side of the post indicated. Attach fabric to terminal posts with stretcher bars and tension bands. Space bands at approximately 15 inch intervals. Install fabric and pull taut to provide a smooth and uniform appearance free from sag, without permanently distorting the fabric diamond or reducing the fabric height. Fasten fabric to line posts at approximately 15 inch intervals and fastened to all rails and tension wires at approximately 12 inch intervals.

c. Cut fabric by untwisting and removing pickets. Accomplish splicing by weaving a single picket into the ends of the rolls to be joined. Install the bottom of the fabric 2-1 plus or minus 1/2 inch above the ground.

d. After the fabric installation is complete, exercise the fabric by applying a 50 pound push-pull force at the center of the fabric between posts; use a 30 pound pull at the center of the panel to ensure fabric deflection of not more than 2.5 inches when pulling fabric from the post side of the fence. Every second fence panel is required to meet this requirement. Resecure and retest all failed panels at the Contractor's expense.

3.2.6 Supporting Arms

Install barbed wire supporting arms and barbed wire as indicated on the drawings and as recommended by the manufacturer. Anchor supporting arms to the posts in a manner to prevent easy removal with hand tools with 3/8 inch diameter plain pin rivets or, at the Contractor's option, with studs driven by low-velocity explosive-actuated tools for steel, wrought iron, ductile iron, or malleable iron. Do not use explosive-actuated tool to drive studs into gray iron or other material that can be fractured. Use a minimum of two studs per support arm. Pull barbed wire taut and attach to the arms with clips or other means that will prevent easy removal.

3.2.7 Barbed Tape Installation

Install stainless steel reinforced barbed tape per ASTM F1911 and as detailed on the drawings. Stretch out barbed tape to its manufacturer's recommended length, set on top of the barbed wire and "V" shaped support arms, then secure it to the barbed wire. Secure the barbed tape to the barbed wire at the two points and at every spiral turn of both coils as shown on the drawings. Install stainless steel reinforced or non-reinforced barbed tape for ground applications in accordance with manufacturer's recommendations.

3.2.8 Gate Installation

a. Install gates at the locations shown. Mount gates to swing as indicated. Install latches, stops, and keepers as required. Install Slide or Lift gates as recommended by the manufacturer.

b. Attach padlocks to gates or gate posts with chains. Weld or otherwise secure hinge pins, and hardware assembly to prevent removal.

c. Submit 6 copies of operating and maintenance instructions. Outline the step-by-step procedures required for system startup, operation, and shutdown. Include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Include in the maintenance instructions routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. Also include the general gate layout, equipment layout and simplified wiring and control diagrams of the system as installed.

3.2.9 Grounding

a. Ground fencing as indicated on drawingsandspecified.

b. Ground fences crossed by overhead powerlines in excess of 600 volts and ground all electrical equipment attached to the fence.

c. Ground fences on each side of all gates, at each corner, at the closest approach to each building located within 50 feet of the fence, and where the fence alignment changes more than 15 degrees. Ensure grounding locations are located no more than 650 feet apart. Bond each gate panel with a flexible bond strap to its gate post. Ground fences crossed by powerlines of 600 volts or more at or near the point of crossing and at distances not exceeding 150 feet on each side of crossing.

d. Provide ground conductor consisting of No. 8 AWG solid copper wire. Use grounding electrodes that measures 3/4 inch by 10 foot long and are a copper-clad steel rod. Drive electrodes into the earth so that the top of the electrode is at least 6 inches below the grade. Where driving is impracticable, bury electrodes a minimum of 12 inches deep and radially from the fence. Install the top of the electrode to be less than 2 feet or more than 8 feet from the fence. Clamp ground conductor to the fence and electrodes with bronze grounding clamps to create electrical continuity between fence posts, fence fabric, and ground rods. Measure total resistance of the fence to ground and ensure it is not greater than 25 ohms.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Cleanup

Remove waste fencing materials and other debris from the work site each workday.

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SECTION 32 32 23.13

SEGMENTAL CONCRETE BLOCK RETAINING WALL
02/20

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

Measurement of segmental retaining wall for payment will be made on the basis of the face area in the vertical plane of segmental concrete units. The pay lines of the structure will be neat lines taken off the approved shop drawings; and will extend from the block-leveling pad interface to the top of wall, excluding any fencing or barrier. Payment will be made at the respective unit price per square foot (SF) listed on the Bidding Schedule.

1.1.2 Payment

Payment will be full compensation for engineering services, excavation and preparatory work, and furnishing all material, labor and equipment to complete the work.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 252	(2009; R 2017) Standard Specification for Corrugated Polyethylene Drainage Pipe
AASHTO M 288	(2021) Standard Specification for Geosynthetic Specification for Highway Applications

ASTM INTERNATIONAL (ASTM)

ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C140/C140M	(2022a) Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C1262/C1262M	(2018) Standard Test Method for Evaluating the Freeze-Thaw Durability of Dry-Cast Segmental Retaining Wall Units and Related

	Concrete Units
ASTM C1372	(2017) Standard Specification for Dry-Cast Segmental Retaining Wall Units
ASTM D448	(2012; R 2017) Standard Classification for Sizes of Aggregate for Road and Bridge Construction
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D1241	(2015) Materials for Soil-Aggregate Subbase, Base, and Surface Courses
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	(2017; E 2018) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4595	(2017) Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D5321/D5321M	(2020) Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
ASTM D6638	(2011) Determining Connection Strength

Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)

ASTM D6706	(2001; R 2013) Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GG6	(1996) Grip Types for Use in Wide Width Testing of Geotextiles and Geogrids

NATIONAL CONCRETE MASONRY ASSOCIATION (NCMA)

NCMA TR127B	(2010) Design Manual for Segmental Retaining Walls

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

FHWA NHI-00-043	(2000) Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines (ISDDC)

1.3 DEFINITIONS

1.3.1 Blocks

Blocks, for the purpose of this specification, refers to segmental concrete retaining wall units.

1.3.2 Drainage Aggregate

Granular soil or aggregate placed within, between, and/or immediately behind segmental concrete units.

1.3.3 Fill

Soil or aggregate placed in, behind, or below the wall.

1.3.4 Reinforced Fill

Soil placed and compacted within the neat line volume of reinforcement as outlined on the plans.

1.3.5 Retained Fill

Soil placed and compacted behind the reinforced fill.

1.3.6 Reinforcement

Geogrid or a geotextile products manufactured for use as reinforcing in segmental block retaining walls. Steel products are not allowed.

1.3.7 Long Term Design Strength

The long term design strength (LTDS) is:

$$LTDS = T_{ult} / (RF_D * RF_{ID} * RF_{CR})$$

where:

T_{ult} is the ultimate strength
RF_D is the reduction factor for chemical and biological durability
RF_{ID} is the reduction factor for installation damage
RF_{CR} is the reduction factor for creep

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G[, [_____]]

SD-03 Product Data

Segmental Concrete Units; G

SD-04 Samples

Segmental Concrete Units; G[, [_____]]

Geogrid Reinforcement; G[, [_____]]

SD-05 Design Data

Calculations; G[, [_____]]

Survey And Grade Results; G[, [_____]]

SD-06 Test Reports

Soil Testing; G[, [_____]]

Reinforcement Testing; G[, [_____]]

SD-07 Certificates

Supplier Qualifications

Manufacturer's Representative

Geogrid Reinforcement; G[, [_____]]

Geotextile Reinforcement; G[, [_____]]

1.5 QUALITY CONTROL

1.5.1 Contractor Qualifications

Furnish components and equipment from a manufacturer regularly engaged in the manufacturing of products that are of similar material, design and workmanship. Submit descriptive technical data on the blocks, wall caps, masonry adhesive, reinforcement, geotextile filter materials and equipment to be used. Include all material properties specified under PART 2 PRODUCTS. Include a copy of any standard manufacturer's warranties for the products. Provide standard products with satisfactory commercial or industrial use for 2 years before award of this contract. Submit documentation to demonstrate the job foreman or the company directly responsible for the wall installation has[completed a minimum of 10 segmental concrete retaining wall projects][at least 2 years experience].

1.5.2 Supplier Qualifications

[Submit documentation showing that the installer and supplier meet the qualifications listed. To be considered acceptable, demonstrate experience in the supply of similar size and types of segmental retaining walls on previous projects.]

1.5.3 Manufacturer's Representative

Provide a qualified and experienced representative from the block or reinforcement manufacturer who is available to consult and conduct site visits on an as-needed basis during the wall construction [at least once during construction] [as requested by the Contracting Officer].

1.6 DELIVERY, STORAGE, AND HANDLING

Check products upon delivery to ensure that the proper material has been received and is undamaged. For geosynthetics, follow the guidelines presented in ASTM D4873/D4873M.

1.6.1 Segmental Concrete Units and Wall Caps

Protect blocks from damage and exposure to cement, paint, excessive mud, and like materials. Check materials upon delivery to assure that the block dimensions are within the tolerances specified.

1.6.2 Geosynthetic Labeling

Label each roll with the manufacturer's name, product identification, roll dimensions, lot number, and date manufactured.

1.6.3 Geosynthetic Handling

Handle and unload geosynthetic rolls by hand, or with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Do not drag, lift by one end, lift by cables or chains, or drop to the ground any geosynthetic rolls.

1.6.4 Geosynthetic Storage

Protect geosynthetics from cement, paint, excessive mud, chemicals, sparks and flames, temperatures in excess of 160 degrees F, and any other environmental condition that may degrade the physical properties. If stored outdoors, elevate rolls from the ground surface. Protect geosynthetics, except for extruded grids, with an opaque waterproof cover. Deliver to the site in a dry and undamaged condition. Do not expose geotextiles to direct sunlight for more than 7 days.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

This work element includes engineering services in addition to the construction requirements. Provide engineering services that include design of the wall in accordance with the National Concrete Masonry Association design method, and providing shop drawings indicating all features of the complete design.

The NCMA design method for segmental retaining walls considers potential failure modes categorized by external, internal, local, compound, and global stability. The Government has considered the global stability and has provided the minimum design requirements on the drawings. Provide engineering services that include analysis of the wall for all modes of stability and shop drawings indicating all features of the complete design.

2.1.1 Design Requirements

Complete all stability analyses in accordance with either the NCMA TR127B, or the Federal Highway Administration/AASHTO method detailed in FHWA NHI-00-043. Follow only one method for the complete design, including reinforcement design strength, layout, stability calculations, and seismic effects. Design the segmental retaining wall system under the direction of a professional engineer. Affix engineer's stamp to all drawings.[At least one site visit by the engineer is required during the construction phase.] The design engineer must stamp all drawings and calculations.

2.1.2 Design Parameters

Include in all calculations the determination of long term design strength of reinforcement specific to this project in accordance with the NCMA TR127B or FHWA NHI-00-043. Base the ultimate strength or index strength on the minimum average roll value tensile strength of the product using the wide width strength test in ASTM D4595. Submit design calculations, including computer output data, program documentation, and all items described under PARAGRAPH: SEGMENTAL RETAINING WALL DESIGN.Itemize list of each reduction factor and include backup data to justify each reduction factor included in the calculations. Include analysis of all failure modes listed in the NCMA TR127B. Include a clear outline of material properties and assumptions.[Use the following soil parameters and water elevation for stability analysis, and select additional soil parameters as required to complete the analysis.]

Moist Unit Weight of reinforced fill	[_____] pcf
Saturated Unit Weight of reinforced fill	[_____] pcf
Internal Friction Angle of reinforced fill	[30][_____] degrees
Cohesion of reinforced fill	[0][_____] psf
Water Elevation in reinforced fill	[_____] feet

2.1.2.1 External Stability Design Requirements

As a minimum requirement, ensure the length of the reinforcing at the base of the wall is no less than 0.7 times the total height of the blocks.

[2.1.2.2 Seismic Design Requirements

Complete the seismic stability analysis in accordance with NCMA TR127B or FHWA NHI-00-043. Assume the pseudo-acceleration value with a 10 percent probability of exceedance in 50 years (referred to as the A value by NCMA and FHWA) is [_____].

]2.1.2.3 Global Stability Design Requirements

Use the requirements listed in Table 1 to determine the minimum long term design strength of the lowest [_____] reinforcement layer[s]. Use reinforcement lengths at least as long as the lengths shown on the drawings.

2.1.3 Layout

Show on the shop drawings (fabrication and installation drawings) all information needed to fabricate and erect the walls including the leveling pad elevations; the shape and dimensions of wall elements; the number, size, type, and details of the soil reinforcing system and anchorage; and identification of areas requiring coping. Include with the shop drawings all items described under paragraph SEGMENTAL RETAINING WALL DESIGN. If approved by the Contracting Officer, shop drawings may consist of marked up contract drawings showing exact dimensions for the blocks supplied, required coping, and other minor revisions. The design and layout of the internal reinforcement are subject to the following:

a. Incorporate all features indicated in the contract documents in the final design and construction.

b. The leveling pad elevations may vary, as long as they are no higher than the embedment depth profile.

c. Run each reinforcement level as continuous as practical throughout the profile. If a geotextile filter is present, layout the reinforcement so that interference with the geotextile is minimized.

d. Identify any reinforcement not placed with the machine direction as the design reinforcement direction on the shop drawings.

e. Do not combine geogrid and geotextile, nor products from different manufacturers, within one wall. Limit the number of reinforcement products to avoid confusion in placement. For walls under 12 feet high, use reinforcement of the same grade and strength (i.e. design with one reinforcement strength).

2.2 COMPONENTS

2.2.1 Segmental Concrete Units

Submit two samples of each proposed block which is typical of the size, texture, color, and finish.

2.2.1.1 Face color

[Tan/Grey/Brown/Natural Limestone][_____]

2.2.1.2 Face Texture

[Split face typical of broken mortar/brick face][_____]

2.2.1.3 Face Appearance

[Straight, single-surface face/sculptured with 3-surface beveled face/rounded, smooth-curved face][_____]

2.2.1.4 Block Size

A minimum of 2/3 square feet of face area, and minimum 6 inch height

2.2.1.5 Bond Configuration

No bond configuration is required for straight face blocks. Design beveled or sculptured face blocks to stack with a half-bond (joints located at midpoint of vertically adjacent blocks). Finish the block edges so that vertical joints are flush.

2.2.1.6 Structural requirements

Use segmental concrete blocks meeting the requirements of ASTM C1372. or ASTM C94/C94M, except for the following modifications:

a. Minimum 28-day compressive strength of [4000 psi], based on net area in accordance with ASTM C140/C140M.

b. A maximum moisture absorption rate of 9 pcf, in accordance with ASTM C140/C140M.

c. Provide concrete with a minimum oven dry density of 125 pcf.

d. Provide blocks with a minimum of 80 psf of wall face area (determined without void filling).

e. For freeze-thaw durability tested in accordance with ASTM C1262/C1262M, comply with either of the following: (1) eight loss of each of 5 specimens after 100 cycles is 1 percent or less; or (2) weight loss of each of 5 specimens after 150 cycles is 1.5 percent or less. [when tested in a 3 percent saline solution: (1) weight loss of each of 5 specimens after 40 cycles is 1 percent or less; or (2) weight loss of 4 out of 5 specimens after 50 cycles is 1.5 percent or less.]

2.2.2 Wall Caps

Place segmental concrete block units as caps on top of all segmental concrete retaining walls. Provide cap blocks with a color and texture on exposed faces to match that of the other blocks and meet the requirements for the other blocks except that the minimum height 3 inches. Provide cap blocks with abutting edges saw cut or formed to provide tight, flush abutting joints with no gaps in the joints when placed end to end in the alignment shown on the drawings.

2.2.3 Geogrid Reinforcement

Provide a geosynthetic manufactured for reinforcement applications consisting of a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil, aggregate, or other fill materials. Ensure the geogrid structure is dimensionally stable and able to retain its geometry under manufacture, transport and installation. Ensure the geogrid is manufactured with 100 percent virgin resin consisting of polyethylene, polypropylene, or polyester, and with a maximum of 5 percent in-plant regrind material. Provide polyester resin with a minimum molecular weight of 25,000 and a carboxyl end group number less than 30. Stabilize polyethylene and polypropylene with long term antioxidants.

2.2.4 Geotextile Reinforcement

Provide geotextile consisting of a pervious sheet of polymeric material with long-chain synthetic polymers composed of at least 95 percent by weight polyethylene, polypropylene, or polyesters. Manufacture the geotextile with 100 percent virgin resin, and with a maximum of 5 percent in-plant regrind material. Form geotextile into a network such that the filaments or yarns retain dimensional stability relative to each other, including the selvages. Provide polyester resin with a minimum molecular weight of 20,000 and a carboxyl end group number less than 50. Stabilize polyethylene and polypropylene with long term antioxidants. For survivability during installation, and in addition to installation damage used in calculating the long term design strength, ensure the geotextile meets the minimum requirements in AASHTO M 288 Class 1, and has a minimum mass per unit area of 8 oz/sy.

2.2.5 Reinforcement Properties

Provide the reinforcement as shown in the approved shop drawing submittal that meets the long term design strength requirements used in the design, and meets the properties listed in Table 1. Reinforcement strength requirements represent minimum average roll values in the machine direction.

The reinforcement indicated must meet the property requirements listed in Table 1. Reinforcement strength requirements represent minimum average roll values in the machine direction.

The reinforcement indicated must meet the property requirements listed in Table 1. Additional reinforcement shown in the approved shop drawing submittal must meet the long term design strength requirements used in the design as well as other properties listed in Table 1. Submit affidavit certifying that the reinforcement meets the project specifications. Ensure the affidavit is signed by an official authorized to certify on behalf of the manufacturer and is accompanied by a mill certificate that verifies physical properties were tested during manufacturing and lists the manufacturer's quality control testing. [If the affidavit is dated after award of the contract and/or is not specific to the project, attach a statement certifying that the affidavit addressed to the wholesale company is representative of the material supplied.] Include in the documents a statement confirming that all purchased resin used to produce reinforcement is virgin resin. Include in the mill certificate the tensile strength tested in accordance with ASTM D4595. Reinforcement strength requirements represent minimum average roll values in the machine direction.

TABLE 1. REINFORCEMENT PROPERTIES		
PROPERTY	REQUIREMENT	TEST DESIGNATION
Permittivity (geotextiles)	[0.5][_____] per second	ASTM D4491/D4491M
UV Resistance	70 percent after 500 HOURS	ASTM D4355/D4355M
Long Term Design	[_____] lb/inch	NCMA TR127B, Method A
Coefficient of Interaction for Pullout	[.85][_____]	ASTM D6706
Coefficient for Direct Shear	[_____] degrees	ASTM D5321/D5321M

2.2.5.1 Long Term Design Strength

Base the long term design strength on reduction factors for installation damage and durability that are applicable to the fill that will be used. Minimum reduction factors for durability include: 1.1 for polyethylene and polypropylene geosynthetics, 1.15 for coated polyester geogrids, and 1.6 for polyester geotextiles. Use a creep reduction factor consistent with the test procedure used for determining the ultimate strength.

2.2.6 Geotextile Filter

Provide geotextiles used as filters that meet the requirements specified in Table 2. The property values (except for AOS) represent minimum average roll values (MARV) in the weakest principal direction. For survivability during installation, provide geotextile meeting the minimum requirements in AASHTO M 288 Class 2, and has a minimum mass per unit area of 8 oz/sy.

TABLE 2. GEOTEXTILE PHYSICAL PROPERTIES		
PROPERTY	TEST REQUIREMENT	TEST METHOD
Grab Tensile, lbs.	[160 nonwoven] [250 woven]	ASTM D4632/D4632M
Apparent Opening Size (U.S. Sieve)	70 - 100	ASTM D4751
Permittivity, sec-1	0.5	ASTM D4491/D4491M

2.3 MATERIALS

2.3.1 Soils and Aggregates

For all material placed as fill, classify material by ASTM D2487 as GW, GP, GC, GM, SP, SM, SC, CL, ML, or SW. Ensure all material used is free of ice; snow; frozen earth; trash; debris; sod; roots; organic matter; contamination from hazardous, toxic or radiological substances; or stones larger than 3 inches in any dimension. Obtain material entirely from one borrow source, unless the Contracting Officer determines that quality control is adequate and the alternate source produces material that is similar in gradation, texture, and interaction with the reinforced and retained fill. Supply any testing required by the Contracting Officer to evaluate alternate sources. Provide materials of a character and quality satisfactory for the purpose intended.

2.3.1.1 Drainage Aggregate

Meet the requirements of ASTM D448, size No.7.

2.3.1.2 Aggregate Base Material

For the wall leveling pads, meet the requirements of ASTM D1241, gradation C.

2.3.1.3 Reinforced Fill

Provide soil placed in the reinforced fill zone consisting of granular material with less than [5][15] percent passing the No. 200 sieve.

2.3.1.4 Retained Fill

Provide soil placed in the retained fill zone consisting of granular material with less than [5][15] percent passing the No. 200 sieve.

2.3.2 Masonry Adhesive

Provide masonry adhesive meeting the following requirements:

a. ASTM C920, Type S, Grade NS, Class 25

b. Recommendations of the block manufacturer

2.3.3 Drainage Pipe

Provide corrugated polyethylene pipe drainage pipe meeting requirements of AASHTO M 252.

PART 3 EXECUTION

3.1 EXAMINATION

Examine site prior to installation. Perform classification of soil materials in accordance with ASTM D2488. The Contracting Officer reserves the right to revise the Contractor classifications. In the case of disagreement, the Contracting Officer's classification governs unless the soils are classified in accordance with ASTM D2487. All testing completed by the Contractor in conjunction with soil material classification is incidental to the contract work.

3.2 PREPARATION

Prepare the leveling pad and reinforced fill zone to bear on undisturbed native soils, or acceptably placed and compacted fill. In the event that it is necessary to remove material to a depth greater than specified or to place fill below the leveling pad not otherwise provided for in the contract, notify the Contracting Officer prior to work and an adjustment in the contract price will be considered in accordance with the contract.

3.2.1 Excavation

Excavate foundation soil as required for leveling pad dimensions and reinforcement placement shown on the construction drawings. Stockpile material for backfilling in a neat and orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent slides or caving. Perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Dispose of surplus material, waste material, and material that does not meet specifications, including any soil which is disturbed by the Contractor's operations or softened due to exposure to the elements and water.

3.2.2 Stockpiles

Keep stockpiles of all material to be incorporated into the work in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grade and seal the ground surface at stockpile locations. Stockpile topsoil separately from suitable backfill material. Protect stockpiles of aggregates and granular soils from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes frozen, saturated, intermixed with other materials, or otherwise out of specification or unsatisfactory for the use intended, then remove and replace affected materials with new material from approved sources at no additional cost to the Government.

3.2.3 Leveling Pad

3.2.3.1 Aggregate Base Leveling Pad

Compact the subgrade below the leveling pad [90%][95%][100%] laboratory maximum density. Place the aggregate base material in lifts not exceeding 6 inches. If the subgrade or aggregate base pumps, bleeds water, or cracks during compaction, notify the Contracting Officer and, if no other changes are directed, replace the aggregate with a concrete leveling pad.

3.2.3.2 Concrete Leveling Pad

Ensure tolerances in screeding are sufficient to place the blocks directly on the leveling pad without mortar, pointing, or leveling course between the blocks and leveling pad.

3.3 INSTALLATION

3.3.1 Block Installation

Construct the wall system components in accordance with the approved shop drawings. Do not incorporate damaged blocks into the retaining wall.

a. Begin block placement at the lowest leveling pad elevation. Place the blocks in full contact with the leveling pad. Place each course of block sequentially for the entire wall alignment to maintain a level working platform for layout of reinforcement and placement of fill.

b. Survey the grade and alignment of the first course and furnish the Survey and Grade Results to the Contracting Officer prior to placing the second course. Include a string line, offset from a base line, or suitable provisions that can be reproduced for quality assurance.

c. Place the blocks with the edges in tight contact. [No gaps are allowed for wall batter and curvature.] Maintain the vertical joints with a minimum 4 inch overlap on the underlying block. Adjust coping as required to keep block alignment with a full depth saw cut. No splitting is allowed.

d. Stacking of blocks prior to filling any lower course of block with drainage aggregate is not allowed.

e. Engage blocks to the block below by use of keys, lips, pins, clips, or other reliable mechanism to provide a consistent wall batter [between 1H:6V and 1H:16V][_____].

f. Join cap units [and the top two course of blocks] using masonry adhesive. Take care to keep adhesive from coming into contact with the face of wall units.

3.3.2 Reinforcement Installation

a. Before placing reinforcement, compact the subgrade or subsequent lift of fill and grade level with the top of the blocks. Ensure the surface is smooth and free of windrows, sheepsfoot impressions, and rocks.

b. Place reinforcement at the elevations and to the extent shown on the construction drawings and the approved shop drawing submittal. Orient reinforcement with the design strength axis perpendicular to the wall face. Spliced connections between shorter pieces of reinforcement are not allowed. Place reinforcement strips immediately next to adjacent strips to provide 100 percent coverage.

c. Install the reinforcement in tension. Pull the reinforcement taut and anchor with staples or stakes prior to placing the overlying lift of fill. Pull the reinforcement to ensure tension is uniform along the length of the wall and consistent between layers.

d. Cover all reinforcement completely with soil so that reinforcement panels do not contact in overlaps. Where the wall bends, place a veneer of fill to a nominal thickness of 3 inches to separate overlapping reinforcement.

3.3.3 Fill Placement

a. Complete fill placement, including drainage aggregate, to the top of each course of facing blocks prior to stacking the subsequent course of blocks.

b. Place reinforced fill from the wall back toward the fill area to ensure that the reinforcement remains taut. Place, spread, and compact fill in such manner that minimizes the development of wrinkles in or movement of the reinforcement.

c. A minimum fill thickness of 6 inches is required prior to operation of vehicles over the reinforcement. Avoid sudden braking and sharp turning. Do not turn tracked equipment within the reinforced fill zone to prevent tracks from displacing the fill and damaging the reinforcement. Do not operate construction equipment directly upon the reinforcement as part of the planned construction sequence. Rubber tired equipment may operate directly on the reinforcement if: the Contractor submits information documenting testing of equipment operating on a similar geogrid product on similar soils, the travel is infrequent, equipment travels slow, turning is minimized, and no damage or displacement to the reinforcement is observed.

d. Place and tamp drainage aggregate directly behind, between, and within the cells of the facing units. Achieve compaction of the drainage aggregate by at least two passes on each lift with a vibratory plate compactor. Take care not to contact or chip the blocks with the compactor. Compact aggregate placed within the block cores and recesses by hand tamping and rodding.

e. At the end of each day, slope the last lift of fill away from the wall in a manner that will allow drainage and direct runoff away from the wall face.

3.3.4 Compaction

Do not place fill on surfaces that contain mud, frost, organic soils, fill soils that have not met compaction requirements, or where the Contracting Officer determines that unsatisfactory material remains in or under the fill. Spread fill and compact in lifts not exceeding the height of one course of blocks.

Compact reinforced and retained fill to 95 percent of the Standard Proctor Density. Exercise care in the compaction process to avoid misalignment of the facing blocks. Do not use heavy compaction equipment (including vibratory drum rollers) within3 feet from the wall face.

3.3.4.1 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D698. The maximum density is hereafter abbreviated as the "Standard Proctor" value.

3.3.4.2 Moisture Control

Maintain control of moisture in the fill to provide acceptable compaction. Do not disk and plow in the reinforced fill zone. Adjust moisture content of cohesive soils at the borrow source before placement. Add water directly to the reinforced fill zone only under conditions where the soil has sufficient porosity and capillarity to provide uniform moisture throughout the fill during compaction.

3.4 FIELD QUALITY CONTROL

3.4.1 Soil Testing

All testing expenses are the Contractor's responsibility. Inspect and approve testing laboratories in accordance with Section 01 45 00.00 10 01 45 00.00 2001 45 00.00 40 QUALITY CONTROL prior to commencement of testing. The Contracting Officer reserves the right to direct the location and select the material for samples to be tested and to direct where and when moisture-density tests are performed. Use nuclear density testing equipment in general accordance with ASTM D6938.

3.4.1.1 Transmittal

Submit test results to the Contracting Officer daily. Include test results as a part of contractor's daily report, taking care to note any deficiencies and ask for direction on corrective action required. Furnish of field testing results to the Contracting Officer on a frequent and regular basis, as directed.

3.4.1.2 Corrective Action.

Tests of materials which do not meet the contract requirements (failing test) do not count as part of the required testing. Retest each failure at the same location the failing test was taken. If testing indicates material does not meet the contract requirements, do not place the material represented by the failing test in the contract work or recompact the failing material. It is the responsibility of the Contracting Officer to determine quantity of material represented by the failing test up to the quantity represented by the testing frequency. The Contractor may increase testing frequency in the vicinity of a failing test in order to reduce removal requirements, as approved by the Contracting Officer. Such increases in testing frequency are at the Contractor's expense and at no additional cost to the Government.

3.4.1.3 Testing Schedule

3.4.1.3.1 Moisture-Density Relations

ASTM D698. One test for each material variation[, not less than [_____] tests total].

3.4.1.3.2 In-Place Densities

ASTM D1556/D1556M or ASTM D6938. Not less than 1 test for each 2 vertical feet per 300 linear feet along wall face.

3.4.1.3.3 Sieve Analysis

ASTM C136/C136M. Drainage Aggregate, 1 test for each source.

3.4.2 Reinforcement Testing

All testing expenses are the Contractor's responsibility. Use a commercial testing laboratory selected by the Contractor and approved by the Contracting Officer for all testing. The Contracting Officer reserves the right to direct the location and select the material for samples. Testing data specific to the blocks and reinforcement to be supplied as follows:

a. The shear strength between blocks as established in accordance with NCMA TR127B.

b. The connection strength between the blocks and the reinforcement as established in accordance with ASTM D6638. If the FHWA design method is used, implement the modifications in FHWA NHI-00-043.

c. The coefficient for direct shear of the reinforcement on a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone as established in accordance with ASTM D5321/D5321M.

d. The coefficient of interaction for pull-out resistance of the reinforcement in a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone as established in accordance with ASTM D6706.

TABLE 3. REINFORCEMENT TESTING		
PROPERTY	TEST DESIGNATION	FREQUENCY
Wide Width Strip Tensile Strength	ASTM D4595	[_____]

Modify ASTM D4595 for geogrids considering recommendations in GSI GRI GG6; and express the tensile strength on a unit length basis by substituting n*a for Ws, where:

Ws = specimen width, (inches)
n = number of ribs in the sample (must be a whole number)
a = nominal rib spacing for the product tested, (inches)

3.4.3 Drainage Pipe

Place drain pipe as indicated on the drawings. Lay drain lines to true grades and alignment with a continuous fall in the direction of flow. Keep the interior of the pipe clean from soil and debris; and cap open ends as necessary.

3.4.4 Construction Tolerances

3.4.4.1 Horizontal

Ensure the top of wall is within [3][___] inches of the plan location.

3.4.4.2 Vertical

Ensure the top of wall elevations is within [0.1][___] feet above to [0.1][___] feet below the prescribed top of wall elevations indicated.

3.4.4.3 Plumbness and Alignment

Ensure the wall batter and alignment offset measured as deviation from a straight edge is within plus or minus [1.25 inches per 10 feet][______] section. Ensure the batter measured from vertical is within [2][_____] degrees of the plan dimension.

3.4.4.4 Block Defects

The blocks will be accepted on the basis of tolerances specified in ASTM C1372.

3.4.4.5 Block Gaps

Ensure gaps between adjacent blocks do not exceed 1/8 inches.

3.5 PROTECTION

Protect work against damage from subsequent operations. Remove disturbed or displaced blocks and replace to conform to all requirements of this section. Do not incorporate damaged material into the wall. Upon completion of wall erection, clean the wall face to remove any loose soil deposits or stains.

-- End of Section --

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SECTION 32 84 23

UNDERGROUND SPRINKLERS
02/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.2	(1983; Errata 1992; R 2017) Gages and Gaging for Unified Inch Screw Threads
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1012	(2021) Performance Requirements for Backflow Preventer with an Intermediate Atmospheric Vent
ASSE 1013	(2021) Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies
ASSE 1020	(2020) Performance Requirements for Pressure Vacuum Breaker Assemblies

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C509	(2015) Resilient-Seated Gate Valves for Water Supply Service
AWWA C606	(2015) Grooved and Shouldered Joints
AWWA C901	(2020) Polyethylene (PE) Pressure Pipe and Tubing, 3/4 In. (19mm) Through 3 In. (76 mm), for Water Service

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B43	(2020) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2287	(2019) Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM D2464	(2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2774	(2021) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM F441/F441M	(2020) Standard Specification for

	Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR Manual	(10th Edition) Manual of Cross-Connection Control

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI WH 201	(2010) Water Hammer Arresters Standard

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-51145	(Rev D; Notice 1; Notice 2; Notice 3) Flux, Soldering, Non-Electronic, Paste and Liquid

1.2 SYSTEM DESCRIPTION

Submit Design Analysis and Calculations verifying that system will provide the irrigation requirements.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Sprinkler System

SD-03 Product Data

Framed Instructions

Field Training

Sprinkler System

Spare Parts

Design Analysis and Calculations

SD-06 Test Reports

Field Tests

SD-07 Certificates

Sprinkler System

SD-10 Operation and Maintenance Data

Sprinkler System; G

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity, and temperature variation; direct sunlight (in the case of plastic or rubber materials); and dirt, dust, or other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the related submittals and not later than the start of the field tests. Include with the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer who has produced similar systems that have performed well for a minimum period of 2 years prior to bid opening. Furnish equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

Secure a plate to each item of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.1.3 Additional Stock

Provide the following extra stock: Two sprinkler heads of each size and type, two valve keys for operating manual valves, two wrenches for removing and installing each type of head, two quick coupler keys and hose swivels, and four irrigation controller housing keys.

2.2 PIPING MATERIALS

2.2.1 Copper Tubing and Associated Fittings

Provide tubing coforming to requirements of ASTM B88, Type K. Provide fittings conforming to ASME B16.22 and ASME B16.18, solder joint. Provide solder conforming to ASTM B32, 95-5 tin-antimony. Provide flux conforming to CID A-A-51145, Type I. Design grooved mechanical joints and fittings for no less than 125 psig service and that are the product of the same manufacturer. Provide ductile iron grooved fitting and mechanical coupling housing conforming to ASTM A536. Use gaskets in grooved joints that are molded synthetic polymer of pressure responsive design and conforming to ASTM D2000 for circulating medium up to 230 degrees F. Provide grooved joints conforming to AWWA C606. Use steel coupling nuts and bolts in grooved joints and conforming to ASTM A183.

2.2.2 Red Brass Pipe and Associated Fittings

Furnish pipe conforming to requirements of ASTM B43, regular. Provide fittings that are Class 250, cast bronze threaded conforming to the requirements of ASME B16.15.

2.2.3 Galvanized Steel Pipe and Associated Fittings

Provide pipe conforming to requirements of ASTM A53/A53M, Schedule 40. Provide Class 150 fittings conforming to requirements of ASME B16.3.

2.2.4 Polyvinyl Chloride (PVC) Pipe, Fittings and Solvent Cement

2.2.4.1 PVC Pipe

Provide pipe conforming to the requirements of ASTM D1785, PVC 1120 Schedule 40 or 80; or ASTM D2241, PVC 1120 SDR 21, Class 200.

2.2.4.2 PVC Fittings

Provide solvent welded socket type fittings conforming to requirements of ASTM D2466, Schedule 40. Provide threaded type fittings conforming to requirements of ASTM D2464, Schedule 80.

2.2.4.3 Solvent Cement

Provide solvent cement conforming to the requirements of ASTM D2564.

2.2.5 Polyethylene (PE) Plastic Piping

Provide pipe conforming to AWWA C901, outside diameter base with dimension ratio (DR) of 9.3 to provide 150 psi minimum pressure rating. Provide fittings conforming to ASTM D3261, DR of 9.3.

2.2.6 Dielectric Fittings

Provide dielectric fittings conforming to ASTM F441/F441M, Schedule 80, CPVC threaded pipe nipples, 4 inch minimum length.

2.2.7 Emitter Hose and Distribution Tubing

Provide emitter hose and distribution tubing conforming to ASTM D2287, maximum inside diameter of 1/2 inch, minimum wall thickness of 90 mils, vinyl plastic extruded from non-rigid chloride, integrally algae-resistant, homogeneous throughout, smooth inside and outside, free from foreign materials, cracks, serrations, blisters and other effects. Provide slip fittings.

2.3 SPRINKLER AND EMITTER HEADS

2.3.1 Pop-Up Spray Heads

2.3.1.1 General Requirements

Pop-up spray heads lay flush with housing, then pop up when water pressure 20 psi is activated in system. The rising member supporting the nozzle must be identical on full, half, third or quarter pattern sprinklers so that nozzles will be interchangeable. Design the sprinkler head to be adjustable for coverage and flow. Provide removable nozzle so head does not have to be removed for flushing or cleaning. Nozzle rises a minimum of 4 inches above the body. Construct the body with a 1/2 inch female thread for installation in a fixed underground pipe system.

2.3.1.2 Shrubbery Sprinkler Heads

Provide conical spray sprinkler heads with adjustable or non-adjustable coverage and designed for permanent aboveground mounting on riser or pop-ups at a height compatible with ground covers. Provide brass nozzles.

2.3.2 Rotary Pop-Up Sprinklers

Provide sprinklers that are capable of covering [_____] feet diameter at [_____] psi with a distribution rate of [_____] gpm, [_____] pop-up, trajectory of [_____], and maximum height of spray of [_____]. Construction must be high impact molded plastic with filter screen, reducible watering radius, and choice of [_____] nozzles and have adjustable radius capabilities.

2.3.3 Bubbler Sprinkler Heads

Provide multiple-spray bubbler heads with adjustable flow and designed for permanent aboveground mounting on risers.

2.3.4 Surface Connected Lawn Sprinkler Heads

Provide impulse type heads with or without sled, ring, or wheel base; multiple T Type; a rotary type with sled, spike or wheel base; or oscillating type with wheel or sled base.

2.3.5 Emitter Heads

Provide self-cleaning, pressure compensating diaphragm with one or six self-piercing barbed outlets emitter heads; each capable of emitting from 1/4 to 2 gallons/hour flow. Flurnish emitter body ultraviolet stabilized, algae, and heat resistant plastic construction.

2.4 VALVES

2.4.1 Gate Valves, Less than 3 Inches

Provide gate valves conforming to the requirements of MSS SP-80, Type 1, Class 150, threaded or soldered ends.

2.4.2 Gate Valves, 3 Inches and Larger

Provide gate valves conforming to the requirements of AWWA C509 and have encapsulated resilient wedge, parallel seats, non-rising stems, and open by counterclockwise turning. End connections must be flanged. Interior construction of valves must be bronze including stem containing a maximum 2 percent aluminum and maximum 16 percent zinc.

2.4.3 Angle Valves, Less Than 2-1/2 Inches

Provide angle valves conforming to the requirements of MSS SP-80, Type 3, Class 150 threaded or soldered ends.

2.4.4 Angle Valves, 2-1/2 Inches and Larger

Provide angle valves conforming to the requirements of MSS SP-85, Type II, Class 250 threaded or flanged ends.

2.4.5 Quick Coupling Valves

Provide quick coupling valves consisting of brass parts and is a two-piece unit consisting of a coupler water seal valve assembly and a removable upper body to allow spring and key track to be serviced without shutdown of main. Provide lockable vinyl lids with spring for positive closure on key removal.

2.4.6 Remote Control Valves, Electrical

Provide remote control valves that are solenoid actuated globe valves of 3/4 to 3 inch size, suitable for 24 volts, 60 cycle, and designed to provide for shut-off in event of power failure. Valve must be cast bronze or brass or plastic housing suitable for service at 150 psi operating pressure with external flow control adjustment for shut-off capability, external plug at diaphragm chamber to enable manual operation, filter in control chamber to prevent valve body clogging with debris, durable diaphragm, and accessibility to internal parts without removing valve from system.

2.4.7 Drain Valves

2.4.7.1 Manual Valves

Furnish manual valves conforming to requirements of MSS SP-80, Type 3, Class 150 threaded or soldered ends for sizes less than 2-1/2 inches and MSS SP-85, Type II, Class 250 threaded or flanged ends for sizes 2-1/2 inches and larger.

2.4.7.2 Automatic Valves

Furnish automatic valves that are brass or plastic, spring loaded ball drip type, 150 pounds and threaded ends, designed to close at 6 foot pressure head with positive seal at 3 psi pressure or greater and be open to drain at less than 3 psi pressure.

2.4.8 Pressure Regulating Master Valve

Provide pressure regulating master valve that is automatic mechanical self-cleaning, self-purging control system having an adjustable pressure setting operated by a solenoid on alternating current with 0.70 amperes at 24 volts. Valve must close slowly and be free of chatter in each diaphragm position, have manual flow stem to adjust closing speed and internal flushing, and one or two inlet tappings capable of being installed as a straight pattern valve. Provide cast bronze or brass body with removable brass seat serviceable from top without removing valve body from system. Operate valve at 150 psi working pressure and pilot range from 10 to 125 psi.

2.4.9 Backflow Preventers

Test, approve, and list reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers in accordance with FCCCHR Manual. Furnish backflow preventers with intermediate atmospheric vent in accordance with ASSE 1012. Furnish reduced pressure principle backflow preventers in accordance with ASSE 1013.

2.4.9.1 Pressure Type Vacuum Breaker

Provide vacuum breaker conforming to the requirements of ASSE 1020 and consisting of bronze or brass construction, with one or two check valves, vacuum relief, inlet and discharge shut-offs valves, field test cocks, and vacuum relief opening of greater diameter than unit.

2.4.9.2 Reduced Pressure Type Backflow Preventers

Provide backflow preventers that are 150 pound flanged cast iron, bronze or brass mounted gate valve and strainer, 304 stainless steel or bronze, internal parts. Total pressure drop through complete assembly must be a maximum of 10 psi at rated flow. Provide red brass or galvanized steel pipe and fittings. Provide strainers consisting of bronze or brass construction with gasket caps. Provide units that have 200-mesh stainless steel screen elements.

2.5 ACCESSORIES AND APPURTENANCES

2.5.1 Valve Keys for Manually Operated Valves

Provide valve keys that are 1/2 inch diameter by 3 feet long, tee handles and keyed to fit valves.

2.5.2 Valve Boxes and Concrete Pads

2.5.2.1 Valve Vaults

Provide valve boxes that are cast iron, plastic lockable, or precast concrete for each gate valve, manual control valve and remote control valve. Use adjustable vault sizes. Cast the word "IRRIGATION" on the cover. Shaft diameter of vault must be minimum 5-1/4 inches. Cast iron vault must have bituminous coating.

2.5.2.2 Concrete Pads

Provide concrete pads that are precast or cast-in-place reinforced concrete construction for reduced pressure type backflow preventers.

2.5.3 Pressure Gauges

Provide pressure gauges conforming to requirements of ASME B40.100, single style pressure gauge for water with 4-1/2 inch dial brass or aluminum case, bronze tube, gauge cock, pressure snubber, and siphon. Scale range must be suitable for irrigation sprinkler systems.

2.5.4 Service Clamps

Provide service clamps that are bronze flat, double strap, with neoprene gasket or "O"-ring seal.

2.5.5 Water Hammer Arresters

Provide water hammer arrester conforming to the requirements of PDI WH 201; stainless steel construction with an encased and sealed bellows compression chamber.

2.5.6 Emitter Head Accessories

2.5.6.1 Strainer

Provide strainer at inlet to each drip line. Provide strainer with stainless steel screen having equivalent of 140-mesh filtration capacity and incorporate flush valves within strainer to clean screen without disassembling unit.

2.5.6.2 Pressure Regulator

Provide pressure regulator at each drip system if supply pressure exceeds 50 psi.

2.5.6.3 Riser Adapters

Provide riser adapters with a rigid piping system.

2.5.6.4 Tubing Stakes

Provide plastic coated steel tubing stakes, or other non-corrosive strong material to secure tubing.

2.5.6.5 Emitter Outlet Check Valve (Bug Cap)

Provide check valves at end of each emitter outlet distribution line. Permit free flow of water with minimum restriction; prevent back siphoning, entry of insects, and contamination into outlet ports.

2.5.6.6 Access Sleeve

Provide access sleeve at buried emitters placed in covered boxes. Secure lids of access sleeve with removable lugs. Secured drip hose in both vertical and horizontal axis.

2.5.6.7 Closure Caps

Provide closure caps in accordance with manufacturer's recommendations.

2.6 AUTOMATIC CONTROLLERS, ELECTRICAL

Provide controller conforming to the requirements of NEMA ICS 2 with 120 or 220-volt single phase service, operating with indicated stations, and grounded chassis. Provide enclosure conforming to NEMA ICS 6 Type 3R, with locking hinged cover, pedestal-mounted or wall-mounted. Program controller for various schedules by setting switches and dials equipped with the following features: A switch for each day of week for one, two or three schedules, allowing each station to be scheduled individually as to days of watering; a minute switch for each station with a positive increment range of 3 to 60 minutes or 0 to 3 hours, set time within one percent; a switch allowing selected schedules to be repeated after each completion of initial watering schedule and allowing each operation to be scheduled throughout a 24-hour day; a circuit breaker for surge protection; and circuit for a 9-volt rechargeable NiCad battery.

2.7 ELECTRICAL WORK

Provide wiring and rigid conduit for electrical power in accordance with NFPA 70, and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.8 CONCRETE MATERIALS

Furnish concrete with a compressive strength of 3,000 psi at 28 days as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.9 WATER SUPPLY MAIN MATERIALS

Provide tapping sleeves, service cut off valves, and connections to water supply mains in accordance with Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

2.10 INSULATING JOINTS

Provide insulating joints and dielectric fittings in accordance with Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install Sprinkler System after site grading has been completed. Perform excavation, trenching, and backfilling for sprinkler system in accordance with the applicable provisions of Section 31 00 00 EARTHWORK, except as modified herein.

a. Submit detail drawings for valves, sprinkler heads, backflow preventers, automatic controllers, emitter heads, and water hammer arresters. Include on the drawings a complete list of equipment and materials, and manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Also show on the drawings complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function as a unit. Show on the drawings proposed system layout, type and number of heads and emitters, zone valves, drain pockets, backflow devices, controllers, and mounting details of controllers.

b. Submit detailed procedures defining the Contractor's provisions for accident prevention, health protection, and other safety precautions for the work to be done. Submit the material supplier's or equipment manufacturer's statement that the supplied material or equipment meets specified requirements. Each certificate must be signed by an official authorized to certify in behalf of material supplier or product manufacturer and must identify quantity and date or dates of shipment or delivery to which the certificates apply. Include As-built Drawings which provide current factual information showing locations of mains, heads, valves, and controllers including deviations from and amendments to the drawings and changes in the work.

c. Submit 6 copies of operation and 6 copies of maintenance manuals for the equipment furnished. One complete set prior to field testing and the remainder upon acceptance. Manuals must be approved prior to the field training course. Detail the step-by-step procedures required for system startup, operation, and shutdown. Include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features.

d. List routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include piping and equipment layout, simplified wiring and control diagrams of the system as installed, and system programming schedule.

3.2.1 Trenching

Hand excavate trench around roots to pipe grade when roots of 2 inches diameter or greater are encountered. Provide trench width of 4 inches minimum or 1.5 times diameter of pipe, whichever is wider. Hand tamp backfill over excavation. When rock is encountered, excavate trench 4 inchesdeeper and backfill with silty sand (SM) or well-graded sand (SW) to pipe grade. Keep trenches free of obstructions and debris that would damage pipe. Do not mix subsoil with topsoil. Bore existing concrete walks, drives and other obstacles at a depth conforming to bottom of adjacent trenches. Provide pipe sleeves for bored pipe that is two pipe diameters larger than sprinkler pipe.

3.2.2 Piping System

3.2.2.1 Cover

Install underground piping to meet the minimum depth of backfill cover specified.

3.2.2.2 Clearances

Provide minimum horizontal clearances between lines of 4 inches for pipe 2 inches and less; 12 inches for 2-1/2 inches and larger. Provide 1 inch minimum vertical clearances between lines.

3.2.2.3 Minimum Slope

Provide minimum slope of 6 inches per 100 feet in direction of drain valves.

3.2.3 Piping Installation

3.2.3.1 Polyvinyl Chloride (PVC) Pipe

a. Provide solvent-cemented joints conforming to the requirements of ASTM D2855.

b. Provide full cut threaded joints with a maximum of three threads remaining exposed on pipe and nipples. Make threaded joints tight without recourse to wicks or fillers, other than polytetrafluoroethylene thread tape.

c. Join piping to conform with requirements of ASTM D2774 or ASTM D2855, and pipe manufacturer's instructions. Install pipe in a serpentine (snaked) manner to allow for expansion and contraction in trench before backfilling. Install pipes at temperatures over 40 degrees F.

3.2.3.2 Soldered Copper Tubing

Ream pipe and remove burrs. Clean and polish surfaces of joint. Apply flux to male and female ends. Insert end of tube into fittings full depth of socket. After soldering, show a solder bead continuously around entire joint circumference. Remove excess acid flux from tubings and fittings.

3.2.3.3 Threaded Brass or Galvanized Steel Pipe

Prior to installation, ream pipe. Cut threads in conformance with ASME B1.2. Apply pipe joint compound to male end only.

3.2.3.4 Insulating Joints

Provide insulating and dielectric fittings where pipes of dissimilar metal are joined and at connections to water supply mains as shown. Install in accordance with Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

3.2.3.5 Grooved Mechanical Joints

Prepare grooves according to the coupling manufacturer's instructions. Furnish grooved fittings, couplings, and grooving tools that are products of the same manufacturer. Provide pipe and groove dimensions complying with the tolerances specified by the coupling manufacturer. Measure the diameter of grooves made in the field using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Measure and record groove width and dimension of groove from end of pipe for each change in grooving tool setup to verify compliance with the coupling manufacturer's tolerances. Do not use grooved joints in concealed locations.

3.2.4 Installation of Valves

3.2.4.1 Manual Valves

Install valves in a valve box extending from grade to below valve body, with a minimum of 4 inches cover measured from finish grade to top of valve stem.

3.2.4.2 Automatic Valves

Set valve plumb in a valve box extending from grade to below valve body, with minimum of 4 inch cover measured from grade to top of valve. Install automatic valves beside sprinkler heads with a valve box.

3.2.4.3 Drain Valves

Entire system must be manually or automatically drainable. Equip low points of system with drain valve draining into an excavation containing 1 cubic foot gravel. Cover gravel with building paper then backfill with excavated material and 6 inches of topsoil.

3.2.5 Sprinklers and Quick Coupling Valves

Install sprinklers and valves plumb and level with terrain.

3.2.6 Installation of Drip Irrigation System

3.2.6.1 Emitter Hose

Bury emitter laterals 6 inches deep. Solvent weld connections in accordance with manufacturer's recommendation to standard weight Schedule 40 PVC fittings and bushings. Install hose in a serpentine manner. When cutting hose, use a shearing tool such as a pipe cutter, knife, or shears. Follow manufacturer's recommended tool and procedures when punching hose for emitters.

3.2.6.2 Emitter Heads

Install emitters in a plastic emitter box. Connect emitter on a rigid PVC nipple to PVC drip lateral with a tee or elbow. Attach tubing to barbed fitting and daylight distribution tubing at root ball secured with stake, with bug cap at end of secured distribution tubing. After installing emitters and before operating system, open end of drip lateral and flush clean. Do not exceed manufacturer's recommendations for the number of emitters on a line for that hose or distribution tubing size and length.

3.2.6.3 Tubing Stakes

Secure main irrigation line with stakes where line is aboveground. Space stakes to ensure that hose does not shift location in presence of foot traffic, operations, gravity on slope installations, or environmental effects. Stake discharge of the emitter distribution tubing to ensure that discharge point of emitter will be maintained at specified position in relation to plant material to be irrigated.

3.2.7 Backflow Preventers

Install backflow preventer in new connection to existing water distribution system, between connection and control valves. Install backflow preventer with concrete pads.

3.2.7.1 Pressure Type Vacuum Breaker

Install pressure type vacuum breaker 12 inches above highest head.

3.2.7.2 Reduced Pressure Type

Flush pipe lines prior to installing reduced pressure device; protect device by a strainer located upstream. Do not install device in pits or where any part of device could become submerged in standing water.

3.2.8 Control Wire and Conduit

3.2.8.1 Wires

Low voltage wires may be buried beside pipe in same trench. Provide rigid conduit where wires run under paving. Number tag wires at key locations along main to facilitate service. Provide one control circuit for each zone and a circuit to control sprinkler system.

3.2.8.2 Loops

Provide a 12 inch loop of wire at each valve where controls are connected.

3.2.8.3 Expansion and Contraction

Bundle and tape multiple tubes or wires together at 10 or 20 foot intervals with 12 inch loop for expansion and contraction.

3.2.8.4 Splices

Provide waterproof electrical splices.

3.2.9 Automatic Controller

Determine exact field location of controllers before installation. Coordinate the electrical service to these locations. Install in accordance with manufacturer's recommendations and NFPA 70.

3.2.10 Thrust Blocks

Place concrete so that sides subject to thrust or load are against undisturbed earth, and valves and fittings are serviceable after concrete has set. Provide thrust blocks as specified in Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

3.2.11 Backfill

3.2.11.1 Minimum Cover

Depth of cover must be 24 inches for 1-1/4 inch pipe or smaller; 24 inches for 1-1/2 to 2 inch pipe; 24 inches for 2-1/2 inch pipe or larger; 36 inches for pipes under traffic loads, farm operations, and freezing temperatures; and 18 inches for low-voltage wires. Fill remainder of trench or pipe cover to within 3 inches of top with excavated soil, and compact soil with plate hand-held compactors to same density as undisturbed adjacent soil.

3.2.11.2 Restoration

Fill top 3 inches topsoil and compact with same density as surrounding soil. Restore lawns and plants in accordance with Sections 32 92 19 SEEDING, 32 92 23 SODDING, 32 92 26 SPRIGGING, and Section 32 93 00 EXTERIOR PLANTS. Restore pavements in accordance with Section as appropriate.

3.2.12 Adjustment

After grading, seeding, and rolling of planted areas, adjust sprinkler heads flush with finished grade. Make adjustments by providing new nipples of proper length or by use of heads having an approved device, integral with head, which will permit adjustment in height of head without changing piping.

3.2.13 Disinfection

Disinfect sprinkler system fed from a potable water system upstream of backflow preventer in accordance with Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

3.2.14 Cleaning of Piping

Prior to the hydrostatic and operation tests, flush the interior of the pipe with clean water until pipe is free of all foreign materials. Flushing and cleaning out of system pipe, valves, and components is not complete until witnessed and accepted by Contracting Officer.

3.3 FRAMED INSTRUCTIONS

Post framed instructions, containing wiring and control diagrams under glass or in laminated plastic, where directed. Frame condensed operating instructions, prepared in typed form, as specified above and posted beside the diagrams. Post the framed instructions before acceptance testing of the system. Submit labels, signs, and templates of operating instructions that are required to be mounted or installed on or near the product for normal, safe operation. After as-built drawings are approved by Contracting Officer, prepare controller charts and programming schedule. Supply one chart for each controller. Chart must be a reduced drawing of actual as-built system that will fit the maximum dimensions inside controller housing. Use black line print for chart and a different pastel or transparent color to indicate each station area of coverage. After chart is completed and approved for final acceptance, seal chart between two 20 mil pieces of clear plastic.

3.4 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members for a total period of 8 hours of normal working time and starting after the system is functionally complete but prior to final acceptance tests. Submit information describing training to be provided, training aids to be used, samples of training materials to be provided, and schedules and notification of training. Cover all of the items contained in the operating and maintenance manuals.

3.5 FIELD TESTS

Provide all instruments, equipment, facilities, and labor required to conduct the tests. Submit performance test reports, in booklet form, showing all field tests performed to adjust each component; and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of control valves.

3.5.1 Hydrostatic Pressure Test

Test piping hydrostatically before backfilling and proved tight at a hydrostatic pressure of 150 psi without pumping for a period of one hour with an allowable pressure drop of 5 psi. If hydrostatic pressure cannot be held for a minimum of 4 hours, make adjustments or replacements and repeat the tests until satisfactory results are achieved and accepted by the Contracting Officer.

3.5.2 Leakage Tests

Perform leakage tests for service main in accordance with Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

3.5.3 Operation Test

At conclusion of pressure test, install sprinkler heads or emitter heads, quick coupling assemblies, and hose valves and test entire system for operation under normal operating pressure. Operation test consists of the system operating through at least one complete programmed cycle for all areas to be sprinkled.

3.6 CLEANUP

Upon completion of installation of system, remove all debris and surplus materials resulting from the work.

-- End of Section --

SECTION 32 84 24

IRRIGATION SPRINKLER SYSTEMS
08/11, CHG 1: 05/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Std 598	(2009) Valve Inspecting and Testing

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 189.1	(2014) Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.2	(1983; Errata 1992; R 2017) Gages and Gaging for Unified Inch Screw Threads
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1010	(2021) Performance Requirements for Water Hammer Arresters
ASSE 1020	(2020) Performance Requirements for Pressure Vacuum Breaker Assemblies
ASSE Series 5000	(2015) Cross-Connection Control Professional Qualification Standard

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C500	(2019) Metal-Seated Gate Valves for Water

	Supply Service
AWWA C511	(2017) Reduced-Pressure Principle Backflow Prevention Assembly
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C901	(2020) Polyethylene (PE) Pressure Pipe and Tubing, 3/4 In. (19mm) Through 3 In. (76 mm), for Water Service
AWWA M14	(2015) Manual: Recommended Practice for Backflow Prevention and Cross-Connection Control

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B43	(2020) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2287	(2019) Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM D2464	(2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2774	(2021) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl

	Chloride) (PVC) Pipe and Fittings
ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM F441/F441M	(2020) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2021) Plastics Piping System Components and Related Materials

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-51145	(Rev D; Notice 1; Notice 2; Notice 3) Flux, Soldering, Non-Electronic, Paste and Liquid

UNDERWRITERS LABORATORIES (UL)

UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

Provide a system pressure calculations and irrigation requirements of the area. If pressure falls above or below indicated values, Contractor shall notify Contracting Officer. For Irrigation Sprinkler System, indicate the following:

a. Head, piping, valve, controller, sensor layout. Provide separate hydrozones for plant materials with different water requirements.

b. Pipe, valve, backflow preventer, and controller.

c. Invert elevations. Indicate obstructions interfering with operation.

d. Water source equipment, including existing mains, piping, valves and meters.

e. System and supply pressures.

f. Indicate wiring diagram between existing power source and controller/water pump.

g. Number and extent of control valve circuits.

h. Provide details of all irrigation components and accessories.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Irrigation Sprinkler System

Drawings including irrigation legend prepared by a licensed, registered or certified Landscape Architect or Irrigation Specialist.

SD-03 Product Data

Piping Materials, tubing, and fittings

Valves and Accessories

Sprinkler Heads

Backflow Preventers

Automatic Controller

Controller Enclosure

Solvent Cement

Control Wiring

Drip Irrigation Equipment and ccessories

Water Hammer Arresters

Water Meter

Rain Shut-Off Device

Freeze Shut-Off Device

Soil Moisture Sensor

Tapping Tee

Valve Boxes and Lids

Drip Head Accessories

SD-05 Design Data

System Pressure Calculations

Irrigation Requirements

SD-06 Test Reports

Valves, and Accessories Tests

Backflow Preventers

Pressure Test

Operation Test

Including verification of sprinkler head layout

Submit record of pressure tests conducted on recording gage.

SD-07 Certificates

Backflow Preventers

ASSE Series 5000, Submit a certificate of Full Approval or a current Certificate of Approval from FCCCHR List for size, and make of backflow preventer being provided for this project. A Certificate of Provisional Approval will not be acceptable.

SD-08 Manufacturer's Instructions

Automatic Controller

Sprinkler Heads

Piping Materials

Tubing and fittings.

Backflow Preventers

Valves

Solvent Cement

Control Wiring

Drip Irrigation and accessories

Water Hammer Arresters

Water Meter

Rain Shut-Off Device

Freeze Shut-Off Device

Soil Moisture Sensor

Submit mounting details for automatic controllers.

SD-10 Operation and Maintenance Data

Piping Materials and Fittings, Data Package 2; G

Sprinkler Heads and Accessories, Data Package 2; G

Backflow Preventers, Data Package 2; G

Valves, Data Package 2; G

Automatic Controller, Data Package 2; G

Drip Irrigation and Accessories, Data Package 2; G

Water Hammer Arresters, Data Package 2; G

Water Meter, Data Package 2; G

Rain Shut-Off Device, Data Package 2; G

Freeze Shut-Off Device, Data Package 2; G

Soil Moisture Sensor, Data Package 2; G2

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Include troubleshooting procedures with respect to valve and controller problems.

SD-11 Closeout Submittals

Controller Charts

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver materials in original rolls, packages, cartons, and containers with the name of manufacturer, brand, and model. Inspect materials delivered to the site for damage.

1.5.2 Storage

Store materials on site in enclosures or under protective covering. Store plastic piping and rubber gaskets under cover out of direct sunlight. Do not store materials directly on ground. Keep inside of pipes and fittings free from dirt and debris.

1.5.3 Handling

Handle and carry pipe, fittings, valves, and accessories in such a manner as to ensure delivery to trench in sound undamaged condition. Do not drag pipe.

1.6 EXTRA STOCK

a. 2 additional sprinkler heads (nozzles, bodies, screens, pressure compensating devices) of each size and type;

b. 2 valve keys for operating manual valves;

c. 2 wrenches for removing and installing each type of head;

d. 2 quick coupler keys and hose swivels;

e. 4 irrigation controller housing keys.

f. 4 irrigation controller enclosure keys; and

g. 2 hand-held remotes compatible with controller system.

1.7 QUALITY ASSURANCE

1.7.1 Required Test

Submit tests signed by an authorized official of a testing laboratory of sprinkler head, valve, automatic controller, emitter heads, vacuum breaker, backflow preventer, and water hammer arrester.

PART 2 PRODUCTS

2.1 PIPING MATERIALS

2.1.1 Copper Tubing and Associated Fittings

2.1.1.1 Tubing

ASTM B88, Type K.

2.1.1.2 Fittings

ASME B16.22 and ASME B16.18, solder joint. Solder, ASTM B32 alloy Grade Sn95 or Sn94. Flux, CID A-A-51145, Type I.

2.1.2 Red Brass Pipe and Associated Fittings

2.1.2.1 Pipe

ASTM B43, regular.

2.1.2.2 Fittings

ASME B16.15, Class 250, cast bronze threaded.

2.1.3 Galvanized Steel Pipe and Associated Fittings

2.1.3.1 Pipe

ASTM A53/A53M, Schedule 40.

2.1.3.2 Fittings

ASME B16.3, Class 150.

2.1.4 Polyvinyl Chloride (PVC) Pipe, Fittings and Solvent Cement

NSF/ANSI 14, seal of approval for potable water.

2.1.4.1 Pipe

ASTM D1785, PVC 1120 Schedule 40 or 80; or ASTM D2241, PVC 1120 SDR 21, . Provide integral lavender-color pipe for non-potable use. Provide ultra-violet resistant piping for on-grade use.

2.1.4.2 Fittings

a. Solvent Welded Socket Type: ASTM D2466, Schedule 40. Provide lavender-colored fittings. Provide ultra-violet resistant fittings.

b. Threaded Type: ASTM D2464, Schedule 80. Provide lavender-colored fittings. Provide ultra-violet resistant fittings.

2.1.4.3 Solvent Cement

ASTM D2564.

2.1.5 Polyethylene (PE) Plastic Piping

2.1.5.1 Pipe

AWWA C901, outside diameter (od) base with dimension ratio (DR) of 9.3 to provide 150 psi minimum pressure rating.

2.1.5.2 Fittings

ASTM D3261, DR of 9.3.

2.1.6 Dielectric Fittings

ASTM F441/F441M, Schedule 80, CPVC threaded pipe nipples, 4 inch length.

2.1.7 Drip Irrigation Tubing

ASTM D2287, maximum inside diameter (id) as required, vinyl plastic extruded from non-rigid chloride, integrally algae-resistant, homogeneous throughout, smooth inside and outside, free from foreign materials, cracks, serrations, blisters and other effects. Provide slip barbed compression fittings.

2.1.8 Pipe Sleeving

a. Provide PVC or cast iron piping two times the diameter of main or lateral piping.

b. Provide gray PVC electrical conduit sized according to number of control wires. Minimum 2 inch size.

2.2 IRRIGATION AND DRIP SPRINKLER HEADS

Provide lavender-colored body, nozzle, and/or cap indicator for non-potable use.

2.2.1 Fixed Riser Irrigation Heads

2.2.1.1 Stream Rotors, Full or Part Circle

Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic. Heavy duty, stainless steel internal construction with plastic body. Provide check valve below each sprinkler body on riser.

2.2.1.2 Gear Rotor Irrigation Head, Full or Part Circle

Single-stream, water lubricated, gear drive type capable of covering the indicated radius at the specified discharge rate. Part circle sprinkler with an adjustable arc coverage of 30 to 360 degrees. Stainless steel internal construction with plastic body, with matched precipitation rate nozzles in standard /low/ flat angle trajectories, filter screen, reducible watering radius, and choice of nozzles.

2.2.1.3 Impact Irrigation Head

Capable of covering the indicated radius at the specified discharge rate, and V pop-up. Provide one or two nozzles to distribute water, an inlet strainer to prevent debris from clogging nozzles, and non-corrosive brass or plastic head and stainless steel assemblies. Seal bearing assembly from abrasives. Provide entire assembly including strainer removable from top of case without disturbing case installation. Provide plastic housing.

2.2.1.4 Spray Irrigation Heads, Full or Part Circle

Capable of covering the indicated radius at the specified discharge rate. Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic. Matched precipitation rate plastic or brass nozzle with an adjustable screw capable of regulating the radius and the flow. Capable of housing under the nozzle; protective, non-clogging filter screen and/or pressure compensating devices. Screen used in conjunction with the adjusting screw from regulating. Provide check valve below each sprinkler body on riser.

2.2.1.5 Adjustable Flood Bubbler Head

Capable of providing the indicated discharge rate, operating over a pressure range of 10 to 60 psi. Constructed of durable ultra-violet resistant plastic with a plastic inlet filter screen to protect the nozzle against clogging, and a stainless steel adjustable screw, capable of shutting off the bubbler and regulating the flow.

2.2.1.6 Pressure Compensating Flood Bubbler Head

Capable of providing the indicated discharge rate. Plastic inlet filter screen bubbler assembly to protect the nozzle against clogging. Permanently assembled design constructed of durable, ultra-violet resistant plastic with a integral rubber flow washer for regulating the discharge rate at an operating pressure range of 20 to 90 psi.

2.2.2 Pop-Up Irrigation Head

2.2.2.1 Stream Rotor Irrigation Head, Full or Part Circle

Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic. Heavy duty, stainless steel internal construction with plastic body. Pop-up height of 3, 4, 6 or 12 inches as measured from top of cap at normal installation to middle of nozzle orifice. Provide check valve in head.

2.2.2.2 Gear Rotor Irrigation Head, Full or Part Circle

Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic. Heavy duty, stainless steel internal construction with plastic body and match precipitation rates for standard low or flat angle trajectories. Single-stream, water lubricated, gear drive type capable of covering the indicated radius at the specified discharge rate. Part circle sprinkler with an adjustable arc coverage of 30 to 360 degrees. Pop-up height of 3, 4, 6 or 12 inches as measured from top of cap at normal installation to middle of nozzle orifice. Provide wiper seal that positively seals against nozzle flange to keep debris out of rotor and cleans debris from pop-up steam as it retracts. Provide check valve in head.

2.2.2.3 Impact Irrigation Head

Capable of covering the indicated radius at the specified discharge rate. Provide one or two nozzles to distribute water, an inlet strainer to prevent debris from clogging nozzles, and non-corrosive brass and plastic head and stainless steel assemblies. Seal bearing assembly from abrasives. Provide entire assembly including strainer removable from top of case without disturbing case installation. Provide plastic housing. Pop-up height of 3, 4, 6 or 12 inches as measured from top of cap at normal installation to middle of nozzle orifice.

2.2.2.4 Spray Irrigation Head, Full or Part Circle

Capable of covering the indicated radius at the specified discharge rate. Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic with wiper seal. Brass or Plastic nozzle with matched precipitation rate and an adjustable screw capable of regulating the radius and flow. Capable of housing under the nozzle; protective, non-clogging filter screen and/or pressure compensating devices. Screen used in conjunction with the adjusting screw from regulating. Pop-up height of 3, 4, 6 or 12 inches as measured from the top of cap at normal installation to middle of nozzle orifice. Provide check valve below each sprinkler body on riser.

2.2.3 Bubbler Irrigation Head

2.2.3.1 Adjustable Flood Bubbler

Capable of providing at the specified discharge rate. operating over a pressure range of 10 to 60 psi. Construct of durable ultra-violet resistant plastic with a plastic inlet filter screen to protect the nozzle against clogging, and a stainless steel adjusting screw, capable of shutting off the bubbler and regulating the flow. Pop-up height of 3, 4, 6 or 12 inches as measured from top of cap at normal installation to middle of nozzle orifice.

2.2.3.2 Pressure Compensating Flood Bubbler

Capable of providing a consistent discharge rate. Plastic inlet filter screen bubbler assembly to protect the nozzle against clogging. Permanently assembled design constructed of durable, ultra-violet resistant plastic with an integral rubber flow washer for regulating the discharge rate at an operating pressure range of 20 to 90 psi. Pop-up height of 3, 4, 6 or 12 inches as measured from top of cap at normal installation to middle of nozzle orifice.

2.2.4 Fixed Drip Head

2.2.4.1 Multi-Port Outlet Device

Multi-outlet, pressure compensating emitter manifold that is ultra-violet resistant, algae, and heat resistant, non-corrosive PVC material for above or below grade installation. Integral 200 mesh fabric screen that can be serviced from the top of the unit by unscrewing the top cap. Six, eight or twelve, top or bottom mounted outlet ports that will accept 1/8-1/4 inch vinyl tubing. The six, eight or twelve ports can be accessed through the top of the unit by unscrewing the lid from the base. Each outlet port accepts a pressure compensating emitter controlling the flow from 0.5 to 24.0 gph per outlet. Operating range of unit is 15 to 50 psi with 1/2 inch female national pipe thread (FNPT) inlet.

2.2.4.2 Single Outlet Pressure Compensating Emission Device

Pressure compensated emitter body constructed of ultra-violet, algae, heat resistant and chemical resistant, non-corrosive PVC material. Diaphragm constructed of a silicone elastomer material. Capable of delivering a nominal flow rate of 0.5 to 24.0 gph at a pressure range of 15 to 50 psi. A self piercing inlet barb type 1/2 inch female national pipe thread (FNPT) inlet mounted onto a 1/2 inch male national pipe thread (MNPT) riser. Barbed emitter outlet configuration that will accept 1/8 or 1/4 inch vinyl tubing.

2.2.4.3 Microspray Device

Capable of covering 0 to 15 feet radius at the indicated pressure with the specified discharge rate with overall pop-up height of 4, 6 or 12 inches. Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic with wiper seal on sprinkler. Matched precipitation rate brass or plastic nozzle with an adjustable screw capable of regulating the radius and flow and capable of housing under the nozzle; protective, non-clogging filter screens and/or pressure compensating devices. Screen used in conjunction with the adjusting screw for regulating. Mount with 1/2 inch female national pipe thread (FNPT) adapter poly flex riser stake.

2.2.4.4 In-Line Tubing Device

Factory installed, heavy-walled flexible polyethylene (PE) tubing, pressure compensating, self-cleaning emitters at spacings of 12, 18, 24 or 36 inches. Emitter flow of 0.5, 1.0 or 2.0 gph with inlet pressure of specified psi. Tubing diameter of 1/2 or 3/4 inch.

2.2.5 Pop-Up Drip Head

Capable of covering 0 to 15 feet radius at the indicated pressure with the specified discharge with overall pop-up height of 4, 6 or 12 inches. Sprinkler body, steam, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic with wiper seal on sprinkler. Provide a heavy-duty, stainless steel retract spring for positive pop-down and a ratcheting system for easy alignment of the pattern. Matched precipitation rate brass of plastic nozzle with an adjusting screw capable of regulating the radius and flow and capable housing under the nozzle; protective, non-clogging filter screens and/or pressure compensating devices. Screen used in conjunction with the adjusting screw for regulating. A side and bottom 1/2 inch female national pipe thread (FNPT) inlet for the 6 or 12 inch model. Mount with 1/2 inch female national pipe thread (FNPT) adapter poly flex riser stake.

2.3 VALVES

Provide lavender-colored assembly for non-potable use.

2.3.1 Isolation Valve

2.3.1.1 Ball Valves, Less than 3 inches

API Std 598, brass or plastic body, threaded or soldered ends.

2.3.1.2 Gate Valves, 3 inches and Larger

AWWA C500, bottom wedging double discs, parallel seats, non-rising stems, open by counterclockwise turning. Provide flanged end connections. Provide bronze interior construction of valves including stem containing a maximum 2 percent aluminum and maximum 16 percent zinc.

2.3.2 Control Valves

2.3.2.1 Pressure Regulating Master Control Valve

Automatic mechanical self-cleaning, self-purging control system having an adjustable pressure setting operated by a solenoid on alternating current (ac) with 0.70 amperes at 24 volts. Valve shall close slowly and be free of chatter in each diaphragm position. Provide a manual flow stem to adjust closing speed and internal flushing. Provide an adjusting screw for setting pressure and schrader valve for monitoring pressure. Provide one or two inlet tappings capable of being installed as a straight pattern valve. Provide heavy duty cast iron, brass or plastic valve body with brass seat that is removable and serviceable from top without removing valve body from system. Maximum working pressure of valve is 150 psi and pilot range from 10 to 125 psi.

2.3.2.2 Remote Control Valve, Electrical

Solenoid actuated globe or angle valves of 3/4 to 3 inch size, alternating current (ac), 60/50 cycle as indicated in rush current and as specified holding current. Provide brass or plastic valve housing suitable for service at 150 psi operating pressure. Provide pressure regulating module capable of regulating outlet pressure between 15 to 25 psi (plus or minus) 5 psi and adjustable screw for setting pressure schrader valve connection for monitoring pressure.

2.3.2.3 Manual Angle Control Valve, Manual Globe Control Valve

Less than 2 1/2 inch MSS SP-80, type 3, Class 150 threaded or soldered ends. Angle or globe valve 2 1/2 inch and larger MSS SP-85, Type II, Class 250 threaded or flanged ends.

2.3.3 Quick Coupling Valves

Two piece unit consisting of a coupler water seal valve assembly and a removable upper body to allow spring and key track to be serviced without shutout of main. Provide brass parts. Provide yellow, lavender, vinyl or rubber lockable lids with springs for positive closure on key removal.

2.3.4 Hose Bib

One piece consisting of all brass construction with full flow 1/2, 3/4 or one inch hose connection outlet and with attached handle or removable key handle with gaskets and washers.

2.3.5 Drain Valves

2.3.5.1 Manual

MSS SP-80, Type 3, Class 150 threaded or soldered ends for sizes less than 2 1/2 inches. MSS SP-85, Type II, Class 250 threaded or flanged ends for sizes 2 1/2 inches and larger.

2.3.5.2 Automatic

Brass, spring loaded ball drip type, 150 pounds and threaded ends, designed to close at 6 foot pressure head with positive seal at 3 psi pressure or greater and be open to drain at less than 3 psi pressure.

2.3.6 Backflow Preventers

2.3.6.1 Reduced Pressure Type Backflow Preventers

AWWA C511. Provide backflow preventers complete with 150 psi rated flanged cast iron, bronze or brass mounted gate or ball valve , 304 stainless steel or bronze, internal parts. Total pressure drop through complete assembly shall be a maximum of 10 psi at rated flow. Listing of particular make, model/design, and size in FCCCHR List will be acceptable as required proof for testing and certification.

a. Piping Assembly: Red brass pipe and fittings or Galvanized steel pipe and fittings.

b. Strainers: Bronze or brass construction with gasket caps. Equip units with No. 200 mesh stainless steel screen elements.

2.3.6.2 Pressure Type Vacuum Breaker

ASSE 1020 bronze or brass construction, with one or two check valves, vacuum relief, inlet and discharge shut-offs valves, and field test cocks, and with vacuum relief opening of greater diameter than unit.

2.3.6.3 Atmospheric Vacuum Breaker

AWWA M14, vacuum relief, inlet and discharge openings, and with vacuum relief opening of greater diameter than unit.

2.4 ACCESSORIES AND APPURTENANCES

2.4.1 Tapping Tee

Bronze flat, double strap, with neoprene gasket or "O"-ring seal.

2.4.2 Water Meter

Provide a submeter in accordance with ASHRAE 189.1. Meter to include roll sealed register, magnetic drive, straight reading (odometer shall indicate in gallons, large numerals, glass lens for legibility,) low flow indicator to detect leaks, tamper proof seal pin to detect theft; sturdy durable, corrosion resistant main case, electrical grounding continuity; nutating disc measuring chamber with minimum head loss.

2.4.3 Drip Head Accessories

2.4.3.1 Strainer

Provide strainer at inlet to each drip control valve assembly. Provide polyester fabric screen attached to a PVC frame having the equivalent of 150 or 200 mesh filtration capacity. Compact "Y" body and cap configuration. Incorporate flush valves within strainer to clean screen without disassembling unit.

2.4.3.2 Riser Adapters

PVC material, threaded, barbed or soldered to attached drip heads to tubing, pop-up irrigation body, or rigid piping and tubing to rigid piping.

2.4.3.3 Tubing Stakes

Plastic, plastic coated steel, or other non-corrosive strong material to secure tubing.

2.4.3.4 Bug Cap

Provide check valves at end of each emitter outlet distribution line. Valves shall permit free flow of water with minimum restriction; prevent back siphoning, entry of insects, and contamination into outlet ports.

2.4.3.5 Subterranean Drip Box and Cover

Construct of ultra-violet resistant PVC. Two slots in bottom of box to allow for installation of distribution tubing onto the emission device.

2.4.3.6 Line Flushing Valve

Construct of PVC with maximum flow rate of 15 gpm with minimum flushing water volume of one gallon at a minimum 4 psi to a maximum 25 psi at a point of discharge.

2.4.3.7 Valve Boxes

Cast-iron or precast concrete manufactured in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION valve box for each isolation valve, control valve, quick coupling valve and drain valve. Provide box sizes that are suitable and adjustable for valve used.

a. Cast the word "IRRIGATION" on cover.

b. Stencil, engrave, or brand controller and valve sequence on remote control valve cover. Letters minimum 4 inches height.

2.4.4 Backflow Preventer Accessories

2.4.4.1 Pressure Gages

ASME B40.100, single style pressure gage for water with 4 1/2 inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and siphon. Provide scale range suitable for irrigation systems.

2.4.4.2 Water Hammer Arresters

ASSE 1010; stainless steel construction with an encased and sealed bellows compression chamber.

2.4.4.3 Backflow Preventer Enclosure

Frame to be constructed of 3/16 inch stainless steel or steel angle iron with 1 1/2 inch No. 9 expanded metal covering. Construct in a one piece single swing or two piece double hinge configuration. Provisions for pad locking and lighting handles. Size to fit backflow assembly to installed. Color to be green . Lock for enclosure provided by others.

2.4.4.4 Concrete Pads

Cast-in-place reinforced concrete construction for reduced pressure type backflow preventers.

2.4.5 Moisture Sensing Device

2.4.5.1 Automatic Rain Shut-Off Device

One piece, maintenance and adjustment free, reacts to a minimum 1/8 inch of rain water, unaffected by humidity levels, commercial grade materials, no exposed mechanical switch or electrodes, solid state construction with internal relay operating voltage of 24 to 30 VAC, static charge pretested, maximum switch current of one amp.

2.4.5.2 Automatic Freeze Shut-Off Device

Construct of a PVC cylinder with a sensing element mounted at top of cylinder capable of interrupting the control valve common wire as temperatures approach 32 degrees F. Operating voltage 24 VAC, maximum current one amp. Static charge protection with snubber network.

2.4.5.3 Soil Moisture Sensor Device

24 VAC, field adjustable and capable of interrupting irrigation cycles for pre-determined moisture level at moisture probe location. Waterproof field adjustment module with bypass switch.

2.4.6 Air/Vacuum Relief

Construct of PVC with a maximum operating pressure of 140 psi.

2.4.7 Water Booster Package

Booster pump package to be a prefabricated system, pre-piped, pre-wired and mounted on a steel skid base minimum 3 inch welded angle iron or channel brackets, hot dipped galvanized, with a minimum 9/16 inch holes at each corner for bolting to concrete with anchors. Field assembled pump systems are not acceptable.

2.4.7.1 Pump

Pump to be end suction close coupled or in-line type, bronze impeller and wear rings, bronze shaft sleeve, mechanical seal with high-resist seat, integral flanged suction and discharge connections, keyed motor shaft, back pull-out type, with centerline discharge for automatic venting and Type 304 stainless steel internal parts and fittings.

2.4.7.2 Motor

Motor to be as specified, ball bearing design, stainless steel shaft, non-over loading on full range of the impeller curve without use of the service factor and including rodent and insect screens over the openings. Single phase motors to be totally enclosed fan cooled and open drip-proof with a minimum 1.15 service factor. Three phase motors to be totally enclosed fan cooled, open drip-proof with a minimum 1.15 service factor.

2.4.7.3 Piping and Fittings

Piping and fittings to be flanged spools of Schedule 40 steel and Class 150 weld flanges, hot dipped galvanized after fabrication. Spacer spools to be welded and galvanized. Companion flanges at suction and discharge header connections to be Schedule 40 steel and galvanized.

2.4.7.4 Gages

Gages shall be 2 1/2 inch diameter, liquid filled for vibration dampering, 0-200 pounds, stainless steel casing, with brass needle valve shut-off cocks.

2.4.7.5 Butterfly Valve

Butterfly valves and adjustable handles to be sandblasted and epoxy coated, nuts and bolts to be cad plated, shut off valves to be centerline butterfly lug type, wafer style, drilled and tapped, with bronze disc, capable of remaining installed in the piping.

2.4.7.6 Check Valves

A combination pressure reducing and non-slam check valve to be installed with booster pump package to reduce effect of varying suction pressure.

2.4.7.7 Pump Control Panels

Pump control panels to be 14 gage type UF, type 304 stainless steel with continuous welded seams, door with continuous hinge, all welds passivated to eliminate corrosion, UL listed, NEMA 3R enclosure with holes in bottom to allow for all inlet wiring for main power control accessories and louvers with insect screens on opposite sides for cross ventilation, deadfront, keylockable and padlockable, with main disconnect switch, circuit breaker with adjustable overloads on all legs and adjustable inrush current trip setting on units exceeding 41 amps, heavy duty contactor, 115 volt control circuit transformer with circuit breaker disconnect. A plug-in module type pump start relay shall be mounted and hard wired in the pump panel. A electronic flow switch with 0-60 seconds adjustable time delay relay, mounted and hard wired in the pump panel, to operate as a no-flow safety shut down. NEMA 3R non-fused main disconnect switch, mounted on exterior of pump panel, hard wired to panel circuit breaker.

]2.4.8 Flow Meter

Shall be as indicated, female national pipe threaded ends and replaceable metering insert. 9 volt direct current output with a pulse rate which is proportional to the gpm, a 0.067 amperes fuse link to protect metering insert and 14 gage output feeder wire to be powered by the controller. Provide brass or plastic meter housing suitable for service at 150 psi operating pressure.

2.5 AUTOMATIC CONTROLLER ELECTRICAL SOLAR BATTERY

Controller, NEMA ICS 2 with 120-volt single phase service with surge protection , operating with indicated stations, and grounded chassis. Provide in an enclosure with locking hinge cover.

2.5.1 Controller Features

a. Multi-station controller with independent programs that can run concurrently.

b. Allows an infinite number of cycles per day by placing the program in a looping mode.

c. Ability to be programmed in one second increments, from one second to 12 hours .

d. A water budgeting capability in all stations within a program in one percent increments from one percent to 255 percent .

e. A programmable watering calendar ranging from one to 16 .

f. A single-station timed manual feature that allows a station to be turned on manually for its programmed watering time.

g. A semi-automatic manual cycle feature.

h. A true manual operation with safety shut-off at midnight and indicate which station is on by means of L.E.D.S.i. UL listed, having a re-settable circuit breaker, cadmium plated, weatherproof steel case, and keyed lock.

2.5.2 Controller Enclosure

Controller Enclosure must be NEMA ICS 2 mounted as indicated on the Drawings . Enclosure must be indoor wall mounted plastic cabinet outdoor pedestal mounted plastic powder-coated metal, color to be beige stainless steel____.

2.6 ELECTRICAL CIRCUITS

2.6.1 Control Wiring for Electrically Operated Valves

NFPA 70, copper conductor 14 gage wire, Type UF.

2.6.2 Conduit

UL 651, rigid polyvinyl chloride conduit, Schedule 40.

2.7 CONCRETE MATERIALS

2500 psi compressive concrete strength at 28 days as specified under Section 03 30 00 CAST-IN-PLACE CONCRETE.

PART 3 EXECUTION

3.1 INSTALLATION

Install sprinkler system after site grading has been completed.

3.1.1 Trenching

Hand trench around roots to pipe grade when roots of 2 inches diameter or greater are encountered. Make width of trench 4 inches minimum or 1 1/2 times diameter of pipe, whichever is wider. Backfill and hand tamp over excavation. When rock is encountered, excavate 4 inches deeper and backfill with silty sand (SM) or well-graded sand (SW) to pipe grade. Keep trenches free of obstructions and debris that would damage pipe. Do not mix subsoil with topsoil. Bore under existing concrete walks, drives and other obstacles at a depth conforming to bottom of adjacent trenches. Install pipe sleeve, two pipe diameters larger than sprinkler pipe, to fill bore. Prior to backfilling of trench, Contracting Officer shall verify and approve location of all irrigation heads.

3.1.2 Piping System

3.1.2.1 Clearances

a. Minimum horizontal clearances between lines: 4 inches for 2 inch pipe and less; 12 inches for 2 inch pipe and more.

b. Minimum vertical clearances between lines: one inch.

3.1.2.2 Minimum Pitch

Down 6 inches per 100 feet in direction of drain valves.

3.1.2.3 Thrust Blocks

Install thrust blocks at bends, tees, plugs and valves or 2 1/2 inches and larger mainline piping. Place concrete so that sides subject to thrust or load are against undisturbed earth, and valves and fittings are serviceable after concrete has set.

3.1.2.4 Minimum Backfill Cover

a. 18 inches for pressure mainline pipe and valve control wire.

b. 12 inches for non-pressure lateral pipe.

c. 24 inches for all piping under paved or non-paved pedestrian paths.

d. 36 inches for all piping under traffic loads, farm operations, freezing temperatures.

e. Install pipe sleeves at depths indicated in "c" and "d".

When rock is encountered. Provide minimum 4 inches of silty sand (SM) or well graded sand (SW) cover on top of all piping. Fill remainder of trench or pipe cover to within 3 inches of top with excavated soil, and compact soil with plate hand-held compactors to same density as undisturbed adjacent soil.

3.1.2.5 Restoration

Fill top 3 inches with topsoil and compact with same density as surrounding soil. Restore turf and plants according to Section 32 92 19 SEEDING, Section 32 92 23 SODDING,Section 32 92 26 SPRIGGING, and Section 32 93 00 EXTERIOR PLANTS. .

3.1.2.6 Sterilization

Sprinkler system fed from a potable water system sterilized upstream of backflow preventer in accordance with AWWA C651. Sterilize new water lines for a minimum of 24 hours to meet local state federal health test requirements before placing in service. Minimum retention period shall be 3 hours.

3.1.3 Piping Installation

3.1.3.1 Polyvinyl Chloride (PVC) Pipe

a. Solvent-Cemented Joints: ASTM D2855.

b. Threaded Joints: full cut with a maximum of three threads remain exposed on pipe and nipples. Make threaded joints tight without recourse to wicks or fillers, other than polytetrafluoroethylene thread tape.

c. Piping: ASTM D2774 or ASTM D2855, and pipe manufacturer's instructions. Install pipe in a serpentine (snaked) manner to allow for expansion and contraction in trench before backfilling. Install pipes at temperatures over 40 degrees F.

3.1.3.2 Soldered Copper Tubing

Ream pipe and remove burrs. Clean and polish contact surfaces of joint. Flux both male and female ends. Insert end of tube into fittings full depth of socket. After soldering, a solder bead shall show continuously around entire joint circumference. Remove excess acid flux from tubings and fittings.

3.1.3.3 Threaded Brass or Galvanized Steel Pipe

Prior to installation ream pipe. Cut threads as specified in ASME B1.2. Make joints with pipe joint compound applied to male end only.

3.1.3.4 Polyethylene (PE) Pipe and Drip Tubing

Bury drip tubing and PE pipe 12 inches deep. Solvent weld, compression connection or barbed connection in accordance with manufacturers recommendation. Install hose in serpentine manner. When cutting hose, use a shearing tool such as a pipe cutter, knife or shears. Use only manufacturer's recommended tool and procedure when installing drip heads.

3.1.3.5 Dielectric Protection

Where pipes of dissimilar metal are joined, make connection with dielectric fitting.

3.1.4 Irrigation Heads

Install plumb and level with terrain. Irrigation heads must not spray directly on or within 3-feet of building.

3.1.4.1 Fixed Riser Irrigation Heads

Nozzle mounted on fixed riser minimum 6 inches above grade in mulched planter beds, 12 inches above grade in planter beds with groundcover. Provide swing joint assembly attachment between lateral lines and fixed risers.

3.1.4.2 Pop-Up Irrigation Head

Install plumb and level with terrain. Provide swing joint assembly attachment between lateral line and pop-up body. Top of irrigation head shall be flush wit surrounding finish grade. In recreational fields, install all pop-up rotors with stainless steel risers 5 inches below finish grade per manufacturer's recommendations.

3.1.4.3 Drip Heads

Install drip heads in plastic drip box. Connect drip head to a rigid PVC nipple, drip head stake or directly to tubing. Attach tubing to barbed fitting and daylight distribution tubing at rootball secured with stake. Add bug cap at end of secured distribution tubing. After installing drip heads and before operating system, open end of drop lateral and flush lines clean. The number of drip heads on a line shall not exceed manufacturer's recommendations for that hose or distribution tubing size and length.

3.1.5 Valves

3.1.5.1 Isolation Valves

Install in a valve box extending from grade to below valve body, with a minimum of 4 inches cover measured from finish grade to top of valve stem.

3.1.5.2 Control Valves

Plumb valve in a valve box extending from grade to below valve body, with minimum of 4 inch cover measured from grade to top of valve. Install automatic valves beside sprinkler heads with a valve box.

3.1.5.3 Quick Coupling Valves

Install in a valve box extending from grade to below valve body, with a minimum of 4 inches cover measured from finish grade to top of valve stem. Install 2 inches above finish grade in planter bed, level with finish grade in turf areas.

3.1.5.4 Hose Bibb

Install above grade or below grade in valve box with support.

3.1.5.5 Drain Valves

Entire system shall be manually or automatically drainable. Equip low point of each underground line with drain valve draining into an excavation containing gravel. Cover gravel with building paper. Backfill with excavated material and 6 inches of topsoil.

3.1.6 Backflow Preventers

a. Install backflow preventer in new connection to existing water distribution system, between connection and control valves. Install with concrete pads. Install with concrete pads in turf only.

b. Flush pipe lines prior to installing device.

c. Device shall not be installed in pits or where any part of the device could become submerged in standing water

d. Install device a minimum of 12 inches from trees, walls, fences, structures and other obstructions.

3.1.6.1 Reduced Pressure Backflow Preventer

a. Protect device by a strainer located upstream.

b. Install device a minimum of 12 inches between finish grade and bottom of relief port.

c. Where freezing conditions occur, locate device inside a building and pipe the relief valve port through an air gap to a drain.

d. Install water meter above grade, upstream of unit of unit as a part of assembly. Provide galvanized steel support with concrete footing.

3.1.6.2 Pressure Vacuum Breaker

a. Install device a minimum of 12 inches between highest irrigation head and bottom of air relief valve.

b. Where freezing conditions occur, locate device inside a building and pipe the relief valve port through an air gap to a drain.

3.1.6.3 Atmospheric Vacuum Breaker

Install device minimum of 12 inches between highest irrigation head and bottom of relief valve located downstream of irrigation control valve.

3.1.7 Accessories

3.1.7.1 Connection To Existing Water Supply Systems (Tapping Tee)

Use tapping or drilling machine valve and mechanical joint type sleeves for connections to be made under pressure. Bolt sleeves around mains; bolt valve conforming to AWWA C500 to the branch. Open valve, attach drilling machine, make tap, close valve, and remove drilling machine, without interruption of service. Notify Contracting Officer in writing at least 15 days prior to the date the connections are required; receive approval before any service is interrupted. Provide materials required to make connections into the existing water supply systems and perform excavating, backfilling, and other incidental labor as required. Furnish the labor and the tapping or drilling machine for making the actual connections to the existing systems.

3.1.7.2 Water Meter

Install meter upstream of backflow preventer per manufacturer's recommendations and local PWC Utility Department Instructions. Plumb meter in a valve box extending from grade to below meter body, with a minimum of 4 inch cover measured from top of grade to top of meter.

3.1.7.3 Valve Boxes and Lids

a. Install with one cu ft pea gravel sump below valve.

b. Support valve box with brick or concrete block .

c. Provide wire screen between gravel sump and bottom of valve body for rodent protection.

d. For turf areas, install flush with finish grade.

e. For planter beds, install 2 inches above finish grade.

f. For sloped conditions, install valve box level with terrain.

3.1.7.4 Backflow Preventer Enclosure

a. Install with concrete pad.

b. Place hinges so direction of swing will not conflict with other site features.

3.1.7.5 Rain and Freeze Shut-Off Devices

a. Install as per manufacturer's recommendations.

b. For wall mounted controllers, attach devices to side of building or eave, minimum 8 feet above finish grade and a minimum of 12 inches from building wall or eave.

c. For pedestal mounted controllers, mount to side of controller housing on top of minimum 42 inches high pole outside of irrigation coverage in vandal-resistant enclosure.

3.1.7.6 Soil Moisture Sensing Device

a. Bury the device at depth per manufacturer's recommendation in the effective root zone of hydrozone to be monitored.

b. Place a sensor-protection plate, indicator or valve box with cover above the device.

c. Provide waterproof connection to all field splices in valve boxes.

3.1.7.7 Air/Vacuum Relief Valve

Locate at highest point in piping system.

3.1.8 Electrical Circuits

Bury wires beside mainline pipe in same trench. Provide gray electrical conduit where wires run under paved or non-paved pedestrian paths and vehicular roads. Tag wires at controller and control valve location with plastic tie wrapped tags. Provide one control wire to each control valve location and one common wire looped from controller to each control valve. Provide one separate control valve wire of a different color from controller to each control valve cluster.

3.1.8.1 Loops

Provide a 12 inch loop of wire at each valve where controls are connected.

3.1.8.2 Expansion and Contraction

Bundle multiple tubes or wires and tape together at 10 or 20 foot intervals with 12 inch loop for expansion and contraction.

3.1.8.3 Splices

Make electrical splices waterproof. Locate all field electrical splices in valve boxes.

3.1.9 Automatic Controller

Determine exact location of controllers in field before installation. Coordinate the electrical service to these locations. Install in accordance with manufacturer's recommendations and NFPA 70.

3.1.10 Flushing

After piping, risers, and valves are in place and connected, but prior to installation of sprinkler heads and valves, flush piping system under a full head of water. Maintain flushing for 3 minutes.

3.1.11 Adjustment

After grading, plant installation, and rolling of planted areas, adjust sprinkler heads flush with finished grade. Make adjustments by providing new nipples of proper length or by use of heads having an approved device, integral with head, which will permit adjustment in height of head without changing piping.

3.1.12 Sterilization

Sprinkler system fed from a potable water system shall be sterilized upstream of backflow preventer in accordance with AWWA C651. Sterilize new waterlines for a minimum of 24-hours, to meet local, state, federal, health test requirements before placing in service. Minimum retention period shall be 3 hours.

3.2 FIELD QUALITY CONTROL

The Contractor will conduct and the Contracting Officer and the QC representative will witness field inspections and field tests specified in this section. Perform field tests, and provide labor, equipment, and incidentals required for testing.

3.2.1 Pressure Test

3.2.1.1 Duration

During pressure test, maintain a hydrostatic pressure of 150 psi without pumping for a period of one hour with an allowable pressure drop of 5 psi before backfilling system.

3.2.1.2 Leaks

Correct leaks. Make necessary corrections to stop leakage.

3.2.1.3 Retest

Retest system twice until pressure can be maintained for duration of test.

3.2.2 Operation Test

3.2.2.1 Accessories

At conclusion of pressure test, install irrigation heads or drip heads, quick coupling assemblies, and hose bib, and test entire system for operation under normal operating pressure. Make necessary corrections or adjustments to raise or lower pressure for each system if tests results do not match pressure requirements.

3.2.2.2 Acceptance

Operation test is acceptable if system operates through at least one complete cycle for areas to be irrigated.

3.2.3 Controller Charts

Provide one chart for each controller supplied. Indicate in chart area controlled by automatic controller. The chart is a reduction of the actual plans that will fit the maximum dimensions inside controller housing. Use black line print for chart and a different pastel or transparent color to indicate each station area of coverage. After chart is completed and approved for final acceptance, seal chart between two 20 mil pieces of clear plastic.

-- End of Section --

SECTION 32 92 19

SEEDING
08/17, CHG 1: 08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C602	(2020) Agricultural Liming Materials
ASTM D4427	(2018) Standard Classification of Peat Samples by Laboratory Testing
ASTM D4972	(2018) Standard Test Methods for pH of Soils

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act	(1940; R 1988; R 1998) Federal Seed Act
DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

95 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 84 24 IRRIGATION SPRINKLER SYSTEMS, Section 32 92 23 SODDING, Section 32 92 26 SPRIGGING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wood Cellulose Fiber Mulch

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil Composition Tests (reports and recommendations).

SD-07 Certificates

State Certification and Approval for Seed

SD-08 Manufacturer's Instructions

Erosion Control Materials

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

A delivery schedule shall be provided at least 10 calendar days prior to the first day of delivery.

1.5.1.1 Delivered Topsoil

Prior to the delivery of any topsoil, its availability shall be verified in paragraph TOPSOIL. A soil test shall be provided for topsoil delivered to the site.

1.5.1.2 Soil Amendments

Soil amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's chemical analysis. In lieu of containers, soil amendments may be furnished in bulk. A chemical analysis shall be provided for bulk deliveries.

1.5.1.3 Seed Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.4 Pesticides

Pesticide material shall be delivered to the site in the original, unopened containers bearing legible labels indicating the EPA registration number and the manufacturer's registered uses. For additional requirements refer to Base specific environmental sections.

1.5.1.5 Fertilizer Gypsum Sulfur Iron and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer gypsum sulphur iron and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Inspection

Seed shall be inspected upon arrival at the job site for conformity to species and quality. Seed that is wet, moldy, or bears a test date five months or older, shall be rejected. Other materials shall be inspected for compliance with specified requirements. The following shall be rejected: open soil amendment containers or wet soil amendments; topsoil that contains slag, cinders, stones, lumps of soil, sticks, roots, trash or other material over a minimum 1-1/2 inch diameter; and topsoil that contains viable plants and plant parts. Unacceptable materials shall be removed from the job site.

1.5.3 Storage

Materials shall be stored in designated areas. Seed, lime, and fertilizer shall be stored in cool, dry locations away from contaminants. Chemical treatment material shall be stored according to manufacturer's instructions and not with seeding operation materials.

1.5.3.1 Seed, Fertilizer Gypsum Sulfur Iron and Lime Storage

Store in cool, dry locations away from contaminants.

1.5.3.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.3.3 Handling

Except for bulk deliveries, do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Seed

Apply seed within twenty four hours after seed bed preparation.

PART 2 PRODUCTS

2.1 SEED

2.1.1 Classification

Provide State-approved seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weedseed content, and inert material. Label in conformance with AMS Seed Act and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected. Field mixes will be acceptable when field mix is performed on site in the presence of the Contracting Officer.

2.1.2 Permanent Seed Species and Mixtures

Permanent seed species and mixtures shall be proportioned by weight and in a mixture as shown on the drawings or approved by the Contracting Officer.

2.1.3 Temporary Seed Species

Temporary seed species for surface erosion control or overseeding shall be as indicated or approved by the Contracting Officer.

2.1.4 Quality

Weed seed shall be a maximum 1 percent by weight of the total mixture.

2.1.5 Seed Mixing

The mixing of seed may be done by the seed supplier prior to delivery, or on site as directed.

2.1.6 Substitutions

Substitutions will not be allowed without written request and approval from the Contracting Officer.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph COMPOSITION. When available topsoil must be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil must be furnished by the Contractor.

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH must be tested in accordance with ASTM D4972. Topsoil must be free of sticks, stones, roots, and other debris and objectionable materials. Other components must conform to the following limits:

Silt	[25-50][7 to 17][_____] percent
Clay	[10-30][4 to 12][_____] percent
Sand	[20-35][70 to 82][_____] percent
pH	[5.5 to 7.0][_____]
Soluble Salts	[600] [_____] ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade hydrate or burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 80 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427. Shred and granulate peat to pass a 1/2 inch mesh screen and condition in storage pile for minimum 6 months after excavation.

2.3.6 Sand

Clean and free of materials harmful to plants.

2.3.7 Perlite

Horticultural grade.

2.3.8 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.8.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.9 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 80 percent, calcium 18 percent, sulfur 14 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.10 Calcined Clay

Calcined clay must be granular particles produced from montmorillonite clay calcined to a minimum temperature of 1200 degrees F. Gradation: A minimum 90 percent must pass a No. 8 sieve; a minimum 99 percent must be retained on a No. 60 sieve; and material passing a No. 100 sieve must not exceed 2 percent. Bulk density: A maximum 40 pounds per cubic foot.

2.4 FERTILIZER

2.4.1 Granular Fertilizer

[Organic][synthetic], granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

[_____] percent available nitrogen
[_____] percent available phosphorus
[_____] percent available potassium
[_____] percent sulfur
[[_____] percent iron

]2.4.2 Hydroseeding Fertilizer

Controlled release fertilizer, to use with hydroseeding and composed of pills coated with plastic resin to provide a continuous release of nutrients for at least 6 months and containing the following minimum percentages, by weight, of plant food nutrients.

[_____] percent available nitrogen
[_____] percent available phosphorus
[_____] percent available potassium
[[_____] percent sulfur
][[_____] percent iron

]2.5 MULCH

Mulch must be free from noxious weeds, mold, and other deleterious materials.

2.5.1 Straw

Stalks from oats, wheat, rye, barley, or rice. Furnish in air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Straw must contain no fertile seed.

2.5.2 Hay

Air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Hay must be sterile, containing no fertile seed.

2.5.3 Wood Cellulose Fiber Mulch

Use recovered materials of either paper-based (100 percent post-consumer content) or wood-based (100 percent total recovered content) hydraulic mulch. Processed to contain no growth or germination-inhibiting factors and dyed an appropriate color to facilitate visual metering of materials application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 5.5 to 8.2. Use with hydraulic application of grass seed and fertilizer.

2.6 WATER

Source of water must be approved by Contracting Officer and of suitable quality for irrigation, containing no elements toxic to plant life.

2.7 EROSION CONTROL MATERIALS

Erosion control material must conform to the following:

2.7.1 Erosion Control Blanket

100 percent agricultural straw or 70 percent agricultural straw/30 percent coconut fiber matrix stitched with a degradable nettings, designed to degrade within 12 months.

2.7.2 Erosion Control Fabric

Fabric must be knitted construction of polypropylene yarn with uniform mesh openings 3/4 to 1 inch square with strips of biodegradable paper. Filler paper strips must have a minimum life of 6 months.

2.7.3 Erosion Control Net

Net must be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately one inch square.

2.7.4 Hydrophilic Colloids

Hydrophilic colloids must be physiologically harmless to plant and animal life without phytotoxic agents. Colloids must be naturally occurring, silicate powder based, and must form a water insoluble membrane after curing. Colloids must resist mold growth.

2.7.5 Erosion Control Material Anchors

Erosion control anchors must be as recommended by the manufacturer.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 EXTENT OF WORK

Provide soil preparation prior to planting (including soil conditioners as required), fertilizing, seeding, and surface topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.1.1 Topsoil

Provide 4 inches of off-site topsoil, on-site topsoil or existing soil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer pH adjusters soil conditioners into soil a minimum depth of 4 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.1.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.1.1.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SEEDING

3.2.1 Seed Application Seasons and Conditions

Immediately before seeding, restore soil to proper grade. Do not seed when ground is muddy, frozen or snow covered or in an unsatisfactory condition for seeding. If special conditions exist that may warrant a variance in the above seeding dates or conditions, submit a written request to the Contracting Officer stating the special conditions and proposed variance. Apply seed within twenty four hours after seedbed preparation. Sow seed by approved sowing equipment. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing.

3.2.2 Seed Application Method

Seeding method must be broadcasted and drop seeding or hydroseeding.

3.2.2.1 Broadcast and Drop Seeding

Seed must be uniformly broadcast at the rate of [_____] pounds per 1000 square feet. Use broadcast or drop seeders. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing. Cover seed uniformly to a maximum depth of 1/4 inch in clay soils and 1/2 inch in sandy soils by means of spike-tooth harrow, cultipacker, raking or other approved devices.

3.2.2.2 Hydroseeding

First, mix water and fiber. Wood cellulose fiber, paper fiber, or recycled paper must be applied as part of the hydroseeding operation. Fiber must be added at 1,000 pounds, dry weight, per acre. Then add and mix seed and fertilizer to produce a homogeneous slurry. Seed must be mixed to ensure broadcasting at the rate of [_____] pounds per 1000 square feet. When hydraulically sprayed on the ground, material must form a blotter like cover impregnated uniformly with grass seed. Spread with one application with no second application of mulch.

3.2.3 Mulching

3.2.3.1 Hay or Straw Mulch

Hay or straw mulch must be spread uniformly at the rate of 2 tons per acre. Mulch must be spread by hand, blower-type mulch spreader, or other approved method. Mulching must be started on the windward side of relatively flat areas or on the upper part of steep slopes, and continued uniformly until the area is covered. The mulch must not be bunched or clumped. Sunlight must not be completely excluded from penetrating to the ground surface. All areas installed with seed must be mulched on the same day as the seeding. Mulch must be anchored immediately following spreading.

3.2.3.2 Mechanical Anchor

Mechanical anchor must be a V-type-wheel land packer; a scalloped-disk land packer designed to force mulch into the soil surface; or other suitable equipment.

3.2.3.3 Asphalt Adhesive Tackifier

Asphalt adhesive tackifier must be sprayed at a rate between 10 to 13 gallons per 1000 square feet. Sunlight must not be completely excluded from penetrating to the ground surface.

3.2.3.4 Non-Asphaltic Tackifier

Hydrophilic colloid must be applied at the rate recommended by the manufacturer, using hydraulic equipment suitable for thoroughly mixing with water. A uniform mixture must be applied over the area.

3.2.3.5 Asphalt Adhesive Coated Mulch

Hay or straw mulch may be spread simultaneously with asphalt adhesive applied at a rate between 10 to 13 gallons per 1000 square feet, using power mulch equipment which must be equipped with suitable asphalt pump and nozzle. The adhesive-coated mulch must be applied evenly over the surface. Sunlight must not be completely excluded from penetrating to the ground surface.

3.2.4 Rolling

Immediately after seeding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width. If seeding is performed with cultipacker-type seeder or by hydroseeding, rolling may be eliminated.

3.2.5 Erosion Control Material

Install in accordance with manufacturer's instructions, where indicated or as directed by the Contracting Officer.

3.2.6 Watering

Start watering areas seeded as required by temperature and wind conditions. Apply water at a rate sufficient to insure thorough wetting of soil to a depth of 2 inches without run off. During the germination process, seed is to be kept actively growing and not allowed to dry out.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations at the Contractor's expense. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

SECTION 32 92 23

SODDING
04/06, CHG 1: 08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C602	(2020) Agricultural Liming Materials
ASTM D4427	(2018) Standard Classification of Peat Samples by Laboratory Testing
ASTM D4972	(2018) Standard Test Methods for pH of Soils

TURFGRASS PRODUCERS INTERNATIONAL (TPI)

TPI GSS	(1995) Guideline Specifications to Turfgrass Sodding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

100 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 84 24 IRRIGATION SPRINKLER SYSTEMS, , Section 32 92 19 SEEDING, Section 32 92 26 SPRIGGING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil composition tests (reports and recommendations).

SD-07 Certificates

Nursery Sod farm certification for sods. Indicate type of sod in accordance with TPI GSS.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Sod Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer Gypsum Sulfur Iron and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer gypsum sulphur iron and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Sod Storage

Lightly sprinkle with water, cover with moist burlap, straw, or other approved covering; and protect from exposure to wind and direct sunlight until planted. Provide covering that will allow air to circulate so that internal heat will not develop. Do not store sod longer than 24 hours. Do not store directly on concrete or bituminous surfaces.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Sod

Place sod a maximum of thirty six hours after initial harvesting, in accordance with TPI GSS as modified herein.

PART 2 PRODUCTS

2.1 SODS

2.1.1 Classification

Nursery grown, certified as classified in the TPI GSS. Machine cut sod at a uniform thickness of 3/4 inch within a tolerance of 1/4 inch, excluding top growth and thatch. Each individual sod piece shall be strong enough to support its own weight when lifted by the ends. Broken pads, irregularly shaped pieces, and torn or uneven ends will be rejected.Wood pegs and wire staples for anchorage shall be as recommended by sod supplier.

2.1.2 Purity

Sod species shall be genetically pure, free of weeds, pests, and disease.

2.1.3 Planting Dates

Lay sod from [_____] to [_____] for warm season spring planting and from [_____] to [_____] for cool season fall planting.

2.1.4 Composition

2.1.4.1 Proportion

Proportion grass species as follows.

Botanical Name	Common Name	Percent
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]

2.1.4.2 Sod Farm Overseeding

At the sod farm provide sod with overseeding of annual rye grass seedortype recommended by seed producer. Rye grass is not allowed on Airfield.

[2.2 WILDFLOWER SOD

2.2.1 Classification

Certified, Field grown wildflower sod, machine cut at a uniform thickness of one inch within a tolerance of 1/4 inch, excluding top growth. Top growth shall be a maximum height of 3 inches. Each individual wildflower sod piece shall be strong enough to support its own weight when lifted by the ends. Broken pads, irregular shaped pieces, and torn or uneven ends will be rejected. Wood pegs and wire staples for anchorage on slope conditions, three to one or greater, shall be used as recommended by wildflower sod supplier.

2.2.2 Composition

Proportion wildflower species as follows:

Botanical Name	Common Name	Percent
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]

]2.3 TOPSOIL

2.3.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph entitled "Composition." When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK31 23 00.00 20 EXCAVATION AND FILL.

2.3.2 Off-Site Topsoil

Conform to requirements specified in paragraph entitled "Composition." Additional topsoil shall be furnished by the Contractor.

2.3.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH shall be tested in accordance with ASTM D4972. Topsoil shall be free of sticks, stones, roots, and other debris and objectionable materials. Other components shall conform to the following limits:

Silt	[25-50][7 to 17][_____] percent
Clay	[10-30][4 to 12][_____] percent
Sand	[20-35][70 to 82][_____] percent
pH	[5.5 to 7.0][_____]
Soluble Salts	[600] [_____] ppm maximum

2.4 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.4.1 Lime

Commercial grade hydrate or burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 80 percent.

2.4.2 Aluminum Sulfate

Commercial grade.

2.4.3 Sulfur

100 percent elemental

2.4.4 Iron

100 percent elemental

2.4.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427. Shred and granulate peat to pass a 1/2 inch mesh screen and condition in storage pile for minimum 6 months after excavation.

2.4.6 Sand

Clean and free of materials harmful to plants.

2.4.7 Perlite

Horticultural grade.

2.4.8 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.4.8.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.4.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.4.9 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 91 percent, calcium 22 percent, sulfur 17 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.4.10 Calcined Clay

Calcined clay shall be granular particles produced from montmorillonite clay calcined to a minimum temperature of 1200 degrees F. Gradation: A minimum 90 percent shall pass a No. 8 sieve; a minimum 99 percent shall be retained on a No. 60 sieve; and a maximum 2 percent shall pass a No. 100 sieve. Bulk density: A maximum 40 pounds per cubic foot.

2.5 FERTILIZER

2.5.1 Granular Fertilizer

[Organic][synthetic], granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

[_____] percent available nitrogen
[_____] percent available phosphorus
[_____] percent available potassium
[_____] percent sulfur
[[_____] percent iron]

2.6 WATER

Source of water shall be approved by Contracting Officer and of suitable quality for irrigation containing no element toxic to plant life.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Extent Of Work

Provide soil preparation (including soil conditioners), fertilizing, and sodding of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.2 Soil Preparation

Provide 4 inches of off-site topsoil or on-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer pH adjusters soil conditioners into soil a minimum depth of 4 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.2.1 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.1.2.2 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SODDING

3.2.1 Finished Grade and Topsoil

Prior to the commencement of the sodding operation, the Contractor shall verify that finished grades are as indicated on drawings; the placing of topsoil, smooth grading, and compaction requirements have been completed in accordance with Section 31 00 00 EARTHWORK31 23 00.00 20 EXCAVATION AND FILL.

The prepared surface shall be a maximum 1 inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove from the surface debris and stones over a minimum 5/8 inch in any dimension.

3.2.2 Placing

Place sod a maximum of 36 hours after initial harvesting, in accordance with TPI GSS as modified herein.

3.2.3 Sodding Slopes and Ditches

For slopes 2:1 and greater, lay sod with long edge perpendicular to the contour. For V-ditches and flat bottomed ditches, lay sod with long edge perpendicular to flow of water. Anchor each piece of sod with wood pegs or wire staples maximum 2 feet on center. On slope areas, start sodding at bottom of the slope.

3.2.4 Finishing

After completing sodding, blend edges of sodded area smoothly into surrounding area. Air pockets shall be eliminated and a true and even surface shall be provided. Frayed edges shall be trimmed and holes and missing corners shall be patched with sod.

3.2.5 Rolling

Immediately after sodding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width.

3.2.6 Watering

Start watering areas sodded as required by daily temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to minimum depth of 6 inches. Run-off, puddling, and wilting shall be prevented. Unless otherwise directed, watering trucks shall not be driven over turf areas. Watering of other adjacent areas or plant material shall be prevented.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

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SECTION 32 93 00

EXTERIOR PLANTS
08/17, CHG 1: 08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA P5	(2015) Standard for Waterborne Preservatives
AWPA T1	(2022) Use Category System: Processing and Treatment Standard
AWPA U1	(2022) Use Category System: User Specification for Treated Wood

AMERICANHORT (AH)

ANSI/ANLA Z60.1	(2004) American Standard for Nursery Stock

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM C602	(2020) Agricultural Liming Materials
ASTM D2729	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D4427	(2018) Standard Classification of Peat Samples by Laboratory Testing
ASTM D4972	(2018) Standard Test Methods for pH of Soils
ASTM D5268	(2019) Topsoil Used for Landscaping Purposes
ASTM D5852	(2000; R 2007; E 2014) Standard Test Method for Erodibility Determination of Soil in the Field or in the Laboratory by the Jet Index Method
ASTM D6629	(2001; R 2012; E 2012) Selection of

	Methods for Estimating Soil Loss by Erosion

L.H. BAILEY HORTORIUM (LHBH)

LHBH	(1976) Hortus Third

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA A300P1	(2017) ANSI A300 Part1: Tree Care Operations - Trees, Shrubs and Other Woody Plant Maintenance Standard Practices - Pruning
TCIA Z133	(2017) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 84 24 IRRIGATION SPRINKLER SYSTEMS, Section 32 92 19 SEEDING, Section 32 92 23 SODDING, Section 32 92 26 SPRIGGING, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

State Landscape Contractor's License

Time Restrictions and Planting Conditions

Indicate anticipated dates and locations for each type of planting.

SD-03 Product Data

Peat

Composted Derivatives

Rotted Manure

Organic Mulch Materials

Gypsum

Drainage Pipe

Mulch; G

Ground Stakes

Recycled Plastic Edging

Fertilizer

Weed Control Fabric; G,

Root Control Barrier; G

Staking Material

Wood Edging

Metal Anchors

Antidesiccants

Erosion Control Materials

Photographs; G

SD-04 Samples

Mulch; G

Submit of mulch.

SD-06 Test Reports

Topsoil Composition Tests; ; Soil Test of proposed area; Soil Test location map

Percolation Test; ; Percolation Test of proposed area

SD-07 Certificates

Nursery Certifications

SD-10 Operation and Maintenance Data

Plastic Identification

When not labeled, identify types in Operation and Maintenance Manual.

1.4 QUALITY ASSURANCE

1.4.1 Topsoil Composition Tests

Commercial test from an independent testing laboratory including basic soil groups (moisture and saturation percentages, Nitrogen-Phosphorus-Potassium (N-P-K) ratio, pH (ASTM D4972), soil salinity), secondary nutrient groups (calcium, magnesium, sodium, Sodium Absorption Ratio (SAR)), micronutrients (zinc, manganese, iron, copper), toxic soil elements (boron, chloride, sulfate), cation exchange and base saturation percentages, and soil amendment and fertilizer recommendations with quantities for plant material being transplanted. Soil required for each test must include a maximum depth of 18 inches of approximately one quart volume for each test. Areas sampled should not be larger than one acre and should contain at least 6-8 cores for each sample area and be thoroughly mixed. Problem areas should be sampled separately and compared with samples taken from adjacent non-problem areas. The location of the sample areas should be noted and marked on a parcel or planting map for future reference.

1.4.2 Nursery Certifications

a. Indicate on nursery letterhead the name of plants in accordance with the LHBH, including botanical common names, quality, and size.

b. Inspection certificate.

c. Mycorrhizal fungi inoculum for plant material treated

1.4.3 State Landscape Contractor's License

Construction company must hold a landscape contractors license in the state where the work is performed and have a minimum of five years landscape construction experience. Submit copy of license and three references for similar work completed in the last five years.

1.4.4 Plant Material Photographs

Contractor must submit nursery photographs, for government approval prior to ordering, for each tree larger than 24-inch box/ 2-inch caliper size.

1.4.5 Percolation Test

Immediately following rough grading operation, identify a typical location for one of the largest trees and or shrubs and excavate a pit per the project details. Fill the pit with water to a depth of 12 inches. The length of time required for the water to percolate into the soil, leaving the pit empty, must be measured by the project Landscape Architect and verified by the Contracting Officer. Within six hours of the time the water has drained from the pit, the Contractor, with the Contracting Officer and project Landscape Architect present, must again fill the pit with water to a depth of 12 inches. If the water does not completely percolate into the soil within 9 hours, a determination must be made whether a drainage system or a soil penetrant will be required for each tree and or shrub being transplanted.

1.4.6 Erosion Assessment

Assess potential effects of soil management practices on soil loss in accordance with ASTM D6629. Assess erodibility of soil with dominant soil structure less than 2.8 to 3.1 inches in accordance with ASTM D5852.

1.4.7 Pre-Installation Meeting

Convene a pre-installation meeting a minimum of one week prior to commencing work of this section. Require attendance of parties directly affecting work of this section. Review conditions of operations, procedures and coordination with related work. Agenda must include the following:

a. Tour, inspect, and discuss conditions of planting materials.

b. Review planting schedule and maintenance.

c. Review required inspections.

d. Review environmental procedures.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Branched Plant Delivery

Deliver with branches tied and exposed branches covered with material which allows air circulation. Prevent damage to branches, trunks, root systems, and root balls and desiccation of leaves.

1.5.1.2 Soil Amendment Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, gypsum, sulfur, iron, and lime may be furnished in bulk with a certificate indicating the above information. Store in dry locations away from contaminates.

1.5.1.3 Plant Labels

Deliver plants with durable waterproof labels in weather-resistant ink. Provide labels stating the correct botanical and common plant name and variety as applicable and size as specified in the list of required plants. Attach to plants, bundles, and containers of plants. Groups of plants may be labeled by tagging one plant. Labels must be legible for a minimum of 60 days after delivery to the planting site.

1.5.2 Storage

1.5.2.1 Plant Storage and Protection

Store and protect plants not planted on the day of arrival at the site as follows:

a. Shade and protect plants in outside storage areas from the wind and direct sunlight until planted.

b. Heel-in bare root plants.

c. Protect balled and burlapped plants from freezing or drying out by covering the balls or roots with moist burlap, sawdust, wood chips, shredded bark, peat moss, or other approved material. Provide covering which allows air circulation.

d. Keep plants in a moist condition until planted by watering with a fine mist spray.

e. Do not store plant material directly on concrete or bituminous surfaces.

1.5.2.2 Fertilizer, Gypsum, pH Adjusters and Mulch Storage

Store in dry locations away from contaminants.

1.5.2.3 Topsoil

Prior to stockpiling topsoil, eradicate on site undesirable growing vegetation. Clear and grub existing vegetation three to four weeks prior to stockpiling existing topsoil.

1.5.2.4 Root Control Barrier and Weed Control Fabric

Store materials on site in enclosures or under protective covering in dry location. Store under cover out of direct sunlight. Do not store materials directly on ground.

1.5.3 Handling

Do not drop or dump plants from vehicles. Avoid damaging plants being moved from nursery or storage area to planting site. Handle plants carefully to avoid damaging or breaking the earth ball or root structure. Do not handle plants by the trunk or stem. Puddle bare-root plants after removal from the heeling-in bed to protect roots from drying out. Remove damaged plants from the site.

1.5.4 TIME LIMITATION

Except for container-grown plant material, the time limitation from digging to installing plant material must be a maximum of 90 days. The time limitation between installing the plant material and placing the mulch must be a maximum of 24 hours.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

Coordinate installation of planting materials during optimal planting seasons for each type of plant material required.

1.6.1 Planting Dates

Planting dates for all plants shall be in accordance with the requirements of the local agriculturecounty extension service office.1.6.2 Restrictions

Do not plant when ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit

1.7 GUARANTEE

All plants must be guaranteed for one year beginning on the date of inspection by the Contracting Officer to commence the plant establishment period, against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by the Government or by weather conditions unusual for the warranty period. Transplanted plants require no guarantee.

Guarantee plants except palmsinstalled during fall planting season until the following August 1 ; guarantee plants installed during spring planting season until the following October 1 . Transplanted plants require no guarantee. The minimum guarantee must be 90 days from the time of planting. Replace palms which are not alive at the end of a one-year period.

Remove and replace dead planting materials immediately unless required to plant in the succeeding planting season. At end of warranty period, replace planting materials that die or have 25 percent or more of their branches that die during the construction operations or the guarantee period.

1.8 PLASTIC IDENTIFICATION

Provide product data indicating polymeric information in Operation and Maintenance Manual.

Type 1: Polyethylene Terephthalate (PET, PETE).

Type 2: High Density Polyethylene (HDPE).

Type 3: Vinyl (Polyvinyl Chloride or PVC).

Type 4: Low Density Polyethylene (LDPE).

Type 5: Polypropylene (PP).

Type 6: Polystyrene (PS).

Type 7: Other. Use of this code indicates that the package in question is made with a resin other than the six listed above, or is made of more than one resin listed above, and used in a multi-layer combination.

PART 2 PRODUCTS

2.1 PLANTS

2.1.1 Regulations and Varieties

Existing trees and shrubs to remain must be protected and a planting plan be arranged around them. Furnish nursery stock in accordance with ANSI/ANLA Z60.1, except as otherwise specified or indicated. Each plant or group of planting must have a "key" number indicated on the nursery certifications of the plant schedule. Furnish plants, including turf grass, grown under climatic conditions similar to those in the locality of the project. Plants specified must be indigenous, low maintenance varieties, tolerant of site's existing soils and climate . Spray plants budding into leaf or having soft growth with an antidesiccant before digging. Plants of the same specified size must be of uniform size and character of growth. Plants must be chosen with their mature size and growth habit in mind to avoid over-planting and conflict with other plants, structures or underground utility lines. All plants must comply with all Federal and State Laws requiring inspection for plant diseases and infestation.

2.1.2 Shape and Condition

Well-branched, well-formed, sound, vigorous, healthy planting stock free from disease, sunscald, windburn, abrasion, and harmful insects or insect eggs and having a healthy, normal, and undamaged root system.

2.1.2.1 Deciduous Trees and Shrubs

Symmetrically developed and of uniform habit of growth, with straight boles or stems, and free from objectionable disfigurements.

2.1.2.2 Evergreen Trees and Shrubs

Well developed symmetrical tops with typical spread of branches for each particular species or variety.

2.1.2.3 Ground Covers and Vines

Number and length of runners and clump sizes indicated, and of the proper age for the grade of plants indicated, furnished in removable containers, integral containers, or formed homogeneous soil section.

2.1.3 Plant Size

Minimum sizes measured after pruning and with branches in normal position, must conform to measurements indicated, based on the average width or height of the plant for the species as specified in ANSI/ANLA Z60.1. Plants larger in size than specified may be provided with approval of the Contracting Officer . When larger plants are provided, increase the ball of earth or spread of roots in accordance with ANSI/ANLA Z60.1.

2.1.4 Root Ball Size

All box-grown, field potted, field boxed, collected, plantation grown, bare root, balled and burlapped, container grown, processed-balled, and in-ground fabric bag-grown root balls must conform to ANSI/ANLA Z60.1. All wrappings and ties must be biodegradable. Root growth in container grown plants must be sufficient to hold earth intact when removed from containers. Root bound plants will not be accepted.

2.1.4.1 Mycorrhizal fungi inoculum

Before shipment, root systems must contain mycorrhizal fungi inoculum.

2.1.5 Growth of Trunk and Crown

2.1.5.1 Deciduous Trees

A height to caliper relationship must be provided in accordance with ANSI/ANLA Z60.1. Height of branching must bear a relationship to the size and species of tree specified and with the crown in good balance with the trunk. The trees must not be "poled" or the leader removed.

a. Single stem: The trunk must be reasonably straight and symmetrical with crown and have a persistent main leader.

b. Multi-stem: All countable stems, in aggregate, must average the size specified. To be considered a stem, there must be no division of the trunk which branches more than 6 inches from ground level.

2.1.5.2 Palms

Palms must have the specified height as measured from the base of the trunk to the base of the fronds or foliage in accordance with ANSI/ANLA Z60.1. The palm must have straight trunk and healthy fronds or foliage as typical for the variety grown in the region of the project. Palms trimmed or pruned for delivery must retain a minimum of 6 inches of foliage at the crown as a means of determining plant health.

2.1.5.3 Deciduous Shrubs

Deciduous shrubs must have the height and number of primary stems recommended by ANSI/ANLA Z60.1. Acceptable plant material must be well shaped, with sufficient well-spaced side branches, and recognized by the trade as typical for the species grown in the region of the project.

2.1.5.4 Coniferous Evergreen Plant Material

Coniferous Evergreen plant material must have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. The coniferous evergreen trees must not be "poled" or the leader removed. Acceptable plant material must be exceptionally heavy, well shaped and trimmed to form a symmetrical and tightly knit plant. The form of growth desired must be as indicated.

2.1.5.5 Broadleaf Evergreen Plant Material

Broadleaf evergreen plant material must have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. Acceptable plant material must be well shaped and recognized by the trade as typical for the variety grown in the region of the project.

2.1.5.6 Ground Cover and Vine Plant Material

Ground cover and vine plant material must have the minimum number of runners and length of runner recommended by ANSI/ANLA Z60.1. Plant material must have heavy, well developed and balanced crown with vigorous, well developed root system and must be furnished in containers.

2.2 TOPSOIL

2.2.1 Existing Soil

Modify to conform to requirements specified in paragraph COMPOSITION.

2.2.2 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph COMPOSITION. When available topsoil must be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK31 23 00.00 20 EXCAVATION AND FILL.

2.2.3 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil must be furnished by the Contractor.

2.2.4 Composition

Evaluate soil for use as topsoil in accordance with ASTM D5268. From 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH must be tested in accordance with ASTM D4972. Topsoil must be free of sticks, stones, roots, plants, and other debris and objectionable materials. Other components must conform to the following limits:

Silt	[25-50][7 to 17][_____] percent
Clay	[10-30][4 to 12][_____] percent
Sand	[20-35][70 to 82][_____] percent
pH	[5.5 to 7.0][_____]
Soluble Salts	[600] [_____] ppm maximum

2.3 SOIL CONDITIONERS

Provide singly or in combination as required to meet specified requirements for topsoil. Soil conditioners must be nontoxic to plants.

2.3.1 Lime

Commercial grade hydrated or burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 80 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427 as modified herein. Shred and granulate peat to pass a 1/2 inch mesh screen and condition in storage pile for minimum 6 months after excavation. Peat must not contain invasive species, including seeds.

2.3.6 Sand

Clean and free of materials harmful to plants.

2.3.7 Perlite

Horticultural grade.

2.3.8 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, invasive species, including seeds, and soil stabilized with nitrogen and having the following properties:

2.3.8.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.9 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 80 percent, calcium 18 percent, sulfur 14 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.10 Vermiculite

Horticultural grade for planters.

2.3.11 Rotted Manure

Well rotted horse or cattle manure containing maximum 25 percent by volume of straw, sawdust, or other bedding materials; free of seeds, stones, sticks, soil, and other invasive species.

2.4 PLANTING SOIL MIXTURES

100 percent topsoil as specified herein.

Sandy topsoil: one part topsoil to one part peat; clay topsoil: two parts topsoil to one part peat. Thoroughly mix all parts of planting soil mixture to a uniform blend throughout.

2.5 FERTILIZER

Fertilizer for groundcover, wildflowers and grasses is not permitted. Fertilizer for trees, plants, and shrubs must be as recommended by plant supplier, except synthetic chemical fertilizers are not permitted. Fertilizers containing petrochemical additives or that have been treated with pesticides or herbicides are not permitted.

2.5.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

[_____] percent available nitrogen
[_____] percent available phosphorus
[_____] percent available potassium
[_____] percent sulfur
[[_____] percent iron

]2.5.2 Fertilizer Tablets

Organic, plant tablets composed of tightly compressed fertilizer chips forming a tablet that is insoluble in water, is designed to provide a continuous release of nutrients for at least 24 months and contains the following minimum percentages, by weight, of plant food nutrients:

[20] [_____] percent available nitrogen
[20] [_____] percent available phosphorus
[5] [_____] percent available potassium

2.6 WEED CONTROL FABRIC

2.6.1 Roll Type Polypropylene or Polyester Mats

Fabric must be woven, needle punched or non-woven and treated for protection against deterioration due to ultraviolet radiation. Fabric must be minimum 99 percent opaque to prevent photosynthesis and seed germination from occurring, yet allowing air, water and nutrients to pass thru to the roots. Minimum weight must be 5 ounces per square yard with a minimum thickness of 20 mils with a 20 year (minimum) guarantee.

2.7 DRAINAGE PIPE FOR PLANT PITS AND BEDS

Plastic polyvinyl chloride pipe, unperforated conforming to ASTM D3034 SDR 35 perforated conforming to ASTM D2729.

2.8 MULCH

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.8.1 Inert Mulch Materials

Provide recycled stone, or other recycled material complying with ASTM D6155.

2.8.2 Organic Mulch Materials

Provide wood cellulose fiber, wood chips, shredded hardwood, pine straw mulch, pine needles, or from site when available. Wood cellulose fiber must be processed to contain no growth or germination-inhibiting factors, dyed with non-toxic, biodegradable dye to an appropriate color to facilitate visual metering of materials application. Paper-based hydraulic mulch must contain 100 percent post-consumer recycled content. Wood-based hydraulic mulch must contain 100 percent total recovered materials content.

2.8.3 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 2-1/2 by 2-1/2 inch screen. It must be cleaned of all sticks a minimum one inch in diameter and plastic materials a minimum 3 inches length. The material must be treated to retard the growth of mold and fungi.

2.9 STAKING AND GUYING MATERIAL

2.9.1 Staking Material

2.9.1.1 Tree Support Stakes

Rough sawn hard wood free of knots, rot, cross grain, bark, long slivers, or other defects that impair strength. Stakes must be minimum 2 inches square or 2-1/2 inch diameter by 8 feet long, pointed at one end. Paint or stain wood stakes dark brown..

2.9.1.2 Ground Stakes

Rough sawn hard wood or plastic, 2 inches square are by 3 feet long, pointed at one end.

2.9.2 Guying Material

2.9.2.1 Guying Wire

12 gauge annealed galvanized steel, ASTM A580/A580M.

2.9.2.2 Guying Cable

Minimum five-strand, 3/16 inch diameter galvanized steel cable or plastic coated.

2.9.3 Hose Chafing Guards

New or used 2 ply 3/4 inch diameter reinforced rubber or plastic hose, black or dark green, all of same color.

2.9.4 Flags

White 1/2 inch diameter PVC pipe, 6 inches or 12 inches long, fastened to guying wires or cables.

2.9.5 Turnbuckles

Galvanized or cadmium-plated steel with minimum 3 inch long openings fitted with screw eyes. Eye bolts must be galvanized or cadmium-plated steel with one inch diameter eyes and screw length 1-1/2 inches, minimum.

2.9.6 Deadmen

4 by 8 inch rectangular or 8 inch diameter by 36 inch long, pine or fir wood material.

2.9.7 Metal Anchors

2.9.7.1 Driven Anchors

Malleable iron, arrow shaped, galvanized, sized as follows:

Tree Caliper	Anchor Size
2 inches and under	3 inches
3 to 6 inches	4 inches
6 to 8 inches	6 inches
8 to 10 inches	8 inches
10 to 12 inches	10 inches

2.9.7.2 Screw Anchors

Steel, screw type with welded-on 3 inch round helical steel plate, minimum 3/8 inch diameter, 15 inches long.

2.10 EDGING MATERIAL

2.10.1 Wood Edging

As specified in Section 06 10 00 ROUGH CARPENTRY. Redwood, Cypress or Western Red Cedar wood edging must be free of solvent at time of delivery. Minimum 8 by 1/2 inch treated in accordance with AWPA U1 and AWPA T1 with preservatives conforming to AWPA P5 before installation. Anchoring stakes must be the same material as wood edging, 1/2 by 2 inches, 12 inches long.

2.10.2 Recycled Plastic Edging

Plastic lumber as specified in Section 06 10 00 ROUGH CARPENTRY. 100 percent recycled polyethylene edging, resistant to insects, termites, boring worms, splintering and rotting, and must not absorb moisture or promote bacterial growth. Minimum 1 by 6 inch, capable of bending a minimum 24-36 radius, integrally colored brown with slip joint connections. Anchors and stakes must be of the same manufacturer and color as the edging.

2.10.3 Concrete Edging

Extruded or Cast-in-place 6 by 6 by inch concrete mowstrip. Provide tooled or saw cut contraction joints to a depth of 3/4 inch after the surface has been finished. Provide joints every 5 lineal feet. Provide 1/2 inch thick expansion joints at change of direction and where mowstrip abuts rigid pavement. Provide #4 reinforcement bar and other devices necessary to install and secure reinforcement. Provide a floated finish, then finish with a flexible bristle broom. 3,000 psi compressive concrete strength at 28 days as specified under Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.11 ANTIDESICCANTS

Sprayable, water insoluble vinyl-vinledine complex which produce a moisture retarding barrier not removable by rain or snow. Film must form at temperatures commonly encountered out of doors during planting season and have a moisture vapor transmission rate (MVT) of the resultant film of maximum 10 grams per 24 hours at 70 percent humidity.

2.12 EROSION CONTROL MATERIALS

Erosion control material must conform to the following:

2.12.1 Erosion Control Blanket

100 percent agricultural straw or 70 percent agricultural straw/30 percent coconut fiber matrix stitched with a degradable nettings, designed to degrade within 12 months.

2.12.2 Erosion Control Material Anchors

Erosion control anchors must be as recommended by the manufacturer.

2.13 ROOT CONTROL BARRIER

Flexible and permeable geotextile fabric with permanently attached time-released nodules. Color to be black or gray. Pre-formed, round, tapered cylinder linear barrier with integral vertical root deflecting ribs constructed of ultraviolet resistant polypropylene material. Color to be black.

2.14 WATER

Source of water to be approved by Contracting Officer and suitable quality for irrigation and must not contain elements toxic to plant life, including acids, alkalis, salts, chemical pollutants, and organic matter. Use collected storm water or graywater when available.

2.15 MYCORRHIZAL FUNGI INOCULUM

Mycorrhizal fungi inoculum must be composed of multiple-fungus inoculum as recommended by the manufacturer for the plant material specified.

2.16 SOURCE QUALITY CONTROL

The Contracting Officer will inspect plant materials at the project site and approve them. Tag plant materials for size and quality.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide soil preparation, including soil conditioners and soil amendments prior to planting. Provide tree, shrub, vine, groundcover, seed, and sod planting, post-planting fertilizer, edging, staking, guying, weed control fabric, erosion control material, root control barrier installation, mulch topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.2 ALTERNATIVE HERBICIDE TREATMENT (SOLARIZING SOIL)

Within 48 hours of subsoil preparation, saturate soil with water to a depth of 3 feet. Immediately stake polyethylene sheeting over area to be planted. Stake tightly to surface of soil. Maintain sheeting in place for a minimum of 6 weeks. Immediately after removing sheeting, cover area to be planted with topsoil. Do not till soil prior to applying topsoil.

3.3 PREPARATION

3.3.1 Protection

Protect existing and proposed landscape features, elements, and sites from damage or contamination. Protect trees, vegetation, and other designated features by erecting high-visibility, reusable construction fencing. Locate fence no closer to trees than the drip line. Plan equipment and vehicle access to minimize and confine soil disturbance and compaction to areas indicated on Drawings.

3.3.2 Layout

Stake out approved plant material locations and planter bed outlines on the project site before digging plant pits or beds. The Contracting Officer reserves the right to adjust plant material locations to meet field conditions. Do not plant closer than 36 inches to a building wall, pavement edge, fence or wall edge and other similar structures. Provide on-site locations for excavated rock, soil, and vegetation.

3.3.3 Erosion Control

Provide erosion control and seeding with native plant species to protect slopes.

3.3.4 Soil Preparation

3.3.4.1 pH Adjuster Application Rates

Apply pH adjuster at rates as determined by laboratory soil analysis of the soils at the job site and shall be in accordance with the requirements of the local agriculture county extension service office.

3.3.4.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site and shall be in accordance with the requirements of the local agriculture county extension service office.

3.3.4.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site and shall be in accordance with the requirements of the local agriculture county extension service office.

3.3.5 Root Control Barrier

Install geotextile fabric in the soil in a vertical horizontal and surrounding application. Use appropriate holding device to assure fabric position. For vertical or horizontal application, a minimum 2 inch soil cover is required over the top surface or edge. A minimum 18 inch extension of fabric beyond the structure area to be protected is required to prevent root growth from growing around fabric edges. Install cylindrical or linear polypropylene barrier a minimum 1/2 or one inch above finish grade to prevent root growth over the barrier. Backfill the outside of the barrier with 3/4 to one gravel a minimum width of 2 inches. For linear barrier application use appropriate device to connect two pieces.

3.3.6 Subsoil Drainage for Plant Pits and Beds

Provide as indicated. Lay perforated drain pipe with perforations down. Backfill trenches as specified in Section 31 00 00 EARTHWORK31 23 00.00 20 EXCAVATION AND FILL.

3.4 PLANT BED PREPARATION

Verify location of underground utilities prior to excavation. Protect existing adjacent turf before excavations are made. Do not disturb topsoil and vegetation in areas outside those indicated on Drawings. Where planting beds occur in existing turf areas, remove turf to a depth that will ensure removal of entire root system. Measure depth of plant pits from finished grade. Depth of plant pit excavation must be as indicated and provide proper relation between top of root ball and finished grade. Install plant material as specified in paragraph PLANT INSTALLATION. Do not install trees within 10 feet of any utility lines or building walls.

3.5 PLANT INSTALLATION

3.5.1 Individual Plant Pit Excavation

Excavate pits at least twice as large or 16 inches larger in diameter as the size of ball or container to depth shown.

3.5.2 Plant Beds with Multiple Plants

Excavate plant beds continuously throughout entire bed as outlined to depth shown.

3.5.3 Handling and Setting

Move plant materials only by supporting the root ball or container. Set plants on hand compacted layer of prepared backfill soil mixture 6 inches thick and hold plumb in the center of the pit until soil has been tamped firmly around root ball. Set plant materials, in relation to surrounding finish grade, one to 2 to depth at which they were grown in the nursery, collecting field or container. Replace plant material whose root balls are cracked or damaged either before or during the planting process.

Plant material must be set in plant beds according to the drawings. Backfill soil mixture must be placed on previously scarified subsoil to completely surround the root balls, and must be brought to a smooth and even surface, blending to existing areas.

3.5.3.1 Balled and Burlapped Stock

Backfill with prepared soil mixture or topsoil to approximately half the depth of ball and then tamp and water. Carefully remove or fold back excess burlap and tying materials from the top a minimum 1/3 depth from the top of the rootball. Tamp and complete backfill, place mulch topdressing, and water. Remove wires and non-biodegradable materials from plant pit prior to backfill operations.

3.5.3.2 Bare-Root Stock

Plant so roots are arranged in a natural position. Place roots in water a minimum of 30 minutes prior to planting. Carefully work prepared soil mixture or topsoil among roots. Tamp remainder of backfill, place mulch topdressing and water.

3.5.3.3 Container Grown Stock

Remove from container and prevent damage to plant or root system.

3.5.3.4 Ground Covers and Vines

Plant after placing mulch topdressing. Do not remove plant materials from flats or containers until immediately before planting. Space at intervals indicated. Plant at a depth to sufficiently cover all roots. Start watering areas planted as required by temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 6 inches without run off or puddling. Smooth planting areas after planting to provide even, smooth finish. Mulch as indicated.

3.5.4 Earth Mounded Watering Basin for Individual Plant Pits

Form with topsoil around each plant by placing a mound of topsoil around the edge of each plant pit. Watering basins must be 6 inches deep for trees and 4 inches deep for shrubs. Construct watering basin in a 4-1/2 foot diameter circle around specimen (not planted in a close group) trees and shrubs.

3.5.5 Weed Control Fabric Installation

Remove grass and weed vegetation, including roots, from within the area enclosed by edging. Completely cover areas enclosed by edging with specified weed control fabric prior to placing mulch layer. Overlap cut edges 6 inches.

3.5.6 Erosion Control Material

Install in accordance with manufacturer's instructions.

3.5.7 Placement of Mulch Topdressing

Place specified mulch topdressing on top of weed control fabric covering total area enclosed by edging. Place mulch topdressing to a depth of 3 inches.

3.5.8 Mulch Topdressing

Provide mulch topdressing over entire planter bed surfaces and individual plant surfaces including earth mound watering basin around plants to a depth of 3 inches after completion of plant installation and before watering. Keep mulch out of the crowns of shrubs. Place mulch a minimum 2 to 3 inches away from trunk of shrub or tree. Place on top of any weed control fabric.

3.5.9 Installation of Edging

Uniformly edge beds of plants to provide a clear cut division line between planted area and adjacent lawn. Construct bed shapes as indicated. Install wood, plastic or concrete edging material as indicated and as per manufacturer's instructions. Install edging material in a perfect 4 foot diameter circle inside the 4-1/2 foot watering basin, around individual specimen trees and shrubs not planted in a close group. Install edging with minimum one inch left above ground level.

3.5.10 Fertilization

3.5.10.1 Fertilizer Tablets

Place fertilizer planting tablets evenly spaced around the plant pits to the manufacturer's recommended depth.

3.5.10.2 Granular Fertilizer

Apply granular fertilizer as a top coat prior to placing mulch layer and water thoroughly.

3.5.11 Watering

Start watering areas planted as required by temperature and wind conditions. Slow deep watering must be used. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 12 inches without run off or puddling. Watering of other plant material or adjacent areas must be prevented.

3.5.12 Staking and Guying

3.5.12.1 Staking

Stake plants with the number of stakes indicated complete with double strand of 12 gage guy wire as detailed. Attach guy wire half the tree height but not more than 5 feet high. Drive stakes to a depth of 2-1/2 to 3 feet into the ground outside the plant pit. Do not injure the root ball. Use hose chafer guards where guy wire comes in contact with tree trunk.

3.5.12.2 Guying

Guy plants as indicated. Attach two strands of guying wire or guying cable around the tree trunk at an angle of 45 degrees at approximately 1/2 of the trunk height . Protect tree trunks with chafing guards where guying wire or cable contacts the tree trunk. Anchor guys to deadmen wood blocks, wood ground stakes, malleable iron anchors or steel screw anchors. Fasten flags to each guying wire or cable approximately 2/3 of the distance up from ground level. Provide turnbuckles as indicated.

3.5.12.3 Chafing Guards

Use hose chafing guards, as specified where guy wire or cable will contact the plant.

3.5.12.4 Deadmen

Place deadmen minimum 18 inches below ground surface. Place equal distance from tree trunk and around the plant pit.

3.5.12.5 Wood Ground Stakes

Drive wood ground stakes into firm ground outside of plant pit with top of stake flush with ground. Place equal distance from tree trunk and around the plant pit.

3.5.12.6 Iron Anchors

Drive malleable iron anchors into firm ground outside of plant pit a minimum 30 inches below finish grade. Place equal distance from tree trunk and around the plant pit.

3.5.12.7 Steel Screw Anchors

Insert steel screw anchors as recommended in manufacturer's data. Place equal distance from tree trunk and around the plant pit.

3.5.12.8 Flags

Securely fasten flags on each guy wire andcable approximately two-thirds of the distance up from ground level.

3.5.13 Pruning

Prune in accordance with safety requirement of TCIA Z133.

3.5.13.1 Trees and Shrubs

Remove dead and broken branches. Prune to correct structural defects only. Retain typical growth shape of individual plants with as much height and spread as practical. Do not cut central leader on trees. Make cuts with sharp instruments. Do not flush cut with trunk or adjacent branches. Collars must remain in place. Pruning must be accomplished by trained and experienced personnel and must be accordance with TCIA A300P1.

3.5.13.2 Wound Dressing

Do not apply tree wound dressing to cuts.

3.6 RESTORATION AND CLEAN UP

3.6.1 Restoration

Turf areas, pavements and facilities that have been damaged from the planting operation must be restored to original condition at the Contractor's expense.

3.6.2 Clean Up

Excess and waste material must be removed from the installed area and must be disposed offsite at an approved landfill, recycling center, or composting center. Separate and recycle or reuse the following landscape waste materials: nylon straps, wire, ball wrap, burlap, wood stakes, _____. Adjacent paved areas must be cleared.

-- End of Section --

SECTION 33 01 30.16

TV INSPECTION OF SEWER LINES
11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07	(2019) DOD Pest Management Program

1.2 DEFINITIONS

1.2.1 CCTV Video

CD or DVD storage media containing the recorded video.

1.2.2 Cleaning

To remove soil or solid deposited materials from a pipe segment when the pipe is less than half full of deposited materials.

1.2.3 Defects

Defects in the pipe, manholes, structures, and services include cracks, separation of joints, collapsed pipe, grade irregularities, leaks, roots, grease buildup, offset joints, reverse grades, obstructions, delamination, missing pipe, restrictions, fractures and similar structural irregularities.

1.2.4 Entry Point

The leading edge of the access point or the manhole or structure wall where the pipe segment begins. Only the pipe is video inspected from manhole or structure wall to manhole or structure wall and does not include any portion of the manhole or structure.

1.2.5 Exit Point

The point where the downstream access manhole or structure wall is encountered. Only the pipe is video inspected from manhole or structure wall to manhole or structure wall and does not include any portion of the manhole or structure.

1.2.6 Heavy Cleaning

To remove soil or solid deposited materials from a pipe segment when the materials in the pipe are between half full to full.

1.2.7 Hydraulically Propelled Cleaning Tools

Tools that depend upon water pressure to provide their cleaning force.

1.2.8 National Association of Sewer Service Companies (NASSCO)

National Association of Sewer Service Companies (NASSCO) identifies the generally accepted industry standards for CCTV inspection, observation coding, and certification.

1.2.9 Pipe Segment

The length of pipe from entry point to exit point along the main or service.

1.2.10 Pipeline Assessment and Certification Program (PACP)

A CCTV Inspection standardization certification and observation coding system sponsored by NASSCO.

1.2.11 Point Repair

The location of a failure where a repair is has occurred.

1.2.12 Post-Installation CCTV (Post-TV)

Post-TV inspection is used to determine the slip lining of sanitary or storm sewers has been completed in accordance with the contract documents.

1.2.13 Pre-Installation CCTV (Pre-TV)

Pre-TV inspection is a video inspection of existing sewer lines to confirm cleaning activities, locations of service connections, and identify defects in the existing sewer system infrastructure prior to any work being performed.

1.2.14 Re-TV Inspection

Upon the completion of repairs made after performing a Post-TV Inspection or Warranty TV inspection, the mains or services are re-inspected by performing a Re-TV inspection. Also, refers to rework for a TV-Inspection that has video interruptions, gaps, or is not continuous.

1.2.15 TV Inspection Log

Information collected and recorded by the CCTV operator for each CCTV inspection effort and includes pertinent information for the respective inspection section; such as, date of inspection, location of site, CCTV technician, direction of CCTV inspection with manhole or structure identifiers, weather conditions, pipe size(s), pipe materials, conditions found, locations where the conditions were found.

1.2.16 Warranty CCTV (Warranty-TV)

Warranty-TV inspection is used to determine the slip lining of sanitary or storm sewers does not have any defects present, remains in compliance with project specifications and Post-TV inspection.

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Disposal Plan

Submit a disposal plan prior to performing any work that might generate waste materials. Include a complete description of the materials that are expected to be encountered and their proposed disposal sites. No changes to the disposal plan will be made without prior written acceptance by the Contracting Officer.

1.3.2 Sewage Handling Permit

Prior to commencing application of herbicide, obtain and maintain a valid State sewage handling permit and permits required by local jurisdictions. Submit a copy of this permit to the Contracting Officer prior to beginning any cleaning or pump and haul operations.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Traffic Control Plan; G

Disposal Plan; G

Herbicide Application Plan; G

List of Equipment

Sewage Handling Permit; G

SD-03 Product Data

Herbicide; G

Cleaning Products; G

SD-05 Design Data

Herbicide Application Records

SD-06 Test Reports

Calibration Test

SD-07 Certificates

Qualifications; G

CCTV Technician's Qualifications; G

Pre-TV Inspection; G

Post-TV Inspection; G

Warranty-TV Inspection; G

RE-TV Inspection; G

SD-11 Closeout Submittals

Pest Management Report

Verification of Measurement

Records of Disposals

1.5 QUALITY CONTROL

1.5.1 Regulatory Requirements

Comply with DODI 4150.07 for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent, and submit copies of records when requested by the Contracting Officer. These forms may be obtained from the Armed Forces Pest Management Board web site: https://www.acq.osd.mil/eie/afpmb/docs/standardlists/dd1532-1.xlsm

1.5.2 Qualifications

For the application of herbicides, use the services of an applicator who is commercially certified in the state where the work is to be performed as required by DODI 4150.07. Herbicide applicators must also be certified in the U.S. Environmental Protection Agency (EPA) pesticide applicator category which includes sewer root pest control. Submit a copy of the pesticide applicator certificates.

1.5.3 CCTV Technician's Qualifications

Provide a CCTV technician with three years of total experience with the CCTV technology. Submit a current PACP Operator certification for personnel performing closed circuit television inspection and pipeline assessments.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Delivery

Deliver herbicides to the site in the original unopened containers bearing legible labels indicating the EPA registration number, manufacturer's registered uses and in new or otherwise good condition as supplied by the manufacturer or formulator.

1.6.2 Inspection

Inspect herbicides upon arrival at the job site for conformity to type and quality in accordance with paragraph HERBICIDE. Each label must bear evidence of registration by the EPA or under appropriate regulations of the host county. Inspect other materials for conformance with specified requirements. Remove unacceptable materials from the job site.

1.6.3 Storage

Storage of herbicides on the installation will not be permitted unless it is written into the contract.

1.6.4 Handling

Handle and mix herbicides in accordance with the manufacturer's label. Prevent contamination by dirt, water, and organic material. Protect herbicides from weather and the elements as recommended by the manufacturer's label. Spill kits must be maintained on applicator vehicles and must be available at the mixing site. Conduct herbicide mixing at a site designated by the contracting officer with adequate spill containment.

1.7 PROJECT/SITE CONDITIONS

Application of herbicide will not be permitted during or immediately following heavy rains, when conditions may allow runoff, or when they may create an environmental hazard. Herbicide applications are not permitted when they may contaminate aquifers or endanger humans or animals.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

TV inspection of sewer pipelines encompasses cleaning, heavy cleaning, CCTV inspection and video recording of the existing sanitary or storm sewer mains included in the contract documents. This work includes by-pass pumping or diversion of sanitary sewer, sound reduction enclosure of by-pass pump, inspection logs, video requirements, permits, traffic control and the legal disposal of materials removed from the mains. It is typically used in coordination with slip lining existing piping.

It includes the mechanical equipment used to clean and dispose of the materials found in sewer pipes and structures, CCTV cameras and recording devices used to record the internal conditions of non-pressurized sewer piping.

2.2 EQUIPMENT

2.2.1 Cleaning Equipment

Utilize mechanically powered equipment necessary for the proper rodding, bucketing, brushing, root cutting, and flushing of the sewers, including a heavy duty power rodding machine that is compatible with the cleaning to be performed.

2.2.1.1 Rodding

Provide rodding equipment capable of rodding distances of up to 1000 feet in one set-up and having the following capabilities:

a. The ability to spin the rod either clockwise or counter-clockwise, and be able to be pushed straight out or pulled back without rotating the machine.

b. The capability of pulling pipe-size swabs or brushes back through the pipeline for cleaning and flushing purposes.

2.2.1.2 Bucket Machine

Provide heavy-duty bucket machines for use on dragline work to clean the pipeline with buckets, brushes, scrapers, swabs or other similar devices in order to effectively remove debris and provide a clean sewer for the CCTV inspection, repair, or lining activities.

2.2.1.3 Hydraulic Flusher

Provide hydraulic high-pressure sewer cleaners used for sewer cleaning, specifically designed and constructed for such cleaning, that have a minimum usable water capacity of 600 gallons and a pump capable of delivering at least 30 gallons per minute (gpm) at 100 psi and having the following capabilities:

a. Pressure regulator nozzle capable of adjustment from 1 psi to 1500 psi.

b. Constructed for ease of use and safety of operation with two or more high-velocity nozzles capable of producing a scouring action from 15 to 45 degrees in lines designated to be cleaned.

c. A high-velocity gun for washing and scouring the manhole or structure walls and floor capable of producing flows from a fine spray to a solid stream.

d. Carry its own water tank, auxiliary engines, pumps, and hydraulically driven hose reel.

2.2.1.4 Sanitary Sewer Cleaning Equipment

Provide movable dam type hydraulically propelled equipment constructed in such a way that a portion of the dam may be collapsed at any time during the cleaning operation to protect against flooding of the sanitary sewer and having the following capabilities:

a. A movable dam equal in diameter to the pipe being cleaned.

b. A flexible scraper around the periphery to ensure the removal of grease.

Sewer cleaning balls or other equipment, which cannot be collapsed, are not allowed when cleaning sanitary sewer.

2.2.2 CCTV Equipment

Provide a video system capable of producing a sharply focused, well-lit and color balanced picture in accordance with the following requirements:

2.2.2.1 Pipe Inspection Camera and Associated Equipment

a. Provide a pipe inspection camera system that produces a video using a pan and tilt, radial viewing, that pans a minimum of 275 degrees and rotates 360 degrees. Illumination sensitivity of 3 Lux or less and a minimum of 460 lines of resolution is required.

b. Utilize video cameras specifically designed and constructed for CCTV inspection.

c. Provide a camera that is operative in 100 percent humidity conditions.

d. Provide a camera with an accurate footage counter that displays on the monitor the exact distance of the camera to the nearest 1/10 of a foot.

e. Provide a camera with a height adjustment so that the camera lens is typically centered in the pipe, or higher depending on water levels in the pipe.

f. Provide equipment that will produce digital color images and allows the CCTV technician to remotely balance the iris and color to produce a clear and true video of the pipeline.

g. Provide lighting for the camera that is suitable to provide a clear color picture of the entire periphery of the pipe.

h. Provide a reflector in front of the camera as necessary to enhance the lighting on dark or large diameter pipes.

i. Provide an accompanying computer and recording device capable of projecting and recording the facility location, project name, Contractor's name, date, line size, material type, line identification, manhole or structure ID numbers and ongoing footage counter onto the video screen.

2.3 MATERIALS

2.3.1 Herbicide

Provide herbicides currently registered by the EPA or approved for such use by the appropriate agency of the host county and approved by the Contracting Officer. Select herbicides that will eliminate root growth, inhibit future root growth, and are suitable for the wastewater treatment plant, and climatic conditions at the project site. Herbicides must be applied at the highest labeled rate. Submit manufacturer's label and Safety Data Sheet (SDS) for herbicides proposed for use.

2.3.2 Cleaning Products

Select cleaning products that do not present a health and safety concern, are allowed for use in the sewer system according to Federal and State regulations, will not adversely affect the water quality of the water being conveyed in the sewer system, are suitable for the wastewater treatment plant and the climatic conditions at the project site. Submit manufacturer's label and SDS for the cleaning products proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Traffic Control

a. Submit a detailed Traffic Control Plan to the Contracting Officer at least 10 days in advance when the manholes used to perform the TV inspection are located in or adjacent to the road. Comply with all applicable State Highway, Local and Installation requirements when preparing the traffic control plan.

b. Provide labor, signs, barricades, cones, arrow boards, flaggers, and any additional equipment necessary to complete the work.

3.1.2 Herbicide Application Plan

Prior to commencing application of herbicides, submit a herbicide application plan with the proposed sequence of treatment including dates and times of application. Include the herbicide trade name, EPA registration number, chemical composition, formulation, application rate, method of application, area or volume treated, and amount applied. Include a copy of the pesticide applicator certificates.

3.1.3 Sewer Line Cleaning

Immediately prior to conducting CCTV activities, thoroughly clean the segment of sewer pipe to be video inspected. Clean the segments using hydraulically propelled, high-velocity jet, or mechanically powered equipment.

a. During cleaning and preparation operations, undertake precautions to protect the sewer system and property from damage. Restore property damaged as a result of such cleaning and preparation operations to pre-existing conditions.

b. During the course of normal cleaning operations immediately report pre-existing damage such as broken or missing pipe to the Contracting Officer.

c. When hydraulically propelled cleaning tools or tools which retard the flow in the sewer line are utilized, take precautions to ensure that the water pressure created does not damage or cause flooding on the adjacent site.

d. Maintain access to fire hydrants for the purpose of fire protection at all times.

e. If cleaning of an entire sewer section cannot be successfully performed from one manhole or structure, set up the equipment on the other entry or exit point and attempt cleaning again.

f. If successful cleaning cannot be performed from the opposite end or the equipment fails to traverse the entire pipeline section, cease cleaning those specific sewer sections, notify the Contracting Officer and CCTV inspect both sides of the pipeline section to determine the cause of the blockage.

3.1.3.1 Sanitary Sewer Cleaning

Minimize the interruptions to the existing flows to perform the cleaning of the sewers. Prevent sewage backups and immediately clear back-ups resulting from the cleaning operations. When possible, utilize the flow in the sewer system to provide the necessary pressure for the hydraulic cleaning devices. Return sewage diverted during cleaning operations to the sanitary system and do not discharge onto any surface, or into any water body or storm drain system.

3.1.4 Manhole or Structure Cleaning

Clean concrete and masonry surfaces prior to CCTV inspection. Completely remove grease, laitance, loose bricks, mortar, unsound concrete, loose or damaged wall mounted steps (cut flush with wall), and other materials.

Utilize water blasting (minimum 1200 psi) with compatible nozzles as the primary method of cleaning. It is acceptable to use other methods of cleaning such as concrete cleaners, degreasers or mechanical means to clean the surfaces. Thoroughly rinse, scrub, and neutralize the surfaces in order to remove cleaning agents and their reactant products. Do not allow material to pass to pipeline sections, which could adversely affect water quality, cause stoppages, accumulations of sand in wet wells, or damage to pumping equipment.

3.1.5 Flow Control

Reduce the flow depth to allow a minimum of 80 percent of the pipe wall to be displayed at all times during inspection so that defects, features, and other notable information can be collected.

3.1.5.1 Flow Reduction

Flow depth reduction can be accomplished by:

a. Providing bypass pumping.

b. High-pressure jet nozzle.

c. Plugging or by pulling the camera with a swab.

d. Performing the CCTV inspection during periods of minimal flow.

3.1.5.2 Floating the Camera

Video inspection performed while floating the camera is not acceptable. Lower water levels as indicated in paragraph FLOW CONTROL.

3.1.6 Root Removal

Remove roots in the designated sewer sections and manholes or structures. Ensure complete removal of roots to the joints. Use mechanical equipment that can be operated remotely, such as rodding machines, bucket machines, winches using root cutters and porcupines, and equipment such as high-velocity jet cleaners. Capture and remove roots from the sewerline at the downstream manhole or structure.

3.1.7 Material Removal and Disposal

Remove sludge, dirt, roots, grease, and other solid or semi-solid material resulting from cleaning operations at the downstream manhole or structure of the section being cleaned.

3.1.7.1 Dams or Weirs

When hydraulic cleaning equipment is used, place dam or weir in the downstream manhole or structure to trap such materials. Do not allow material to pass from pipeline section to pipeline section, which could cause stoppages, accumulations of sand in wet wells, or damage to pumping equipment.

3.1.7.2 Sludge and Debris Storage

Under no circumstances is sludge or other debris removed during these operations to be stored, dumped or spilled into streets, ditches, storm drains, or other sanitary sewer systems.

a. Dispose of solids and semi-solids resulting from the cleaning operations no less often than the end of each work day in accordance with the approved Disposal Plan.

b. Under no circumstances will debris be allowed to accumulate on the work site beyond the end of each work day, except in totally enclosed containers and as acceptable by the Contracting Officer.

c. Continuously maintain the haul route and work areas neat, clean, and reasonably free of odor. Cleanup any spill which occurs during the transport of cleaning or surface preparation by-products. Perform the cleanup of any such material pursuant to this Contract and in accordance with applicable law and environmental regulations.

d. Immediately notify the Contracting Officer of any spill and begin clean up any such spill or waste.

e. The Government will charge to the Contractor for any costs incurred or penalties imposed upon the Government as a result of the spill, dump or discard.

f. Under no circumstances is this material to be discharged into the waterways or any place other than where authorized to do so in accordance with the approved Disposal Plan.

3.1.7.3 Hauling of Waste Material

Provide vehicles hauling such waste material that meet the following requirements:

a. Provide transport vehicles of the type(s) approved for this application by the jurisdictions where those vehicles will be operated in the performance of activities associated with this Contract.

b. Provide transport vehicles with watertight bodies equipped and fitted with seals and covers to prohibit material spillage or drainage.

c. Clean vehicles to prevent deposits of material on roadways.

d. Load vehicles within legal weight limits and operate safely within traffic speed regulations.

e. The routes used for the conveyance of this material on a regular basis is subject to approval by the local governing bodies having jurisdiction over such routes.

3.2 APPLICATION

3.2.1 Chemical Root Treatment

Where permitted by the Contracting officer, State sewer regulations and the utility provider's requirements use a herbicide to aid in the removal of roots and treat pipeline sections that have root intrusion with an acceptable herbicide in accordance with the following conditions:

a. There can be no adverse effects on the performance of the wastewater treatment plant caused by the active ingredients of the herbicide. If adverse effects are identified in the wastewater treatment system, the

Contractor must immediately suspend the application of the herbicide as directed by the Contracting Officer. Application of herbicides will be terminated, as directed by the Contracting Officer, if the adverse effects cannot be corrected to the satisfaction of the wastewater treatment plant operator.

b. Adhere to safety precautions as recommended by the manufacturer concerning handling and application of the herbicide.

c. Apply the herbicide to the roots in accordance with the manufacturer's recommendations and specifications.

3.2.1.1 Equipment Calibration and Tank Measurement

Submit a list of equipment to be used. Conduct calibration test on the application equipment to be used immediately prior to commencement of herbicide application. Measure the volume and contents of the application tank. Testing must confirm that the application equipment is operating within the manufacturer's specifications and meets the requirements of the herbicide label. Submit written certification of the equipment calibration test results within one week of testing. Where results from the equipment calibration and tank measurements tests are unsatisfactory, re-treatment will be required.

3.2.1.2 Mixing and Application

Perform all work related to formulating, mixing, and application in the presence of a DOD certified pesticide applicator, Pest Management QAE/PAR, or Integrated Pest Management Coordinator. Submit herbicide application records. Records will include the following information: date of application, location and site, type of operation, area treated, name of applicator, pesticide information (trade name, active ingredient, and formulation), amount of pesticide applied, and calculated pounds of active ingredient applied.

A closed system is recommended as it prevents the herbicide from coming into contact with the applicator or other persons. Only use water from designated sources. Fit filling hoses with a backflow preventer meeting local plumbing codes or standards. Prevent overflow during the filling operation. Spill kits must be maintained on applicator vehicles and must be available at the mixing site. Herbicide mixing must be conducted at a site that has been designated by the Contracting Officer and that has adequate spill containment. Inspect the application equipment prior to each day of use for leaks, clogging, wear, or damage. Immediately perform repairs on the application equipment to prevent or eliminate leaks and clogging.

3.2.1.3 Clean Up, Disposal, And Protection

Once application has been completed, proceed with clean up and protection of the site without delay. Clean the site of all material associated with the treatment measures, according to label instructions. Remove and dispose of excess and waste material off Government property.

3.2.1.3.1 Disposal of Herbicide

Dispose of residual herbicides and containers off Government property, and in accordance with the approved disposal plan, label instructions and EPA requirements.

3.2.2 Inspection of Sewer Lines

Inspection of sewer lines applies to Pre-TV inspection, Post-TV inspection, RE-TV inspection and Warranty-TV inspection. Perform inspections of sewer lines in the presence of the Contracting Officer.

3.2.2.1 Communication

Set up hand operated radios, telephones, or other means of communication between the entry and exit points being inspected to ensure uninterrupted communication between members of the CCTV crew when manually operated winches are used to pull the television camera through the line.

3.2.2.2 Flush Main

Introduce a minimum of 1000 gallons of clear, potable water into the upstream manhole or structure or access structure of the mains to be CCTV inspected just prior to inserting the camera. The Contractor is responsible for collecting and disposing of the water in accordance with the approved disposal plan.

3.2.2.3 Camera Operation

Set counter to 0.00 feet at the entry point, which is the beginning manhole or structure wall. Move the camera through the line in either direction at a moderate speed, stopping to permit proper documentation of the sewer's condition or service connection locations. In no case will the camera be operated at a speed greater than 30 feet per minute. Slowly pan and tilt the camera at the beginning and ending manhole, structure connections, service connections, joints, visible defects, and pipe arterial transitions. Provide a full 360 degree view of the pipe, joints, and service connections.

Utilize manual winches, power winches, cable, powered rewinds or other devices that do not obstruct the camera view or interfere with camera operation or CCTV inspection of the pipe conditions as the camera is moved through the sewer line.

3.2.2.3.1 Recording Defects

During CCTV inspection, temporarily stop the camera at each defect or feature along the line.

3.2.2.4 Documentation of CCTV Inspection

Documentation of CCTV inspection applies to Pre-TV inspection, Post-TV inspection, RE-TV inspection and Warranty-TV inspection.

Utilize a data logger and reporting system that is PACP compliant to make a video and audio recording of the CCTV inspections. Submit video recordings, inspection logs, and digital photographs as indicated in the following sub-paragraphs.

3.2.2.4.1 Video Recordings

Provide a color video showing the completed work and document the inspection on a digital recorder. Capture inspection video in either MPEG-4 or Windows Media Video (WMV) format with a minimum resolution of 352 x 240 pixels and an interlaced frame rate at a minimum of 24 frames per second. Save video on CD or DVD. However, the CCTV inspection video of a segment must be wholly contained on a single CD or DVD. The video recording must meet the following requirements:

a. Provide a continuous and uninterrupted recorded video for the pipe segment being examined. Include the official project title, Contracting party, Contractor's name, street name, manhole or structure ID numbers, direction of video and flow, date and time video was recorded, continuous counter text, pipe size and material, material changes in the pipe segment, audio and text call outs of laterals, fixtures and problem areas in the recorded video.

b. Include an audio track recorded by the CCTV technician during the actual inspection work with a description of the parameters of the line being inspected on the video recordings. The audio may be from the voice of the CCTV technician or it may be computer generated.

c. Include the location, pipe diameter, pipe material, defects, service lateral locations and any unusual conditions found in PACP format.

d. Submit labeled CDs or DVDs of the video inspections.

e. Without exception, CCTV inspections must be continuous without video interruption or gaps for pipe segments.

f. Clean, flush, and RE-TV pipe segments with video interruptions or gaps.

3.2.2.4.2 TV Inspection Logs

Submit computer generated records that clearly show the location and orientation in relation to an adjacent manhole or structure of each infiltration point observed during the inspection.

Record other points of significance such as locations and orientations of service connections, missing or broken pipe, roots, the presence of grease, scale or corrosion, bellies, fractures, cracks, and other discernible features using PACP designations.

3.2.2.4.3 Digital Photographs

Submit JPEG images at a minimum resolution of 640 x 480 pixels. Save digital photographs in JPEG file format on CD or DVD. Document noted defects and lateral connections as color digital files and hard copy print-outs. Photo logs are to accompany each photo submitted.

3.2.3 Pre-TV Inspection

Immediately after cleaning has been performed, complete a Pre-TV inspection, in accordance with paragraph INSPECTION OF SEWER LINES. Submit Pre-TV inspection documentation in accordance with paragraph DOCUMENTATION OF CCTV INSPECTION.

3.2.4 Post-TV Inspection

Immediately after visual, deflection, pressure and leak testing and service reconnections are complete on a pipe segment, complete Post-TV inspection accordance with paragraph INSPECTION OF SEWER LINES. Submit Post-TV inspection documentation in accordance with paragraph DOCUMENTATION OF CCTV

INSPECTION. Provide post installation inspection documentation within 10 working days of the liner installation. The Contracting Officer may, at his or her discretion, suspend any further installation of lining materials if post-installation documentation is not submitted within 10 working days. As a result of this suspension, no additional working days will be added to the Contract, nor will any adjustment be made for increase in cost.

3.2.4.1 Post-TV Defects

If defects are found in the mains or services during the Post-TV inspection make repairs according to the specifications. RE-TV all repairs accordance with paragraph INSPECTION OF SEWER LINES. Provide additional RE-TV inspections of complete pipe segments as follows:

a. Perform a RE-TV inspection of the complete pipe segment. If no additional defects are found in the Re-TV inspections, then the Post-TV inspection is complete.

b. If defects are found in these additional inspections make repairs according to the specifications and provide Re-TV inspection for the complete pipe segment.

c. If defects are found in these additional inspections make repairs according to the specifications and Re-TV the repaired pipe segments until no Post-TV defects are found.

3.2.5 Warranty-TV Inspection

Submit Warranty-TV Inspection no later than 30 days prior to the expiration of the warranty. Comply with paragraphs TV INSPECTION OF SEWER LINES and DOCUMENTATION OF CCTV INSPECTION. Complete Warranty-TV inspections in the presence of the Contracting Officer. The Contracting Officer has the option to select the pipe segments for the Warranty-TV inspection. Comply with the following requirements:

a. Provide a complete pipe segment Warranty-TV inspection of pipe segments where a liner repair was performed during Post-TV Inspection.

b. Provide a complete pipe segment Warranty-TV inspection of pipe segments where a point repair was performed.

c. Provide a Warranty-TV inspection of at least one full pipe segment of each size and type of slip lining installed.

d. Provide a Warranty-TV inspection of at least 10 percent of the total length of all pipe segments.

All of Warranty-TV inspections above may be included to satisfy the percentage of total length requirement. If no defects are found in the mains and services in the above minimum pipe segments inspected, then the Warranty-TV inspection is complete.

3.2.5.1 Warranty-TV Defects

If defects are found in the mains or services during the Post-TV inspection make repairs according to the specifications. RE-TV all repairs. Provide additional Warranty-TV inspections of complete pipe segments as follows:

a. Warranty-TV inspect an additional 15 percent of the footage based on the length of the total project. If no additional defects are found in the additional Warranty-TV inspections, then the Warranty-TV inspection is complete.

b. If defects are found in these additional inspections make repairs according to the specifications, RE-TV all repairs and provide Warranty-TV inspections for the remaining pipe segments in the project.

c. If defects are found in these additional inspections make repairs according to the specifications and Re-TV the repaired pipe segments.

3.2.6 RE-TV Inspection

After repairs are made to a main or service, complete RE-TV inspection accordance with paragraph INSPECTION OF SEWER LINES and DOCUMENTATION OF CCTV INSPECTION.

3.3 FIELD QUALITY CONTROL

3.3.1 Verification of Measurement

Once herbicide applications have been completed, measure tank contents to determine the remaining volume. The total volume measurement of used contents for the application must equal the established application rate for the project site conditions. Submit written verification that the volume of herbicide used meets the application rate.

3.3.2 Inspection

3.3.2.1 Technical Representative

Provide a technical representative who is a DOD certified pesticide applicator or Pest Management Quality Assurance Evaluator (QAE)/Performance Assessment Representative (PAR). The technical representative must be present at all meetings concerning root removal and during treatment application. Contact the Integrated Pest Management Coordinator prior to starting work.

3.4 CLOSEOUT ACTIVITIES

3.4.1 Sewer Cleaning

Submit copies of Records of Disposals indicating the disposal site, date, amount, and a brief description of the materials disposed.

3.4.2 Herbicides

Upon completion of work, submit the Pest Management Report DD Form 1532-1, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the target pest, type of operation, brand name of pesticide, formulation, and concentration or rate of application used.

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SECTION 33 01 30.72

RELINING SEWERS
11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE MOP 120	(2009) Trenchless Renewal of Culverts and Storm Sewers

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA M45	(2013; 3rd Ed) Fiberglass Pipe Design

ASTM INTERNATIONAL (ASTM)

ASTM D790	(2017) Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D2412	(2021) Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2990	(2017) Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
ASTM D5813	(2004; R 2018) Standard Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems
ASTM F1216	(2021) Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
ASTM F1504	(2014) Standard Specification for Folded Poly(Vinyl Chloride) (PVC) Pipe for Existing Sewer and Conduit Rehabilitation
ASTM F1533	(2001; R 2009) Standard Specification for Deformed Polyethylene (PE) Liner
ASTM F1606	(2019) Standard Practice for Rehabilitation of Existing Sewers and Conduits with Deformed Polyethylene (PE) Liner

ASTM F1743	(2016) Standard Practice for Rehabilitation of Existing Pipeline and Conduits by Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP)
ASTM F1867	(2006; R 2012) Standard Practice for Installation of Folded/Formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation
ASTM F1871	(2011) Standard Specification for Folded/Formed Poly (Vinyl Chloride) Pipe Type A for Existing Sewer and Conduit Rehabilitation
ASTM F2019	(2011) Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)

1.2 DEFINITIONS

Use the definitions in the applicable standard. When the the applicable standard does not have a definition, use ASCE MOP 120.

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Scheduling

Minimize obstruction and inconvenience to traffic, pedestrians, and tenants.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor Quality Control (CQC) Plan; G

Sequence Of Liner Installation; G

Traffic Control Plan; G

Bypass Plan; G

Disposal Of Process Water; G

SD-02 Shop Drawings

FFP Repair Method; G

SD-03 Product Data

Hydrophilic Seal; G

Lubricant; G

Fabric Tube; G

CIPP Product Data; G

Catalyst; G

Raw Resin Data; G

Flexible Membrane; G

SD-05 Design Data

Engineering Design Calculations; G

Resin To Tube Ratio; G

FFP Engineering Design Calculations; G

SD-06 Test Reports

IR Analyses; G

Temperature Logs; G

Curing Logs; G

CIPP Sample Test Results; G

FFP Temperature Logs; G

FFP Curing Logs; G

FFP Sample Test Results; G

SD-07 Certificates

Contractor's Qualifications; G

Superintendent's Qualifications; G

Certificate of QC Laboratory Accreditation; G

Resin Dye; G

Liner Manufacturer; G

CIPP Installer's Qualifications; G

Shipping Documents; G

Manufacturing Certificate; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions; G

1.5 QUALITY CONTROL

1.5.1 Qualifications

1.5.1.1 Contractor's Qualifications

The Contractor is to have a minimum of three years of continuous experience installing Cured-In Place Pipe (CIPP) in pipe of a similar size, length and configuration. A minimum of 150,000 linear feet of shop wet-out liner installation is required and a minimum of six onsite wet-out installations are required as specifically applicable to this Contract.

A minimum of three years experience using the proposed Fold-And-Form Pipe (FFP) rehabilitation of sewers' product is required as well as the installation of at least 50,000 linear feet of the proposed FFP product(s). Employees and subcontractors performing work on the FFP rehabilitation are to be certified by the FFP rehabilitation system supplier as qualified to perform work with the proposed product. The firm performing the work is to be licensed by the liner process manufacturer.

1.5.1.2 CIPP Installer's Qualifications

The lead personnel including the superintendent, the foreman and the lead crew personnel for the resin wet-out, the CIPP installation, liner curing and the robotic service reconnections each are to have a minimum of three years of total experience with the CIPP technology utilized.

1.5.1.3 Superintendent's Qualifications

The superintendent for the Contract is to have supervised projects in which at least 25,000 linear feet of pipe has been rehabilitated using the product. The superintendent must be on-site during all phases of the work involving the insertion and processing of the liner.

1.5.1.4 Quality Control Specialist

The Quality Control (QC) Specialist is responsible for monitoring and documenting activities related to QC of the liner system from manufacturing through installation. The QC Specialist is to have a minimum of three years of continuous experience installing FFP CIPP of similar size, length and configuration as contained in this contract. The QC Specialist is to be certified by the liner system supplier as qualified to perform work with the proposed liner system.

1.5.1.5 Liner Manufacturer

Use felt material manufactured by companies specializing in felt production for CIPP. The manufacturer is to have manufactured felt material for CIPP for at least two years as documented by references. Submit felt manufacturer, references and location of the manufacturing facility. The felt material manufacturer and facility cannot change during construction unless specifically approved by the Contracting Officer in writing and in advance of its use.

1.5.1.6 Quality Control Laboratory

Select a QC Laboratory that has provided QC testing for at least three completed projects with the proposed liner system; and is independent from, and not associated with, the Contractor. QC Laboratory must be certified to perform testing in accordance with the following standards: ASTM D790, ASTM D2412, ASTM D2990, ASTM D5813, and ASTM F1216. Submit the Certificate of QC Laboratory Accreditation.

1.5.2 Quality Control Plan

Submit a detailed Contractor Quality Control (CQC) Plan that fully represents and conforms to the requirements of these specifications. At a minimum the CQC is to include the following:

a. Defined responsibilities, of the personnel, for assuring that quality requirements, for this Contract are met. Assign these responsibilities to specific personnel.

b. Submit clearly defined proposed procedures for quality control, product sampling and testing as part of the plan.

c. Proposed methods for product performance controls, including method of and frequency of product sampling and testing both in raw material form and cured product form.

d. A scheduled performance and product test result review with the Contracting Officer at a regularly scheduled progress meeting.

e. Prepare Inspection Forms and guidelines for quality control inspections in accordance with the standards specified in this Contract and submitted with the QCP.

f. Outline specific repair or replacement procedures for potential defects that occur in the installed liner system, following repair or replacement procedures that are compatible with the system being used. Submit Repair or Replacement Procedures must adhere to the product manufacturer's written specifications for repair or replacement.

1.6 DELIVERY, STORAGE, AND HANDLING

Ship, store, and handle materials in a manner consistent with the written specifications of the liner system manufacturer to avoid damage. Damage may include, but is not limited to, gouging, abrasion, flattening, cutting, puncturing, or ultra-violet (UV) degradation. Select on site storage locations for approval by the Contracting Officer. Promptly remove and dispose of damaged materials.

As a minimum the FFP delivered to the job site is to contain the manufacturers name or trademark, the nominal outside diameter, the cell classification, the DR designation, and the ASTM designation of the pipe.

1.6.1 Resin

Ship the resin directly from the resin manufacturer's facility to the CIPP wet-out facility. Submit copies of the shipping documents from the resin manufacturer to the Contracting Officer showing dates of shipment, the originating location and the receiving location.

1.7 PROJECT/SITE CONDITIONS

The use of the product is not to result in the formation or production of any detrimental compounds or by-products including cuttings and pipe coupons, at the wastewater treatment plant or environment.

1.7.1 Environmental Requirements

Cool superheated water to below 100 degrees F before discharge. Notify the Contracting Officer and identify any by-products produced as a result of the installation operations. Comply with local waste discharge requirements.

1.7.1.1 Disposal Of Process Water

Submit a procedure for the containment and disposal of process water for approval by the Contracting Officer.

1.8 WARRANTY

1.8.1 Warranty-TV Inspection

a. Complete a Warranty-TV inspection starting no earlier than 60 days prior to expiration of the warranty. Perform Warranty-TV Inspection as specified in Section 33 01 30.16 TV INSPECTION OF SEWER LINES and at a time directed by the Contracting Officer. The specific locations will be selected by the Contracting Officer.

b. Repair any defects or abnormalities in lining, laterals or manhole connections which may materially affect the integrity, strength, function or operation of the pipe in accordance with Repair or Replacement Procedures.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Rehabilitate sewer pipelines by the installation of FFP CIPP.

2.1.1 Design Requirements

2.1.1.1 Structural Requirements

2.1.1.1.1 Cured-In-Place Pipe

Design the CIPP in accordance with the applicable provisions of ASTM F1216 for fully deteriorated or partially deteriorated gravity pipe conditions. Provide engineering design calculations, performed and sealed by a qualified registered Professional Engineer in accordance with ASTM F1216 Appendix X1 Design Considerations for each length of liner to be installed including the thickness of each pipe segment. It is acceptable to submit a design for the most severe line condition and apply that design to all of the line sections of the same diameter. Provide a CIPP system which meets or exceeds the minimum properties specified herein:

a. Provide calculations supporting the liner thickness. The data is to include both the calculated thicknesses and the thicknesses proposed to be installed.

b. The installed, cured liner thickness is the largest thickness as determined by calculations for deflection, bending, buckling and minimum stiffness. The minimum installed, cured liner thickness is as follows, regardless of what the calculations indicate as the required minimum thickness:

6 inch sewer: 4.5 mm

8 inch sewer: 6 mm up to 17 feet deep

8 inch sewer: 7.5 mm up to 25 feet deep

10 inch sewer: 6 mm up to 11 feet deep

10 inch sewer: 7.5 mm up to 18 feet deep

10 inch sewer: 9 mm up to 25 feet deep

12 inch sewer: 7.5 mm up to 12 feet deep

12 inch sewer: 9 mm up to 18 feet deep

12 inch sewer: 10.5 mm up to 25 feet deep

15 inch sewer: 7.5 mm up to 10 feet deep

15 inch sewer: 9 mm up to 14 feet deep

15 inch sewer: 10.5 mm up to 20 feet deep

c. The physical properties and characteristics of the finished liner will vary considerably, depending on the types and mixing proportions of the materials used, and the degree of cure executed. Control these variables and provide a CIPP system which meets or exceeds the minimum properties specified herein:

(1) Design the CIPP to meet or exceed ASTM F1216 Appendixes. The CIPP design is to assume no bonding to the original pipe wall.

(2) The CIPP design engineer is to set the long term (50 year extrapolated) Creep Retention Factor at 50 percent of the initial design flexural modulus as determined by ASTM D790 test method. Use this value unless long term test data ASTM D2990 substantiates a higher retention factor is required.

(3) At a minimum, the CIPP is to meet or exceed the structural properties, as listed below:

	MINIMUM PHYSICAL PROPERTIES	
Property	Test Method	Cured Composite (ASTM F1216)
Flexural Modulus of Elasticity (Short Term) (Felt Tubes) Felt/Fiberglass, Fiberglass meeting manufacturer's specifications	ASTM D790	250,000 psi
Flexural Strength (Short Term) (Felt Tubes) Felt/Fiberglass, Fiberglass meeting Manufacturer's specifications	ASTM D790	4,500 psi

(4) As a minimum, base the required structural CIPP wall thickness on the physical properties of the cured composite and the design of the Contractor's Professional Engineer and in accordance with the Design Equations contained in the Appendix of the ASTM standards, and the following design parameters:

Design Safety Factor	2.0 (1.5 for pipes 36 inch or larger)
Creep Retention Factor	50 percent
Ovality	2 percent or as measured by field inspection
Constrained Soil Modulus	AASHTO LRFD Section 12 and AWWA M45
Groundwater Depth	As specified or indicated on the plans, in the specifications or geotechnical report
Soil Depth (above the crown)	As specified or indicated on the plans
Live Load	Highway, railroad or airport as applicable
Soil Load (assumed)	120 lb/cu.ft.
Minimum service life	50 years

(5) Prior to installation of the lining materials, submit certification of compliance with these specifications or the requirements of the pre-approved CIPP system. Include certified material test results that confirm materials conform to these

specifications. Materials not complying with these requirements will be rejected.

2.1.1.1.2 Fold and Form Pipe

Provide FFP engineering design calculations, performed and sealed by a qualified registered Professional Engineer in accordance with ASTM F1216 Appendix X1 Design Considerations for each length of liner to be installed including the thickness of each pipe segment. It is acceptable to submit a design for the most severe line condition and apply that design to all of the line sections of the same diameter.

a. The physical properties, wall thickness and characteristics of the finished FFP will vary according to the material installed. Provide a FFP system which meets or exceeds the minimum properties specified herein:

(1) Design the FFP in accordance with the applicable ASTM Standard, depending on the material being installed. The FFP design is not to assume bonding to the original pipe wall.

(2) The FFP design engineer is to set the long term (50 year extrapolated) Modulus Retention Factor as a percentage of the flexural modulus as determined by ASTM D790 test method. Base the Modulus Retention Factor on long term test data (ASTM D2990 or equal) submitted by the manufacturer of the product selected to substantiate the long term creep retention factor.

(3) The installed FFP material is to meet or exceed the structural properties, as listed below.

(a) As a minimum, base the required structural FFP wall thickness on the physical properties of the manufactured FFP and according to the design of the Professional Engineer and in accordance with ASTM F1504 and ASTM F1533.

Design Safety Factor	2.0
Modulus Retention Factor	As submitted and specific to type of pipe material
Ovality	2% or as measured by field inspection
Constrained Soil Modulus	Per AASHTO LRFD Section 12 and AWWA M45
Groundwater Depth	As specified or indicated on the Plans
Soil Depth (above the crown)	As specified or indicated on the Plans
Live Load	Highway, railroad or airport as applicable
Soil Load (assumed)	120 lb/cu. ft. (or data from specific project soil borings)
Minimum service life	50 years

MINIMUM PHYSICAL PROPERTIES

Property	Test Method	Per Applicable ASTM
Flexural Modulus of Elasticity	ASTM D790	HDPE - 118,000 psi PVC - 280,000 psi PVC Type A - 145,000 psi
Flexural Strength	ASTM D790	HDPE - N/A PVC - 5,000 psi PVC Type A - 4,100 psi

2.1.2 Performance Requirements

Provide a continuous and tight-fitting liner throughout the entire length of the original pipe. Extend the FFP CIPP the full length of the original pipe, from entry point to exit point, and provide a structurally sound and water-tight new pipe within a pipe. Cleanup, restore existing surface conditions and structures, and repair portions of the FFPCIPP system determined to be defective.

2.1.2.1 Cured-In-Place Pipe

a. Provide a continuous and jointless CIPP from manhole to manhole or access point to access point, free of defects that will affect the long term life and operation of the pipe.

b. Fit the CIPP sufficiently tight within the existing pipe so as to not leak at the manholes, at the service connections or through the wall of the installed pipe. Seal leaks at the manholes or the service connections using a material compatible with the CIPP. If leakage occurs through the wall of the pipe, repair or replace the liner.

c. Design the CIPP for a life expectancy of 50 years or greater and to have a 50 year corrosion resistance to the typical chemicals found in domestic sewage.

d. Robotically re-open existing and confirmed active service connections and any other service laterals to be reinstated as directed by the Contracting Officer to their original shape and to a minimum of 90 percent of their original capacity. Repair over-cut service connections to meet the requirements of these specifications. Re-establish the service openings utilizing a remotely controlled brushing device to smoothly cut and remove jagged edges, material and shavings resulting in the cutting operation.

2.1.2.2 Fold-And-Form Pipe

a. Provide continuous and jointless FFP from manhole to manhole, free of defects that will affect the long term life and operation of the pipe.

(1) The FFP is to fit sufficiently tight within the existing pipe so as to not leak at the manholes, at the service connections, or

through the wall of the installed pipe.

(2) Seal these areas to stop leakage using a material compatible with the FFP. Repair or replace the liner if leakage occurs through the wall of the pipe. Final approval of the liner installation will be based on a leak tight pipe.

b. The installed FFP is to have a 50 year corrosion resistance to the typical chemicals found in domestic sewage.

2.1.3 Tolerances

Maintain the largest possible hydraulic capacity. At a minimum, the rehabilitated pipe is to equal or exceed the full flow capacity of the original pipe before rehabilitation.

All recommended values from the ASTM's referenced in this specification are required.

2.1.3.1 Cured-In-Place Pipe

The installed CIPP thickness tolerance is minus 5 percent to plus 10 percent as compared to the approved liner design.

2.1.3.2 Fold-And-Form Pipe

2.1.3.2.1 Fold-And-Form Poly (Vinyl Chloride) Pipe

Comply with ASTM F1871, ASTM F1867 or ASTM F1504.

2.1.3.2.2 Polyethylene (PE) Liner

Comply with ASTM F1606 or ASTM F1533.

2.2 MATERIALS

2.2.1 Hydrophilic Seals

Submit Hydrophilic Seal information that specifically indicates that the seal material is compatible with the liner material being utilized and the hydrophilic seal will produce a tight fitting, waterproof seal between the liner and the host pipe at the manhole location.

2.2.2 Lubricant

Submit detailed description of the lubricant proposed for the insertion or inversion process. Ensure that the lubricant is compatible with the wastewater treatment plant operations and pre-treatment program.

2.2.3 Cured-In-Place Pipe

Provide a fabric tube manufactured of one or more layers of absorbent non-woven felt fabric, felt fiberglass composite or fiberglass and meet the requirements of ASTM F1216, ASTM F1743, ASTM D5813, and ASTM F2019 that is capable of absorbing and carrying resins, constructed to withstand installation pressures and curing temperatures and have sufficient strength to bridge missing pipe segments, and stretch to fit irregular pipe sections. Submit certified information from the felt manufacturer of the nominal void volume in the fabric tube that will be filled with resin.

When combined as a composite structure, the fabric tube, resins, tube coatings, and other materials must produce CIPP that meets the requirements of this specification. Fabricate the CIPP to a size that will tightly fit the internal circumference and the length of the original conduit when installed.

2.2.3.1 Resin-Impregnated Tube

Provide ASTM F1216 resin-impregnated, flexible tube for installation by inversion. The flexible tube must consist of one or more layers of flexible needled felt, nonwoven or woven material, or a combination of nonwoven and woven materials, capable of carrying resin and withstanding installation pressures and curing temperatures. The tube must be compatible with the resin system used and have a plastic coated outside layer material that is compatible with the resin system used. Make allowance for circumferential stretching during inversion.

Use thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180 deg. F.

2.2.3.2 Thermosetting Resin Pipe

Provide ASTM F1743 coated fabric tube filled with thermosetting resin installed by pull in place methods. The flexible tube must consist of one or more layers of flexible needled felt, nonwoven or woven material, or both, capable of carrying resin and withstanding installation pressures and curing temperatures. The outside layer of the fabric tube should have an impermeable flexible coating whose function is to contain the resin during and after fabric tube impregnation. The outer coating must facilitate monitoring of resin saturation. Allowance should be made for circumferential and longitudinal stretching of the fabric tube during installation. All of the materials used must be compatible with the resin system used and have a plastic coated outside layer material that is compatible with the resin system used.

Use a chemically resistant isophthalic based polyester or vinyl ester thermoset resin and catalyst system or an epoxy resin and hardner that is compatible with the installation process. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180 deg. F.

2.2.3.3 Product Data

Submit CIPP product data from the CIPP manufacturer.

a. Submit product data for the Flexible Membrane (coating) material including the manufacturer's recommended repair (patching) procedure.

b. Include infrared spectrum (IR) analysis for proposed resin and confirmation that the resins meet ASTM D5813.

c. Catalyst product data and quantity.

d. Raw Resin Data, including the manufacturer and description of product components.

2.2.3.4 Test Reports

Include test reports certifying that the materials shipped to the project site conform to the applicable ASTM standards.

a. Submit results of IR analyses of the proposed resin and resin catalyst mixture, performed and certified by the resin manufacturer, prior to manufacturing CIPP.

b. The results of the IR analyses (the resin's chemical fingerprint) will be used to verify that the resin and the resin catalyst composition and mixture being used is the approved resin and resin catalyst system.

2.2.3.5 Certificates

a. Submit a manufacturing certificate that the CIPP was manufactured in accordance with these specifications and ASTM D5813 with each shipment. The certifications are to include:

b. A signed statement by the wet-out manager/supervisor that no fillers were added to the resin system during manufacture of the CIPP.

c. Wet-out forms documenting the wet-out for each section of CIPP manufactured without delay or claim to any confidentiality.

   (1) The wet-out forms are to document the date and time of wet-out, the wet-out supervisor, the wet-out facility address, the location where the CIPP will be installed (by work order and manhole numbers), the CIPP diameter, the length of wet-tube and dry-tube, the thickness of the CIPP, the roller gap setting for establishing the liner thickness, the felt manufacturer, the resin used (by product name and batch or shipment number) and quantity, the catalyst(s) used (by product name) and quantity, quality control samples taken, and other information pertinent to the wet-out process.

d. Submit a Certificate of Authenticity from the resin manufacturer for each shipment to the wet-out facility as part of the Catalyst product data submittal. Include the date of manufacture and the Heat Distortion Temperature.

e. Submit certification that the Resin Dye quantity and type is compatible with the components of the lining system.

2.2.3.6 Manufacturer's Instructions

Submit manufacturer's instruction for installation, repair and patching of the CIPP.

2.2.3.7 Resin

a. Provide a corrosion resistant polyester or vinyl ester resin and catalyst system or epoxy and hardener system that, when cured within the tube composite, meets the requirements of ASTM F1216, ASTM F1743, or ASTM F2019, the physical properties herein, and those, indicated in the design of the CIPP for this project. The resin is to produce CIPP which will comply with or exceed the structural and chemical resistance requirements of this specification.

b. Submit the resin to tube ratio, by volume, as determined by the Design Calculations.

c. Provide the polyester or vinyl ester resin that is PREMIUM, NON-RECYCLED resin only. Do not use Polyethylene Terephthalate (PET) resins, or those containing fillers, additives or enhancement agents. Old resin or reworked resin is not permitted.

d. Do not use Quick-cure or accelerated resin systems that cure in half the specified time or substantially quicker than the minimum three hours.

2.2.4 Fold-And-Form Pipe

Provide an FFP system that is chemical resistant to domestic sewage.

2.2.4.1 Manufacturer's Instructions

Submit manufacturer's instruction for installation and repair of the FFP.

PART 3 EXECUTION

3.1 EXAMINATION

Complete Pre-TV inspection in accordance with Section 33 01 30.16 TV INSPECTION OF SEWER LINES.

3.2 PREPARATION

3.2.1 Traffic Control

a. Submit a detailed Traffic Control Plan to the Contracting Officer at least 10 days in advance when the manholes used to access and install the liner are located in or adjacent to the road. Comply with all applicable State Highway, Local and Installation requirements when preparing the traffic control plan.

b. Provide labor, signs, barricades, cones, arrow boards, flaggers and any additional equipment necessary to complete the work.

3.2.2 Set-Up and Sequence

Submit a sewer Bypass Plan to the Contracting Officer at least 14 days in advance. Coordinate sewer bypass and flow interruptions with the Contracting Officer before proceeding with liner installation.

Submit a Sequence of Liner Installation plan. Include proposed set-up locations in the plan that are coordinated with the Traffic Control Plan.

3.2.3 Sewer Flow Control

Plug the pipe or install a bypass pumping system to facilitate the proper cleaning of pipe lines. In the event of a spill, immediately notify the Contracting Officer and take appropriate actions to stop, contain and cleanup the spill. Immediately clean up raw sewage spills caused by the Contractor's operations and disinfect the spill area using methods and materials approved by the Contracting Officer.

3.2.3.1 Bypassing Existing Sewage Flows

a. Provide for the flow of existing mainline and service connection effluent around the section or sections of pipe designated for liner installation.

b. Provide pump(s) and bypass line(s) of adequate capacity and size to handle peak flows.

c. Plug service connections only after proper notification to the Contracting Officer. Service connections are not to remain plugged overnight.

d. Begin work after plugs or a sewage bypass system and pumping facilities have been installed and tested under full operating conditions, including the bypass of mainline and side sewer flows.

e. Once the lining process has begun, maintain bypass flows until the resin/felt tube composite is fully cured, cooled down, fully televised and the CIPP ends finished.

3.2.4 Cleaning

Select a cleaning method that will prepare the surface for the type of point repair or renewal work being performed taking into consideration the condition of the existing pipeline. Sewer cleaning includes the removal of roots, sediment and debris, incrustations from sewer walls, and removing protruding objects or lateral connections.

a. Clean mains and services as indicated in SECTION 33 01 30.16 TV INSPECTION OF SEWER LINES.

b. Remove internal debris from the existing pipe line that will interfere with the installation of the liner.

3.2.4.1 Line Obstructions

Remove obstructions, correct misalignments, repair broken or collapsed sections and sags that will prohibit the installation or will interfere with the long-term performance of the lining materials by performing a point repair. Make point repairs by open cut repair methods or sectional point repair methods in accordance with ASTM F1216.

3.2.5 Protection

Prevent damage to the existing piping during cleaning.

3.2.6 Surface Preparation

Perform Pre-TV inspections of the pipelines after cleaning has been completed in accordance with SECTION 33 01 30.16 TV INSPECTION OF SEWER LINES.

Confirm the locations of branch service connections prior to installing and curing the liner material. In the event the status of a service connection cannot be adequately defined, the Contracting Officer will make the final decision, prior to installation and curing of the liner, as to the status.

3.3 INSTALLATION

Stop or by-pass sewer flow prior to beginning renewal work such as cleaning, CCTV, installing liners, and re-instating service connections.

3.3.1 Cured-In-Place Pipe

a. Prior to the installation of the liner, place temperature sensors in the host pipe in order to monitor the temperature of the liner wall and to verify correct curing. Place temperature sensors between the host pipe and the liner in the bottom of the host pipe (invert) throughout its length and monitor the temperature on the outside of the liner during the curing process.

b. Place the temperature sensors at intervals as indicated in the sensor manufacturer's written specifications. Place additional sensors where significant heat sinks are likely or anticipated.

c. Monitor the sensors by a computer using a tamper proof data base that is capable of recording temperatures at the interface of the liner and the host pipe.

d. Install the liner in accordance with ASTM F1216 and ASTM F1743 with the following modification: Position the wet-out tube in the pipeline using the method indicated in the manufacturer's instructions. Pull-in or invert through an existing manhole or access point and fully extend to the next manhole or termination point. Prevent damage to the tube during installation.

e. Install and cure the CIPP in the host pipe as indicated in the manufacturer's specifications and as described in the approved submittals.

f. Accomplish curing by utilizing the medium in accordance with the cure schedule. Continuously monitor the curing source, or input and output temperatures and log the temperatures during the cure cycles. Use the manufacturer's recommended cure method and schedule for each line segment installed. Take the liner wall thickness and the existing ground conditions with regard to temperature, moisture level, and thermal conductivity of soil into account during the curing process.

g. For heat cured liners, if one or more temperature sensors do not reach the temperature specified by the manufacturer to achieve proper curing or cooling, the installer is to make necessary adjustments required to conform with the manufacturer's specifications.

h. For UV Cured Liners, record all light train sensor readings along the entire length of the installed liner into a tamper proof computer. Follow the cure procedure in accordance with the manufacturer's written product data.

i. Monitor and record temperatures and curing data throughout the installation process to ensure that each phase of the process is achieved in accordance with the product specifications. Provide curing logs from the system computer that specifically identifies each installed sensor station in the length of pipe, indicates the maximum temperature achieved and the sustained temperature time. Each sensor is to record both the maximum temperature and the minimum cool down temperature and comply with the manufacturer's written product data. Submit temperature logs and curing logs for each pipe segment.

j. Cool in accordance with the approved product specifications.

3.3.1.1 Finish

a. Provide a CIPP that is continuous over the entire length of a sewer line, is free from visual defects such as foreign inclusions, dry spots, pinholes, major wrinkles and de-lamination, and is impervious and free of leakage from the pipe to the surrounding ground or from the ground to inside the lined pipe.

b. Seal the beginning and end of the CIPP to the existing host pipe utilizing a hydrophilic end sealing material compatible with the existing (HOST) pipe and the liner.

c. Provide watertight service connections.

3.3.2 Fold-And-Form Pipe

a. Prior to installation of the FFP, place temperature sensors in the host pipe to monitor the temperatures during the processing of the FFP. Monitor and log temperatures during processing and cool down.

b. Install and process the FFP in the host pipe according to these specifications, ASTM F1867 or ASTM F1606 and the manufacturer's instructions.

c. Position the FFP in the pipeline using the method specified by the manufacturer. Pull-in the FFP through an existing manhole or access point and fully extend the FFP to the next designated manhole or termination point.

d. Complete the processing of the FFP by utilizing the appropriate medium in accordance with the manufacturer's instructions. Use ASTM F1867 or ASTM F1606 and the manufacturer's recommended processing procedure for each line segment installed. Evaluate all factors that may impact installation, such as FFP wall thickness and the existing ground conditions with regard to temperature, moisture level, and thermal conductivity of the host pipe and soil, during the installation of the FFP. Adjust pressures according to site conditions to ensure a tight expansion out against the host pipe.

e. Monitor and record temperatures and curing data throughout the installation process to ensure that each phase of the process is achieved in accordance with the product specifications. Submit FFP temperature logs and FFP curing logs for each pipe segment.

f. Cool in accordance with the approved product specifications.

3.3.2.1 Finish

a. Provide FFP that is fully expanded and continuous over the entire length of a sewer line section, is free from visual defects such as foreign inclusions, dry spots, pinholes, major wrinkles, is impervious and free of any leakage from the pipe to the surrounding ground or from the ground to inside the lined pipe.

b. Seal the beginning and end of the FFP to the existing host pipe using a hydrophilic end sealing material compatible with the existing (host) pipe and the FFP.

c. Provide watertight service connections.

3.3.3 Manhole Connections

Form a tight seal between the rehabilitation (lining) material and the host pipe at the pipe penetration of the manhole wall. Apply the seal consisting of a resin mixture or hydrophilic seal compatible with the installed liner at the manhole-wall interface in accordance with the liner system manufacturer's specifications. Seal annular spaces greater than 1/2 inch with manhole wall repair material. Finish off the seal with non-shrink grout or cementitious liner material placed around the pipe opening from the inside of the manhole in a band at least 4 inches wide. Provide an epoxy coating over the repair on the manhole walls.

Provide a continuous and smooth invert through manholes. If a liner is installed through a manhole, the bottom portion of the liner is to remain. Grout and shape the bench of the manhole as necessary to support the liner. If the liner terminates on either side of the manhole, build up the invert to remove flow restrictions and to form a continuous invert through the manhole.

3.3.4 Cured-In-Place Pipe

a. The wet-out fabric tube is to have a uniform thickness and excess resin distribution that, when compressed at installation pressures, will meet or exceed the design thickness after cure.

b. Install the fabric tube to a size and length that will tightly fit the internal circumference of the host pipe. Allowance for circumferential stretching during installation. Size the tube to the diameter of the existing pipe and the length to be rehabilitated, and be able to stretch to fit irregular pipe sections and negotiate bends. Prior to ordering, measure in the field the minimum tube length necessary to effectively span the designated run between manholes to ensure that the tube will have sufficient length to extend the entire length of the run. Measure the inside diameter of the existing pipelines in the field prior to ordering liner so that the liner can be installed in a tight-fitted condition.

c. Coat the outside or inside layer of the fabric tube (before inversion or pull-in, as applicable) with an impermeable, flexible membrane that contains the resin and facilitates, if applicable, vacuum impregnation and monitoring of the resin saturation during the resin impregnation (wet out) procedure.

d. Do not include material in the fabric tube that may cause delamination in the cured CIPP. Dry or unsaturated layers are not acceptable upon visual inspection as evident by color contrast between the tube fabric and the active resin containing a colorant.

e. Use a light reflective interior pipe surface color so that a clear detailed examination of the CIPP can be made with closed circuit television inspection equipment. Provide a hue of the color dark enough to distinguish a contrast between the fully resin saturated felt fabric and dry or resin lean areas.

f. When seams in the fabric are required, sew them so that the seams are stronger than unseamed felt.

g. Spirally form and sew where the length requires joining.

h. Mark the outside of the fabric tube every 5 feet with the name of the manufacturer or CIPP system, manufacturing lot and production footage.

i. The installer will determine the minimum length of the fabric tube to effectively span the distance from the starting manhole to the terminating manhole or access point, plus that amount required to run-in and run-out for the installation process.

j. As a minimum, provide the fabric tube wall thickness manufactured to the nearest 0.02 in increment, rounded up from the design thickness for that section of installed CIPP. Wall thickness transitions, in 0.02 in increments or greater as appropriate, may be fabricated into the fabric tube between installation entrance and exit access points. Provide a sufficient quantity of resin used in the impregnation to entirely fill the felt voids for the nominal felt thickness.

3.3.4.1 Resin

a. Do not change resins, catalysts, resin/catalysts, or mixing ratios during this Contract unless specifically approved by the Contracting Officer in writing in advance.

b. Use the resin as shipped. Do not add fillers or additives at the wet-out facility except for the required catalyst.

c. Apply the resin to the felt tubing (wet-out) under factory conditions. Protect the materials against ultraviolet (UV) light, excessive heat and contamination at all times.

3.3.5 Reconnections Of Existing Services

a. Make reconnections of existing services after the liner has been installed, fully cured, and cooled down.

b. Make external reconnections with a tee fitting in accordance with the lining system manufacturer's written specifications. Seat and seal saddle connections to the new CIPP using grout or resin compatible with the CIPPFFP following manufacturer's specifications.

c. Utilize a CCTV camera and remote cutting tool for internal reconnections. The machined opening must be at least 90 percent of the service connection opening and the bottom of both openings are required to match. The opening cannot be more than 100 percent of the service connection opening. Smooth the edges of the opening and remove pipe or liner fragments, which may obstruct flow or snag debris. Cut the invert of the sewer connection flush with the invert entering the mainline.

d. In the event that service reinstatements result in openings that are greater than 100 percent of the service connection opening, install a repair, sufficient in size to completely cover the over-cut service connection according to the manufacturer's specifications.

e. Collect coupons of pipe material resulting from service tap cutting at the next manhole downstream of the pipe rehabilitation operation prior to leaving the site. Account for all pipe coupons and do not allow them to pass through the system.

3.4 FIELD QUALITY CONTROL

All costs associated with inspection and the collection, transportation and testing of samples are the responsibility of the Contractor.

3.4.1 Tests

3.4.1.1 Cured-In-Place Pipe

a. Verify the physical properties of the installed CIPP through field sampling and laboratory testing. Use an independent third party laboratory to test CIPP Samples. Test in accordance with ASTM F1216, ASTM F1743, and ASTM D5813 for chemical resistance. Test methods to confirm compliance with the requirements specified in these Contract documents. Measure the installed CIPP thickness for each line section installed. Submit a minimum of one CIPP sample for every line section of installed CIPP to be used to check the liner thickness. Replace sections where the CIPP thickness does not fall within the approved design thickness.

b. Collect samples from the installed CIPP. At a minimum, one sample for each 1000 linear feet of CIPP installed; one sample for each size of CIPP installed; and one plate sample cured with CIPP on pipelines greater than 18 inches in diameter. Cut the samples from a section of cured CIPP that has been inverted or pulled through a like diameter pipe which has been held in place by a heat sink, such as sandbags.

c. Process, cut, and label test samples in the presence of the Contracting Officer. Immediately package the samples in a pre-addressed, postage paid, pre-labeled, unsealed packing, addressed for delivery to the testing laboratory. Seal packages in the presence of the Contracting Officer; and ship or transport to the testing lab.

d. Submit CIPP sample test results.

3.4.1.2 Fold-And-Form Pipe

a. Verify the physical properties of the installed FFP through field sampling and laboratory testing. Use an independent laboratory that specializes in material testing to test FFP Samples. Test in accordance with ASTM F1871 and ASTM F1504 test methods to confirm compliance with the requirements specified in these Contract documents.

b. Take samples from the installed FFP. At a minimum, provide samples from one location per 2500 linear feet of installed pipe. Cut the sample from a section of processed FFP that has been installed through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags. Process, cut, and label test samples in the presence of the Contracting Officer. Immediately package the samples in a pre-addressed, postage paid, pre-labeled, unsealed packing, addressed for delivery to the testing laboratory. Seal packages in the presence of the Contracting Officer; and ship or transport to the testing lab.

c. On pipelines greater in diameter than is practical to produce restrained samples, the Contracting Officer may at his or her discretion designate a location in the newly installed FFP where the Contractor is to take a sample.

d. Identify on the sample and as built drawings the test sample location as referenced to the nearest manhole and station. One re-testing of failed samples will be permitted for proper protocol compliance verification. If properties tested do not meet minimum requirements, repair or replace the FFP pipe section. Sample and test sections of the replaced FFP section.

e. Repair the opening produced from the sample, in accordance with manufacturer's specifications.

f. Submit FFP sample test results.

3.4.2 Inspection

Complete Post-TV, Re-TV and Warranty-TV inspections in accordance with Section 33 01 30.16 TV INSPECTION OF SEWER LINES.

3.4.2.1 Cured-In-Place Pipe

a. Provide the Contracting Officer the opportunity to examine operations during the installation and impregnation of the liner throughout the entire process.

b. Provide full access to witness the CIPP wet-out process and provide information related to the manufacturing as requested by the Contracting Officer, without delay and without claims of confidentiality or product privacy.

3.4.2.2 Fold-And-Form Pipe

a. Use non-destructive methods to measure the thickness for each section of installed FFP.

b. Where leakage is observed through the wall of the pipe, institute localized testing (weirs or similar) that will verify that the leakage rate of the installed liner does not exceed acceptable tolerances for new sanitary sewer installations for the local jurisdictions.

3.4.3 Inspections

Provide Pre-TV, Post-TV, Warranty-TV and Re-TV inspections in accordance with Section 33 01 30.16 TV INSPECTION OF SEWER LINES.

a. Complete Post-TV inspections and repairs to the installed liner before acceptance.

b. Submit as-built drawings for the portions of the sanitary sewer system that were rehabilitated showing complete detail with dimensions, both above and below grade, including invert elevations at the manholes in accordance with Section 01 78 00 CLOSEOUT SUBMITTALS.

c. Include the identification of the work completed on one set of Contract Drawings. Keep legible as-built drawings on the project site at times and maintain them as the work progresses. Continuously update the as-built drawings with accurate dimensions and notations concerning locations, sizes, pipe lengths and specific material types. Include dimensional location, size and type of point repairs on the as-built drawings.

d. Within 10 working days of final acceptance of said work, provide As-built drawings and Inspection forms.

3.4.4 Repair Of Defects

3.4.4.1 Cured-In-Place Pipe

a. Locate and succinctly define defects in the installed CIPP that will not affect the operation and long term life of the product. The warranty CCTV inspection will include pipe segments with noted defects that were not repaired.

b. Locate and succinctly define repairable defects that occur in the installed CIPP based on approved product specifications, including a detailed step-by-step repair procedure.

c. Clearly locate and define un-repairable defects in the CIPP based on the approved product specifications, including a recommended procedure for the removal and replacement of the CIPP.

3.4.4.2 Fold-And-Form Pipe

a. Repair any of the FFP system determined to be defective.

b. Repair or replace any defects which, in the judgment of the Contracting Officer, will affect the integrity or strength of the lining.

c. Prior to the repair of defective work, submit a Shop Drawing indicating the FFP Repair Method.

d. Provide field or workshop demonstration of the method of repair if requested by the Contracting Officer.

e. Make the repairs in full compliance with the FFP manufacturer's specifications.

f. Re-TV repairs to FFP in accordance in accordance with Section 33 01 30.16 TV INSPECTION OF SEWER LINES.

3.5 ADJUSTING AND CLEANING

3.5.1 Lateral Connections

All active lateral connections must be re-opened and remain water tight.

-- End of Section --

SECTION 33 01 50.31

LEAK DETECTION FOR FUELING SYSTEMS
02/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 540	(1999; R 2004) Electrical Installations in Petroleum Processing Plants
API RP 1130	(2007; R 2017) Computational Pipeline Monitoring for Liquids
API RP 2003	(2015; 8th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE 1100	(2005) Emerald Book IEEE Recommended Practice for Powering and Grounding Electronic Equipment

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 77	(2014) Recommended Practice on Static Electricity

NFPA 407	(2022) Standard for Aircraft Fuel Servicing
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Leak Detection System; G

Electronic Monitoring/Alarm Panel

Computational Pipeline Monitoring System

SD-03 Product Data

Leak Detection System; G

Electronic Monitoring/Alarm Panel

Computational Pipeline Monitoring System

SD-06 Test Reports

Leak Detection System Test

SD-07 Certificates

Demonstrations

SD-08 Manufacturer's Instructions

Leak Detection System

SD-10 Operation and Maintenance Data

Leak Detection System; G

Electronic Monitoring/Alarm Panel; G

Computational Pipeline Monitoring System; G

1.3 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship, and that have been in satisfactory commercial or industrial use for a minimum 2 years prior to bid opening. Include applications of the equipment and materials under similar circumstances and of similar size. Materials and equipment must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours, exclusive of the manufacturer's factory tests, can be shown.

2.1.1 Nameplates

Attach nameplates to all specified equipment defined herein. List on each nameplate the manufacturer's name, address, contract number, acceptance date, component type or style, model or serial number, catalog number, capacity or size, and the system which is controlled. Construct plates of melamine plastic, 0.125 inch thick, UV resistance, black with white center core, matte finish surface and square corners . Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive. Provide nameplates with a minimum size of one by 2.5 inches. Provide normal block style lettering with a minimum 0.25 inch height. Accurately align all lettering on nameplates. Key the nameplates to a chart and schedule for each system. Frame charts and schedule under glass, and locate where directed near each system. Furnish two copies of each chart and schedule. Provide nameplate identifying its function.

2.1.2 Metallic Requirements

Do not construct internal parts and components of equipment, piping, piping components, and valves that could be exposed to fuel during system operation of zinc coated (galvanized) metal, brass, bronze, or other copper bearing alloys. Do not install cast iron bodied valves in piping systems that could be exposed to fuel during system operation.

2.2 ELECTRICAL WORK

Provide controllers, integral disconnects, contactors, controls, and control wiring with their respective pieces of equipment. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide switches and devices necessary for controlling and protecting electrical equipment. Provide controllers and contactors that have a maximum of 120-volt control circuits and that have auxiliary contacts for use with the controls provided.

2.2.1 Underground Wiring

Enclose underground electrical wiring in PVC coated conduit. Dielectrically isolate conduit at any steel storage tank connection.

2.2.2 Grounding and Bonding

Perform grounding and bonding in accordance with NFPA 70, NFPA 77, NFPA 407, NFPA 780, API RP 540, API RP 2003, IEEE 142, and IEEE 1100. Provide jumpers to overcome the insulating effects of gaskets, paints, or nonmetallic components.

2.3 LEAK DETECTION SYSTEM

Provide a system, including sensors and detectors, that is intrinsically safe for use in a Class 1, Division 1, Group D environment as defined by NFPA 70. Provide system compatible with the fuel to be handled. Furnish sensors that distinguish and report the difference between hydrocarbons and water. Provide electronic output and transmission from sensors and detectors. Provide sensors that have a minimum probability of detection of 95 percent and a maximum probability of false alarm of 5 percent. Provide sensors and detectors that are compatible with the electronic monitoring/alarm panel. Reuse sensors after an alarm condition is sensed. Submit shop drawings for the leak detection system that include the following.

a. Wiring schematics for all parts of the system showing each operating device and listing their normal ranges of operating values (including pressures, temperatures, voltages, currents, speeds, etc.).

b. Single line diagrams of the entire system, including any required alterations to the existing piping and tank(s).

c. Diagrams for posting that include distance markings such that alarm indications can be correlated to leak location in plan view. Include a piping and wiring display map with schematic diagrams from the leak detection system manufacturer. Frame diagrams under glass or laminated plastic and be posted where indicated by the Contracting Officer.

2.3.1 Underground Storage Tanks

Furnish system that continuously and automatically monitors the interstitial space of an underground tank for breaches in the integrity of the inner and/or outer tank shells. Monitor the interstitial space by using either an electronic capacitance type liquid sensor or a positive pressure system. Monitoring the interstitial space of a fiberglass reinforced plastic (FRP) tank may be performed using a liquid-filled interstitial space monitoring system. Freeze protect (brine) the liquid solution used in a liquid-filled interstitial and contain appropriate corrosion inhibitors. Detect and discriminate between high and low brine level conditions.

2.3.2 Aboveground Vaulted Storage Tanks

Furnish system that continuously and automatically monitors the interstitial space of a vaulted tank for breaches in the integrity of the primary tank and the exterior vaulted shell. Provide a manual access port that can be used to stick the interstice. In addition, provide either (1) a visual method that can automatically monitor the interstitial space such as a Pop-Up gauge, or (2) an electronic method such as an electronic capacitance type liquid sensor.

2.3.3 Underground Piping associated with tanks less than or equal to 50,000 gallons

Provide Leak Detection System associated with tanks less than or equal to 50,000 gallons that continuously and automatically monitors for piping leaks using an automatic line leak detector. Detect a minimum leak rate of 3 gallons per hour at 10 psig line pressure within 1 hour. Detect leaks against a minimum 6 feet of head pressure. Detect leaks from any portion of the underground product piping.

2.3.4 Containment Sumps

Provide Leak Detection System on sumps that continuously and automatically monitors each containment sump and dispenser sump with an electronic capacitance type liquid sensor. Furnish sensor that detects liquids within a minimum of 1 inch above a sump's bottom. The leak detection system must be capable of triggering shutdown of the submersible turbine pump or the dispenser pump.

2.3.5 Monitoring Wells

Continuously and automatically monitor each monitoring well with a hydrocarbon/groundwater vapor sensor. Hydrocarbon/groundwater sensor must distinguish the difference between hydrocarbons and water while totally immersed in groundwater. Sense when the groundwater level has reached a minimum definable setpoint. Provide vapor sensor to detect vapors of the fuel to be handled as well as sense the presence of liquid.

2.4 ELECTRONIC MONITORING/ALARM PANEL FOR PIPELINES ASSOCIATED WITH TANKS GREATER THAN 50,000 GALLONS

Perform continuous integrity checks on the status of each sensor's connections and wiring. Include a battery backup (rechargeable) that can operate the complete leak detection system during a power failure for a minimum period of 48 hours. Submit shop drawings of the panel layout along with panel mounting and support details. Provide panel that is compatible with and connected to the following:

a. Tank interstitial sensors and detectors.

b. Sump sensors and detectors.

c. Automatic line leak detectors.

d. Monitoring well sensors and detectors.

e. Digital tank gauge system as defined in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.4.1 Panel Housing

Provide panel housing that is a NEMA 4 rated enclosure in accordance with NEMA 250 . Provide panel housing consisting of a hinged door to swing left or right (doors must not swing up or down).

2.4.2 Panel Alarms

Account for the effects of thermal expansion or contraction of the fuel product, vapor pockets, tank or piping deformation, evaporation or condensation, as well as groundwater levels (if applicable) prior to initiating an alarm condition. Panel must produce an audible and visual alarm in the event any of the following occur.

a. Sensing of a hydrocarbon liquid from a sensor or detector.

b. Sensing of a hydrocarbon vapor from a sensor or detector.

c. Sensing of water from a sensor or detector.

d. Failure of an automatic line leak test.

e. Loss of pressure in positively pressurized tank interstitial.

f. Sensing a high or low liquid level in liquid-filled tank interstitial.

g. Sensing minimum groundwater setpoint.

h. Failure of any integrity check.

i. Sensing tank high, high-high, or low level alarm conditions.

2.4.2.1 Audible Alarm

Panel must have internal or external speakers that produce a buzzer sound of 70 decibels or greater in the event of a detected alarm condition. The audible alarm must be located in an area easily heard in the control room near the dispensers near the pumps in the event of an alarm condition.

2.4.2.2 Visual Alarm

Provide a visual alarm that illuminates in the event of a detected alarm condition. Include either individual lights for each alarm condition or include a single light and a liquid crystal display (LCD) panel that displaces information regarding each alarm condition. The visual alarm must be located in an area where it can be seen in the control room near the dispensers near the pumps when illuminated in the event of an alarm condition.

2.4.3 Acknowledge Switch

Provide panel with a manual acknowledge switch that will deactivate the audible alarm. Do not deactivate subsequent audible alarms unless depressed manually again for each occurrence. Do not extinguish the visual alarms until the alarm condition has been corrected. Switches must be an integral component located on the front panel and be either a key switch or push button.

2.5 COMPUTATIONAL PIPELINE MONITORING SYSTEM

Provide CPM system conforming to API RP 1130. Detect leaks as small as 0.004 percent of the pipeline volume within 1 hour. Account for thermal effects on the piping and fuel. System must be compatible with the fuel to be handled. Permanently mount system where indicated.Provide as a complete, portable system.

2.6 FINISHES

2.6.1 Factory Coating

Unless otherwise specified, provide equipment and components fabricated from ferrous metal with the manufacturer's standard factory finish. Each factory finish must be capable of withstanding 500 hours exposure to the salt spray test specified in ASTM B117. For test acceptance, the test specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark immediately after completion of the test. For equipment and component surfaces subject to temperatures above 120 degrees F, appropriately design the factory coating for the temperature service.

2.6.2 Field Painting

Field paint surfaces not otherwise specified as specified in Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURESSection 09 90 00 PAINTING, GENERAL. Do not paint stainless steel and aluminum surfaces. Do not coat equipment or components provided with a complete factory coating. Prior to any field painting, clean surfaces to remove dust, dirt, rust, oil, and grease.

PART 3 EXECUTION

3.1 INSTALLATION

Install parts requiring periodic inspection, operation, maintenance, and repair in locations that allow ready access. Install leak detection system and components in accordance with manufacturer's installation instructions.

3.1.1 Storage Tank Sensors/Detectors

Install interstitial tank sensors and detectors at the tank's low end. Install sensors in accordance with the tank manufacturer's recommendations and do not compromise the tank's secondary containment in any manner. Provide sensors that are easily removed from a tank. Connect metal conduit to steel tanks with dielectric fittings.

3.1.2 Automatic Line Leak Detector

Install detector on discharge side of each submersible pump in accordance with the pump and detector manufacturer's recommendations.

3.1.3 Sensors in Sumps

Install sensors in the low point of a sump in accordance with sump and sensor manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

3.2.1 Leak Detection System Test

Activate and test the entire leak detection system in accordance with manufacturer's testing procedures. Use the electronic monitoring/alarm panel to record and present the results.

3.2.2 Storage Tank Tightness Tests

For tanks less than or equal to 50,000 gallons, storage tank tightness tests must be performed in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS. Use the electronic monitoring/alarm panel to record and present the results.

For tanks greater than 50,000 gallons, storage tank tightness test must be performed with a system that is certified to be able to detect leaks at no more than 0.5 gallons per hour.

3.2.3 Tank Fill Tests

Perform high liquid level alarm tests on storage tanks in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS. Use the electronic monitoring/alarm panel to record and present the results.

3.3 DEMONSTRATIONS

Conduct a training session for designated Government personnel in the operation and maintenance procedures related to the equipment/systems specified herein. Include pertinent safety operational procedures in the session as well as physical demonstrations of the routine maintenance operations. Furnish instructors who are familiar with the installation/equipment/systems, both operational and practical theories, and associated routine maintenance procedures. The training session must consist of a total of 8 hours of normal working time and must start after the system is functionally completed, but prior to final system acceptance. Submit a letter, at least 14 working days prior to the proposed training date, scheduling a proposed date for conducting the onsite training.

-- End of Section --

SECTION 33 01 50.55

CLEANING OF PETROLEUM STORAGE TANKS
02/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 500	(2012; Errata 2014) Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division and Division 2
API RP 2003	(2015; 8th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API RP 2027	(2002; R 2012; 3rd Ed) Ignition Hazards Involved in Abrasive Blasting of Atmospheric Storage Tanks in Hydrocarbon Service
API RP 2207	(2017; 7th Ed) Preparing Tank Bottoms for Hot Work
API Std 521	(2014; 6th Ed) Pressure-relieving and Depressuring Systems
API Std 2015	(2018) Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.48	(2015) Line Blanks

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 306	(2019) Standard for the Control of Gas Hazards on Vessels

NFPA 326	(2015) Standard for Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

NIOSH 99-109	(Latest) Certified Equipment List

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-22262	(1993; Rev B; Am 1 1994; Am 2 1996; Notice 1 2021) Abrasive Blasting Media Ship Hull Blast Cleaning
MIL-PRF-680	(2010; Rev C; Notice 1 2015) Degreasing Solvent

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS O-D-1276	(Rev B; Notice 1) Disinfectant-Detergent, General Purpose (Pine Oil)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.120	Hazardous Waste Operations and Emergency Response
29 CFR 1910.134	Respiratory Protection
29 CFR 1910.146	Permit-required Confined Spaces
29 CFR 1910.1025	Lead
29 CFR 1910.1028	Benzene
29 CFR 1910.1200	Hazard Communication
29 CFR 1926.55	Gases, Vapors, Fumes, Dusts, and Mists
40 CFR 260	Hazardous Waste Management System: General
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities

UNDERWRITERS LABORATORIES (UL)

UL 844	(2012; Reprint Oct 2021) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Cleaning Agents

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1.3 DEFINITIONS

1.3.1 Certified Industrial Hygienist (CIH)

As used in this section, refers to an Industrial Hygienist employed by the Contractor and is certified by the American Board of Industrial Hygiene in comprehensive practice.

1.3.2 Marine Chemist

The holder of a valid Certificate issued by the National Fire Protection Association in accordance with the "Rules for Certification of Marine Chemists," establishing him as a person qualified to determine whether construction, alteration, repair, or shipbreaking of vessels, which may involve hazards covered by NFPA 306 can be undertaken with safety.

1.3.3 Hazardous Areas

Hazardous areas must be defined as any area within 100 feet of active aboveground storage tanks, areas within 100 feet of leaking sections of fuel pipelines or other vapor sources, areas within 200 feet of the downwind side of potential vapor emission sources (i.e., pressure-vacuum vents or open vents on active tanks, leaking sections of pipelines), areas within existing tanks, and areas within a dike.

1.3.4 Hot Work Operations

Hot work, for work covered by this section, includes: flame heating, welding, torch cutting, brazing, carbon arc gouging, or any work which produces heat, by any means, of 400 degrees F or more; or in the presence of flammables or flammable atmospheres, other ignition sources such as spark or arc producing tools (except steel hand tools) or equipment, static discharges, friction, impact, open flames or embers, nonexplosion-proof lights, fixtures, motors or equipment. Prepare tank bottoms for hot work in accordance with API RP 2207.

1.3.5 Personal Monitoring

Sampling of lead concentrations within the breathing zone of an employee to determine the 8-hour time weighted average concentration in accordance with 29 CFR 1910.1025. Samples must be representative of the employee's work tasks. Breathing zone must be considered an area within a hemisphere, forward of the shoulders, with a radius of 6 to 9 inches and the center at the nose or mouth of an employee.

1.3.6 Reproductive Hazard

A reproductive hazard is defined as any occupational stressor (biological, chemical, or physical) that has the potential to adversely affect the human reproductive process. For example, it is well known that central nervous system problems often occur in the offspring of mothers exposed to organic mercury during pregnancy. Therefore, based on the example cited, organic mercury can be classified as a reproductive stressor. Many reproductive hazards also cause other adverse health effects; for example, ethylene oxide is also known to be a carcinogen (i.e., produces cancer). Certain reproductive stressors can also have adverse effects on the male reproductive system. (If requested by the Contractor, the Contracting Officer will make available the Navy's standard on reproductive hazards.)

1.3.7 Flammable Liquid

Any liquid having a flash point below 100 degrees F and a vapor pressure not exceeding 40 psia at 100 degrees F.

1.3.8 Combustible Liquid

Any liquid having a flash point at or above 100 degrees F.

1.4 QUALIFICATIONS

a. To Be Considered Qualified: Show proof of having completed work on three previous projects.

b. See certificate requirements for personnel as specified in paragraph CERTIFICATES.

1.5 QUALITY ASSURANCE

1.5.1 Modification of References

Except as modified herein, the work must conform with the recommendations of NFPA 326, API RP 500, API RP 2003, and API Std 2015. Where the word "should" appears in these publications, substitute "must."

1.5.2 Copies of Standards

Furnish four copies of NFPA 326, API RP 500, API RP 2003, and API Std 2015.

1.5.3 Safety Permits and Equipment

Acquire safety permits (specified by the facility safety authorities) and necessary safety equipment.

1.5.4 Regulatory Requirements

a. Obtain permits required to comply with local, State, and Federal regulations.

b. Submit copies of permits required to comply with local, State, and Federal regulations.

c. Hazardous wastes, such as water, sediment, and sludge, must be packaged, labeled, stored, transported, treated and disposed of in accordance with 40 CFR 260 through 40 CFR 266 and State and local regulations. Transporters, sorters, treaters and disposers must be certified and have EPA ID numbers. Payment for disposal of hazardous waste will not be made until a completed hazardous waste manifest from the treatment or disposal facility is returned, and a copy furnished to the Government.

1.5.5 Medical Examinations

Before exposure to lead-contaminated fuel tank and at the completion of the work, provide workers with a comprehensive medical examination as required by 29 CFR 1910.1025 and 29 CFR 1910.1200. The initial examination will not be required if adequate records show that employees have been examined as required by 29 CFR 1910.1025 within the last year and the blood lead levels did not exceed 30 micrograms per 100 grams of whole blood.

1.5.6 Medical Records

Maintain complete and accurate medical records of employees for a period of at least 40-years or for the duration of employment plus 20-years, whichever is longer.

1.5.7 CIH Responsibilities

a. Certify training.

b. Review and approve safety plans and work plan for conformance to the applicable referenced standards.

c. Inspect tank cleaning work for conformance with the approved safety and work plans.

d. Direct monitoring.

e. Ensure work is performed in strict accordance with specifications at all times.

f. Ensure hazardous exposure to personnel and to the environment are adequately controlled at all times.

1.5.8 Training

Train each employee performing tank cleaning, waste disposal, and air sampling operations prior to the time of initial job assignment, in accordance with API Std 2015, 29 CFR 1910.120, 29 CFR 1910.134, 29 CFR 1910.1025, and 29 CFR 1910.1200. The training must also include counseling of each employee on reproductive hazards involved in the work.

1.5.9 Respiratory Protection Program

a. Furnish each employee required to wear a negative pressure respirator or other appropriate type with a respirator fit test at the time of initial fitting and at least every 6 months thereafter as required by 29 CFR 1910.1025 where lead exposure is involved. Fit testing is not required for positive pressure respirators.

b. Establish and implement a respiratory protection program as required by 29 CFR 1910.134, and 29 CFR 1926.55. Also comply with 29 CFR 1910.1025 when exposure to lead is involved.

1.5.10 Pre-Construction Conference

Along with the CIH, marine chemist, or gas-free engineer, meet with the Contracting Officer to discuss in detail the tank cleaning work plan, including work procedures and precautions for the work plan.

1.5.11 Certificates

Submit certificates for the items listed. Where equipment or materials are specified to conform with the standards of organizations, such as National Institute for Occupational Safety and Health (NIOSH), Underwriters Laboratories (UL), and American Petroleum Institute (API), include a label or listing indicating compliance. In lieu of the label or listing, the Contractor may submit a test report from an approved testing organization stating that the item has been tested in accordance with the specified organization's test methods and that the item conforms with the organization's standard or code.

1.5.11.1 Qualifications of Marine Chemist

Submit name, address, and telephone number of the marine chemist selected to perform the required duties. Submit documentation that the marine chemist is certified by the National Fire Protection Association, including the certificate number and date of certification or recertification. The NFPA certification will be acceptable for non-ship work on this contract. Refer to NFPA 306 to determine when a marine chemist is required, how a marine certificate is issued and maintained, and what to expect during an inspection.

1.5.11.2 Qualifications of Certified Industrial Hygienist (CIH)

Submit name, address, and telephone number of the CIH selected to perform responsibilities in paragraph CIH RESPONSIBILITIES. Provide previous experience of the CIH. Submit proper documentation that the Industrial Hygienist is certified by the American Board of Industrial Hygiene in comprehensive practice, including certification number and date of certification/recertification. The CIH must be familiar with the hazards involved in fuel systems work.

1.5.11.3 Testing Laboratory

Submit the name, address, and telephone number of the testing laboratory selected to perform the monitoring, testing, and reporting of airborne concentrations of lead and other contaminants. Provide proper documentation that persons performing the analysis have been judged proficient by successful participation within the last year in the National Institute for Occupational Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program. The laboratory must be accredited by the American Industrial Hygiene Association (AIHA). Provide AIHA documentation along with date of accreditation/reaccreditation.

1.5.11.4 Safety Plan

Submit a safety plan within 45 calendar days after contract award and 30-days prior to commencing work. The safety program must be reviewed and approved by the safety/health officer of the facility. The safety plan must meet requirements of EM 385-1-1, OSHA, and address the following:

a. Identification and evaluation of the hazards and risks associated with each site being studied, including reproductive hazards and precautionary measures to be followed by workers for all hazards.

b. Names and qualifications of each Contractor's representative in charge of the work and present at the job site when tank cleaning and repair work will be performed.

c. Identification of supervisory personnel and alternates responsible for site safety/response operations.

d. Determination of levels of personal protection to be worn for various site operations.

e. List of equipment with adequate nomenclature by item, that will be used at the job site and the date and location where this equipment can be inspected by the Contracting Officer.

f. Establishment of work zones (exclusion area, contamination area, and support area).

g. Establishment of a tank entry and work permit program in accordance with 29 CFR 1910.146, EM 385-1-1, and NFPA 326.

h. Establishment of decontamination methods and procedures.

i. Determination of the number of people required to enter the contamination zones during the initial entries and subsequent operations.

j. Establishment of emergency procedures, such as: escape routes, fire protection, signals for withdrawing work parties from site, emergency communications, wind indicators, including Navy notification.

k. Identification and arrangements with nearest medical facility for emergency medical care for both routine-type injuries and toxicological problems. Submit name, location, and telephone number of this medical facility.

l. Establishment of continual air and personnel monitoring procedures.

m. Establishment of procedures for obtaining and handling potentially contaminated samples.

n. Identification of medical monitoring program, including respirator medical qualification examination for each individual at the work site.

o. Identification of training plan to be instituted, including contents of 29 CFR 1910.1200 and 29 CFR 1910.134; its training contents; and instructor with appropriate training certification. Training plan must also include counseling to each employee on reproductive hazards.

p. Establishment of a respiratory protection program conforming to 29 CFR 1910.134.

q. Establishment of a hazard communication program (29 CFR 1910.1200).

1.5.11.5 Work Plan

The shut down or interruption to normal operations or traffic must be listed on the progress schedule and submitted to the Contracting Officer.

1.5.11.6 Hazardous Waste Disposal Plan

Prepare a Hazardous Waste Disposal Plan and submit within 45 calendar days after contract award for approval by the Contracting Officer, or if there are no hazardous wastes indicated by Government tests, submit the plan 21 days after the Contractor's tests indicate hazardous wastes. The Hazardous Waste Disposal Plan must comply with applicable requirements of Federal, State, and local hazardous waste regulations and must address the following:

a. Identification of hazardous wastes associated with the work, including a sampling and testing plan for each waste stream, the purpose of each test, and the rationale for evaluating the test results. Indicate the representative sampling and specific testing methods, number of samples, and the name and qualifications of the testing laboratory.

b. Estimated quantities of wastes to be disposed in the cleaning of each tank and a description of arrangements made for storage and disposal.

c. Names and qualifications of each Contractor that will be transporting, storing, treating, and disposing of the wastes. Include the facility location and a 24-hour point of contact. Furnish two copies of EPA State and local hazardous waste permit applications permits and EPA Identification numbers.

d. Names and qualifications (experience and training) of personnel who will be working on-site with hazardous wastes.

e. List of waste handling equipment to be used in performing the work, to include cleaning, treatment, volume reduction, and transport equipment.

f. Spill prevention, containment, and cleanup contingency measures to be implemented.

g. Work plan and schedule for waste removal and disposal.

h. Cost for hazardous waste disposal according to this plan.

1.5.11.7 Tank Certification of Safety

Submit certification, in accordance with NFPA 326, from a CIH stating that tank is safe for hot work and that special precautionary measures have been taken for workers to enter the tank to perform the work.

1.5.11.8 Training Certification

Submit certifications signed and dated by the CIH specified in the testing plan and by each employee stating that the employee has received training on work practices and received counseling on and fully understands the reproductive hazards involved with lead and toluene exposure and the work.

1.5.11.9 Hazardous Waste Permits

Submit copies of EPA State and local hazardous waste permit applications permits and EPA Identification numbers of the transporter, treatment, storage and disposal facility that will be accepting hazardous waste. Include the facility location and a 24-hour point of contact.

1.5.11.10 Non-Hazardous Waste Permits

Submit EPA State local permits for disposal site for non-hazardous residues and wastes.

1.5.12 Test Results

1.5.12.1 Required Test Reports

Submit test results required by MIL-A-22262, for blasting abrasive. Submit contractor's independent tests of tank contents (water, sediment, and sludge). Submit tank cleaning test panel results, including water pressure and temperature and nozzle distances used during tank washing procedure.

1.5.12.2 Air Monitoring

Submit monitoring results to the Contracting Officer within 2 working days after the samples are taken, signed by the testing laboratory employee performing the air monitoring, the employee that analyzed the sample, and the CIH.

1.6 DELIVERY AND STORAGE

Deliver equipment and materials to the site in an undamaged condition bearing the manufacturer's name and brand designation. Store equipment and materials off the ground to provide proper ventilation, drainage, and protection against dampness. Replace defective and damaged equipment and materials.

1.7 JOB CONDITIONS

1.7.1 Ventilation

Maintain a vapor-free condition throughout the course of the work inside the tank. The air movers must be non-sparking, explosion-proof, electrically operated or air-driven exhaust type. A rate of one air change per hour must be the lowest acceptable rate, for tanks under 30,000 BBL. For tanks greater than 30,000 BBL, use 10,000 cfm. Air movers must be kept in operation whenever workers are in the tanks; except the air movers must be shut down 15 minutes before taking tests.

1.8 SCHEDULING AND SEQUENCING

1.8.1 Sequence of Primary Phases of the Cleaning Procedure

a. Planning the operations

b. Preparation for cleaning

c. Vapor-freeing of the tank

d. Cleaning the tank

e. Clean-up, residue disposal, inspection, and acceptance.

1.8.2 General Scheduling

Complete the work specified in this section before any other work in the tank is started. The work includes the complete interior cleaning of the storage tanks.

PART 2 PRODUCTS

2.1 MATERIALS

Submit identification for the items by designated name, specification number, project contracting number, and intended use. Submit Safety Data Sheets for materials to be used at the job site, in accordance with 29 CFR 1910.1200.

2.1.1 Cleaning Agents

a. Detergent: FS O-D-1276.

b. Solvent: MIL-PRF-680, Type II, minimum flashpoint of 140 degrees F.

c. Approved commercial cleaning agent.

2.1.2 Abrasive

2.1.2.1 Abrasive for Blasting

Provide sharp, washed, salt-free , angular abrasive material, free from feldspar and other constituents that tend to break down and remain on the surface. Abrasive must not contain magnetic materials and must conform to MIL-A-22262, except that Mohs' hardness must be 7 to 9 .

2.1.2.2 Recycled Abrasive

Screen and air wash abrasive that is recycled at the job site, to remove dirt and fines. Add new abrasive so that the combined new and recycled abrasive mixture meets specified abrasive requirements for chemical composition, moisture, friability, silica, anchor pattern and oil content. Do not recycle abrasive which has picked up toxic or hazardous material. Do not recycle nickel slag.

2.2 EQUIPMENT

Furnish necessary clothing and equipment for the work and protection of people entering the tank. Electrical equipment and wiring must be in accordance with NFPA 70, Class 1, Group D, Division 1. Provide any item or items for the protection of these people including but not limited to the following:

a. Gasoline-Oil-Resisting Rubber Gloves and Boots: Gauntlet type and conductive type respectively (acid-proof rubber is an acceptable material); furnished for each person entering or working inside the tank or handling sludge materials on the exterior of the tank, plus one extra pair each for emergency use.

b. Cotton Coveralls and Hard Hat: Light colored; one change per person per day, and an adequate supply of chemical-resistant disposable coveralls to be worn over cotton coveralls.

c. Respiratory Protection: Provide one of the following types of NIOSH-approved respiratory protective equipment for each person working inside the tank, plus one extra for emergency use. NIOSH 99-109 listing constitutes NIOSH approval.

   (1) Self-contained breathing apparatus with a full facepiece operated in a positive pressure mode.

   (2) A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in a positive pressure mode and an auxiliary positive pressure self-contained breathing apparatus. Provide and use two-way communication equipment when cleaning underground tanks larger than 50,000 gallons capacity or where manhole accesses are deeper than 10 feet from the working level.

   (3) The CIH may specify airline (Type C) respirator in place of those specified above; however, the decision must be based on the results of personal monitoring.

   (4) Use Type CE respirator for abrasive blasting inside the tank.

   (5) CIH must specify respiratory protection if required for personnel handling sludge material outside of the tank.

d. Safety Harness: For each person working inside tank, plus one extra for outside the tank.

e. 1/2-inch Diameter Life Rope of Required Length: For each person working inside the tank.

f. Breathing-Air Supply Source: 29 CFR 1910.134.

g. Combustible Gas Indicator ,Lead-in-Air Analyzer , Hydrogen-Sulfide (H_2S) Indicator , Benzene Indicator and Oxygen Meter. Recommend a portable gas chromatograph or other more accurate instrument for the benzene indicator.

h. Shovels, Buckets, Brooms, Wrenches, Scrapers, Squeegees, Wire Brushes, Scrub-Brushes, Ladders, Staging, and Other Tools: Do not use brooms or brushes that have plastic or synthetic bristles.

i. Lighting: UL 844, explosion-proof, minimum 50 footcandle, floodlight type, or Mining Enforcement and Safety Administration (MESA) approved, explosion-proof, portable battery-powered light.

j. Air Movers for Tank Ventilation: Explosion proof electrically operated or air driven. Nonferrous fan blades. Use velometers for measuring velocity.

k. Disinfectant for Cleaning Face Masks: Cleaner-sanitizer for cleaning and disinfecting respirator facepieces as specified in 29 CFR 1910.134, Appendix B-2.

l. Soap for Personnel Washing: Non-phosphate type.

m. A.B.C. Fire Extinguishers: UL listed 2A: 40B: C, 2A: 20B: C, or 4A: 30B: C; minimum 15 pound capacity.

n. First Aid Kit: One 16-unit kit for each 25 persons.

PART 3 EXECUTION

3.1 PREPARATION FOR ENTRY

Prepare the tank for entry in accordance with NFPA 326. Isolate from sources of energy. Ensure vapors have been controlled or removed. Identify potential hazards and apply control measures to mitigate the hazards. Test and monitor atmospheric conditions to ensure conditions of the Marine Chemist Certificate safety designations have been met.

3.1.1 Isolation From Piping

For tank cleaning prior to out-of-service inspection and minor cold repairs, close the double block and bleed isolation valves and remove the body cavity plugs from the valves. Monitor the body cavity for fuel and maintain the valves in this condition for the duration of the cleaning, inspection, or minor cold repairs, not to exceed one month. Secure the valves in the closed position with mechanical means. Perform lockout tagout procedures on the valves.

For ordinary cleaning prior to out-of-service inspection and hot work or when nozzles are not equipped with double block and bleed valves, or for outages lasting longer than one month, disconnect piping connected to the tank. Provide a solid-plate line blank between two flanges near the tank in accordance with ASME B16.48, or remove a valve or piece of pipe and provide a blind flange compliant with ASME B16.5 to isolate tank. For underground tanks where connected pipelines are buried, blind off the pipelines at the nearest valve box. Isolation means must be of sufficient strength to withstand pressure which might be exerted by the product being blanked off, and must be gasketed on both sides if blind flange is inserted between two flanges. Do not disconnect piping or valves until it is certain the line has been defueled.

Isolate all piping connected to the tank. Perform lockout tagout procedures on any valve remaining connected to the tank.

3.1.1.1 Thermal Relief

Evaluate thermal relief capability on active facility piping isolated from the tank. Should isolation means result in a segment of active piping unprotected from thermal overpressure, provide temporary means consistent with API Std 521 to relieve the overpressure. Consult with operators to determine existing relief pressures and set temporary relief means to ensure overpressure does not occur.

3.1.2 Lockout Tagout

Perform lockout tagout on all electrical circuits and sources of energy to the tank in accordance with EM 385-1-1 and NFPA 326.

3.1.3 Removal of Ignition Sources

Remove sources of ignition from the cleaning area. Do not permit ignition producing devices, including matches, lighters or cigarettes, within 100 feet upwind and 200 feet downwind of a tank, or inside the tank farm, or within the tank firewall, whichever is farther.

3.1.4 Survey of Hazardous Areas

Carefully survey the entire area around the tank to be cleaned to ensure that there are no vapors present in the pit, low places, or hazardous areas and that all unauthorized personnel are cleared from the area. Ensure that there is no possibility of anyone smoking in the immediate vicinity. Hazardous areas are defined as follows:

a. Interior of tanks.

b. Areas within 100 feet from points having flammable vapor emissions which, for example, are from the exhaust manholes of tanks under repair, open vents or pressure vacuum vents (breather valves) of active tanks in the vicinity of tanks under repairs or cleaning. CAUTION: Allowance must be made for 4 or more miles per hour winds by increasing the size of the hazardous area to a minimum of 200 feet on the downward side.

c. For aboveground tanks, all areas within a common impoundment dike up to the height of the dike walls and within 10 feet in all directions of the exterior surfaces of tank shell and roof.

3.2 PROJECT CONDITIONS

3.2.1 Cutting Tank Access Holes

Tanks in this project may not have manholes.

3.2.2 Permission for Each Entry Into a Tank

Obtain written permission from the Contracting Officer prior to each entry into a tank. Permission will be granted only under the following conditions:

a. The Contractor's qualified supervisor is present.

b. The Contractor's personnel have been briefed by the supervisor on the procedure and role of each employee in the event of an emergency.

c. Required equipment is approved and properly located.

d. Personnel are properly equipped with properly fitted protective equipment and have received adequate training from a qualified instructor.

e. The entire area adjacent to the tank is secured.

f. A minimum of two persons outside and two or more persons inside of each tank are provided at all times during cleaning operations.

g. Tank air is monitored and corrective action is taken to ensure that the vapor concentration is less than 10 percent of the lower flammable limit (LFL) , lead-in-air is less than 50 micrograms per cubic meter , hydrogen sulfide is less than 10 ppm permissible exposure level (PEL) , benzene is less than one ppm PEL and oxygen content is a minimum of 19.5 percent.

h. An NFPA certified "Marine Chemist" or CIH has certified that the tank is safe for hot work, and that the required special precautionary measures have been taken due to the potential health hazard to the worker that still exists, even when the vapor concentration is well below the LFL. The Contractor must be responsible for reviewing the record drawing(s) of the tank to be cleaned.

i. People entering the area leave smoking materials such as cigarettes and flame-producing devices at a previously determined location.

j. When work involves handling and disposal of hazardous waste, the Contractor has a copy of 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266 in his possession.

k. Permit only personnel authorized in the safety plan within 100 feet of the tank perimeter.

3.2.3 Traffic Control

Direct traffic minimum 200 feet away from the tank cleaning area. Set up road blocks and warning signs. Do not operate vehicles in hazardous areas.

3.2.4 Lavatory Facilities

Arrange for lavatory and toilet facilities and, in the case of tanks for leaded fuel, provide showers for bathing.

3.2.5 Miscellaneous

Ensure that the manufacturers have labeled containers holding products involving hazards in use or storage, in accordance with 29 CFR 1910.1200. Label containers used to store, transport, or dispose of hazardous waste in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266 and State Regulations. Remove small objects of ferrous metal within the working areas to prevent the accidental striking of a spark. Place equipment upwind of tank openings at highest elevation possible; do not place in a spot lower than the surrounding terrain. Review drawings of the tank to be cleaned and brief workers on the location of pits, sumps, piping, or other tank appurtenances which could be hazardous to personnel. Provide floodlights to illuminate the work area without the need for battery operated handlights. Provide scaffolding, platforms, and ladders for secure, safe accessibility to tank surfaces. Install electrical equipment in accordance with API RP 500. Provide floodlights to illuminate the work area without the need for battery operated handlights. Do not use artificial lights inside tank until the tank is vapor-free. Unless otherwise approved by the Contracting Officer, do not heat tanks during winter to provide personnel comfort or melt ice.

3.2.5.1 Grounding and Bonding for Equipment

Provide grounding and bonding for equipment which may generate static electricity , including air hose to sandblast nozzle. Do not pass the air hose through an area where flammable vapors may exist.

3.2.5.2 Fire Extinguishers

Furnish two carbon-dioxide fire extinguishers of minimum 15 pounds capacity each, in the immediate vicinity of the work. Provide a continuous fire watch. CAUTION: Do not discharge high pressure carbon dioxide extinguishers where explosive vapors exist since the discharge can cause a spark which will ignite the vapors.

3.2.5.3 Disconnection of Pipelines

For normal tank cleaning prior to out-of-service (internal) inspection and minor cold repairs, close the double block and bleed valves on the tank nozzles connected to piping and remove the body cavity plugs from the bottoms of the valves and bleed the valves for the duration of the cleaning, inspection or minor cold repairs. Perform lock-out/tag-out procedures on the valves.

For cleaning prior to hot work or when nozzles are not equipped with double block and bleed valves, or for extended outages lasting longer than one month, disconnect pipelines connected to the tank. Provide a solid-plate blind flange between two flanges near the tank, or remove a valve or piece of pipe and provide a blind flange to prevent flammable material from entering the tank. For underground tanks where connected pipelines are buried, blind off the pipelines at the nearest valve box. Blind flanges must be of sufficient strength to withstand pressure which might be exerted by the material being blanked off, and must be gasketed on both sides if blind flange is inserted between two flanges. CAUTION: Do not disconnect piping or valves until it is certain the line has been emptied of fuel.

3.2.5.4 Removal of Ignition Sources

Remove sources of ignition from the cleaning area. Do not permit ignition producing devices, including matches, lighters or cigarettes, within 100 feet upwind and 200 feet downwind of a tank, or inside the tank farm, or within the tank firewall, whichever is farther.

3.2.5.5 Survey of Hazardous Areas

Carefully survey the entire area around the tank to be cleaned to ensure that there are no vapors present in the pit, low places, or hazardous areas and that all unauthorized personnel are cleared from the area. Ensure that there is no possibility of anyone smoking in the immediate vicinity. Hazardous areas are defined as follows:

a. Interior of tanks.

b. Areas within 100 feet from points having flammable vapor emissions which, for example, are from the exhaust manholes of tanks under repair, open vents or pressure vacuum vents (breather valves) of active tanks in the vicinity of tanks under repairs or cleaning. CAUTION: Allowance must be made for 4 or more miles per hour winds by increasing the size of the hazardous area to a minimum of 200 feet on the downwind side.

c. For aboveground tanks, all areas within a common impoundment dike up to the height of the dike walls and within 10 feet in all directions of the exterior surfaces of tank shell and roof.

3.2.5.6 Exit from a Tank During Emergencies

To permit quick, free exit from a tank during emergencies, keep the area around the tank openings and emergency routes clear of obstructions.

3.3 INSPECTION

3.3.1 Inspection of Equipment

3.3.1.1 Respirators

Respirator users must inspect their respirators in strict accordance with the instructions provided by the manufacturer.

3.3.1.2 Air Hose from Breathing-Air Supply

If air line respirators are used, ensure that:

a. There are no breaks in outside covering;

b. Condition of gaskets is good;

c. Connections are tight; and

d. There are no restrictions in the hose.

3.3.1.3 Safety Harness and Life Line

Ensure that:

a. There is no frayed or weak material; and

b. Condition of harness is good.

3.3.1.4 Breathing-Air Supply Source

Ensure:

a. Good working condition;

b. Location in vapor-free area;

c. Compliance with 29 CFR 1910.134 for breathing air quality, frequency of air analysis, and presence of safety devices; and

d. Backup air supply source.

3.3.1.5 Monitoring Equipment

Calibrate each day before use:

a. Combustible gas indicator

b. Oxygen meter

c. H2S Indicator

d. Lead-in-Air Analyzer

3.3.1.6 Other Equipment

Ensure:

a. Proper grounding and bonding;

b. Explosion-proof motors; and

c. Explosion-proof lighting.

3.3.2 Personnel Inspection

3.3.2.1 Clothing

Personnel for Proper Attire Commensurate with Hazards Involved: Check for:

a. Clean clothing in good condition (wear freshly laundered clothing at the beginning of the job and at the start of each workday thereafter).

b. Boots and gloves of approved type and in good condition.

3.3.2.2 Breathing-Air Supply

If air line respirators are used, ensure that air is supplied to the facepiece at a rate of 4 to 15 cfm. If self-contained breathing apparatus are used, ensure sufficient number of full replacement cylinders are available to last the duration of the job.

3.3.2.3 Harness and Lifeline

Harness and lifeline must be in good condition and properly attached.

3.3.2.4 Gum or Tobacco Chewing

Ensure that gum or tobacco chewing is prohibited.

3.3.2.5 Physical Defects or Injuries

Ensure that people have no physical defects or injuries which may prevent their wearing respirators or which may cause rescue to be difficult. No beards, sideburns, or large mustaches will be allowed on people who must wear respirators.

3.3.2.6 Alcoholic Beverages and Drugs

Ensure that people entering the tank are not under the influence of alcoholic beverages and drugs.

3.3.2.7 Counseling on Reproductive Hazards

Ensure that all employees have been counseled on and fully understand the reproductive hazards related to work in contaminated areas or in leaded gasoline or chemically contaminated tanks since they may be seriously affected by organic lead compounds or other chemical contaminants.

3.3.2.8 Hazardous Areas

Check hazardous areas as defined in paragraph SURVEY OF HAZARDOUS AREAS.

3.4 TABLE OF TANK HISTORY

Tank Number	Tank Location	Tank Capacity	Date Constructed	Type of Lining (If Applicable)	Type of Fuel	Remarks from the Last Inspection

3.5 FUEL REMOVAL

All possible fuel will be pumped or otherwise removed from the tank by the Government. Consider remaining fuel contaminated or waste fuel; pump into 55 gallon drums or other suitable containers for disposal in accordance with approved procedures meeting local, State, and Federal regulations provide oil/water separators for further recovery of fuels and turn over to the Government for use. Dispose of remaining fuel emulsions in accordance with applicable local, State, and Federal regulations. Drums or tanks used for containerizing waste fuel will be furnished by the Contractor . Oil/water separator for fuel separation will be furnished by the Contractor .

3.6 IDENTIFICATION OF TANKS WITH HAZARDOUS WASTE SLUDGES AND RESIDUES

The following tank is or tanks are known or suspected to contain hazardous wastes:

Tank No.	Product	Hazardous Waste, Status, Type and Basis-known or suspect
1	MOGAS	Sludge and sandblast residue; ignitability and lead

3.7 TANK CLEANING

For the interior of tanks with floating roofs, the bottom and up the shell to the height of the floating roof or must be cleaned not to bare metal but only to the surface of sound lining or coating, free of rust, dirt, scale, loose material, fuel, oil, grease, sludge, and other deleterious substances. Do not damage sound existing lining material. Remove unsound or loose lining or coating, and clean surfaces which became exposed to bare substrate. Immediately notify the Contracting Officer if lining or coating is deteriorated or loose. For tanks with floating roofs, provide general cleaning of the top of the roof by means such as sweeping or vacuuming.

3.7.1 Monitoring

Monitoring of airborne concentrations of lead must be in accordance with 29 CFR 1910.1025 of benzene in accordance with 29 CFR 1910.1028, and as specified herein. Air monitoring, testing, and reporting must be performed by a CIH or an Industrial Hygiene (IH) Technician who is under the direction of the CIH.

a. The CIH or the IH Technician under the direction of the CIH must be on the jobsite directing the monitoring, and inspecting the work to ensure that the requirements of the Contract have been satisfied during the entire operation.

b. Take personal air monitoring samples on employees who are anticipated to have the greatest risk of exposure as determined by the CIH. In addition, take air monitoring samples on at least 25 percent of the work crew or a minimum of two employees, whichever is greater, during each work shift.

c. Submit results of air monitoring samples, signed by the CIH, within 2 working days after the air samples are taken. Notify the Contracting Officer immediately of exposure to lead at or in excess of the action level of 30 micrograms per cubic meter of air outside of the lead control area, and 0.5 ppm for benzene.

3.7.1.1 Monitoring During Tank Cleaning Work

Perform personal and area monitoring during the entire tank cleaning operation. Sufficient area monitoring must be conducted at the physical boundary to ensure unprotected personnel are not exposed above 30 micrograms per cubic meter of air for lead and 0.5 ppm for benzene at all times. If the outside boundary lead levels are at or exceed 30 micrograms per cubic meter of air or the benzene levels are at or exceed 0.5 ppm, work must be stopped and the CIH must immediately correct the condition(s) causing the increased levels and notify the Contracting Officer immediately. The CIH must review the sampling data collected on that day to determine if condition(s) requires any further change in work methods. Tank cleaning work must resume when approval is given by the CIH. The Contractor must control the lead level outside of the work boundary to less than 30 micrograms per cubic meter of air and the benzene levels to less than 0.5 ppm at all times. As a minimum, conduct area monitoring daily on each shift in which tank cleaning operations are performed in areas immediately adjacent to the control area. For outdoor operations, at least one sample on each shift must be taken on the downwind side of the control area. If adjacent areas are contaminated, clean and visually inspect contaminated areas. The CIH must certify that the area has been cleaned of contamination.

3.7.2 Lead Hazard Personnel Safety

Due to the lead hazard (inorganic and organic (TEL)) associated with this tank, comply with API Std 2015, and the applicable rules and regulations of the State of Georgia and Federal Occupational Safety and Health Standards. If there is conflict among the API Publications, State, and Federal regulations; the most stringent criteria must apply. Ensure that the requirements for protective clothing and equipment, monitoring to determine exposure levels, and all other relevant controls are complied with. Ensure that employees are counseled on the reproductive hazards associated with lead.

3.7.3 Precautions for Airborne Lead

Since the tank is a known lead hazard, the Contractor must, in accordance with API Std 2015, ensure that the workers inside the tank wear the appropriate protective clothing and respiratory equipment as prescribed by API Std 2015 for the duration of the tank cleaning. Use only the types of respirators specified for "Respiratory Protection" under paragraph EQUIPMENT. After completion of the cleaning operation, the Contractor has the option of allowing people to enter the tank without respiratory protective equipment, only after lead-in-air analysis has been obtained in accordance with API Std 2015.

3.7.4 Water, Sediment, and Sludge Analysis

The water, sediment, and sludge remaining in the tank contain the following quantities of leachable metals as analyzed by the Government in accordance with 40 CFR 261.

a. Water:

b. Sediment:

c. Sludge:

The Government analysis indicates that the water, sediment, and sludge are nonhazardous or hazardous. The Contractor will be responsible for independently testing the water, sediment, and sludge in accordance with 40 CFR 261 to verify the above. Submit laboratory reports to the Contracting Officer describing sampling and testing procedures used, test results, and findings. If the results differ such that the Contractor must handle the waste differently from the method specified, notify the Contracting Officer, and the Contractor will be subject to an equitable adjustment to the Contract under the Changes clause of the Contract Clauses. If the Contractor's tests determine that the water, sediment, and sludge are hazardous, then the hazardous wastes must be packaged, labeled, stored, transported, treated and disposed of in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266. Transporters, storers, treaters and disposers must be certified and have EPA ID numbers. Payment for disposal of hazardous waste will not be made until a completed hazardous waste manifest from the treatment or disposal facility is returned, and a copy furnished to the Government. Nonhazardous or hazardous wastes must be handled and disposed of as described below.

3.7.5 Water Removal and Disposal

Pump or otherwise remove water from the tank. Ensure that the sludge and sediment are not pumped out or mixed with the water. All hazardous water that must be packaged, labeled, stored, transported, treated, and disposed of in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266.

3.7.6 Sludge and Sediment Removal and Disposal

Squeegee or brush any sludge, sediment, or other loose material into piles, shovel into buckets or other suitable containers, and remove from the tank.

3.7.6.1 Sludge Disposal Using Landfill or Berm

Spread nonhazardous sludge as uniformly as possible over the area in a maximum 3-inch thick layer for weathering in the berm area. Fence the area temporarily and mark with a wood or metal sign. When the ambient temperatures are above 32 degrees F, the weathering period must be a minimum of 4 weeks. For colder temperatures, the weathering period must be extended by the number of days the temperature falls below 32 degrees F. After the required time elapses, remove the signs and fences.

Removal of Sludge

Hazardous sediment and sludge in the tank that must be disposed of by the Contractor. Package, label, store, transport, treat, and dispose of hazardous sludge and sediment in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266.

3.7.7 Washing

After water, fuel, and sludge have been removed, thoroughly wash the tank interior. Contractor must limit the water pressure during washing so that it does not cause damage to the existing coating. Contractor must clean a representative test panel with their planned washing procedure. Test panel access must be provided to and examined by the Contracting Officer to determine whether coating damage is occurring as a result as a result of the Contractor's washing procedure. Contractor must modify water temperature and pressures based on cleaning test panel results. Maximum allowable pressure on coated surfaces must be 200 psig and maximum allowable temperature of wash water must be 135 degrees F . Prior to cleaning the tank, tests must be conducted to determine the minimum distance of the nozzle to the steel to prevent damage to the tank coating. Perform Quality Control to inspect the cleaning during the process to ensure the coating is not being removed. Minimize the use of water; substitute brush blasting when practical. Start washing at the top of the walls and columns and work down to the floor. Wash the floor last starting from the sides and working towards the sump. Wash to remove oil, sludge, wax, tar, and other fuel residue adhering to the surface. Wash by any one or a combination of the following methods:

a. Use only fresh water under pressure.

a. Apply a detergent conforming to FS O-D-1276 by spray or brush and soak approximately 30 minutes.

a. Apply a detergent cleaning solution by spray or brush and allow to soak approximately 30 minutes. The cleaning solution must be either a one-to-one ratio of detergent conforming to FS O-D-1276 and solvent conforming to MIL-PRF-680 or an equivalent commercial cleaning agent as approved by the Contracting Officer.

b. Hand-scrub the surfaces vigorously with long-handled stiff-bristle brushes. Wet the brushes intermittently with fresh cleaning agent during scrubbing process. For heavily oil-soaked areas which still appear to retain some residue after first scrubbing, scrub until clean.

c. Rinse the surfaces thoroughly with fresh water.

d. Brush-off blast clean.

3.7.8 Wash Water, Detergent Solution, and Sediment Removal

During the washing process, operate a portable pump continuously with suction hose extended to the tank bottom to remove water, detergent, dirt, oil, or other loose materials washed off. Following the final rinse, pump, squeegee, and mop the tank dry.

a. Prior to discharge or disposal, test the wash water, sediment, and sludge in accordance with paragraph WATER, SEDIMENT, AND SLUDGE ANALYSIS. The Contractor must furnish temporary tanks to hold water and detergent solution until testing is completed.

b. When the wash water is nonhazardous and can be disposed of in the berm area. If the wash water is hazardous it must be handled in accordance with paragraph WATER, SEDIMENT, AND SLUDGE ANALYSIS.

TABLE 2. WASTE WATER DISCHARGE LIMITS TO SEWERS

Item	Limits
(1) pH	5.5-9.5
(2) Oil and Grease (Hydrocarbon)	50 mg/l Max.
(3) Surfactant (MBAS)	30 mg/l Max.
(4) Lead	0.6 mg/l Max.
(5) Total Identifiable Chlorinated Hydrocarbons	0.04 mg/l Max.
(6) Benzene and Derivatives	2.0 mg/l Max.
(7) Organic Solvents	2.5 mg/1 Max.

If the discharge limits are exceeded for any of the above items, dispose of the water and detergent solution as directed by the Contracting Officer. The Contractor may pretreat the wash water to make it suitable for discharge to the sanitary sewer system if approved by the Contracting Officer. Submit the plan for pretreatment to the Contracting Officer for approval 21 days prior to scheduled pretreated discharges.

3.7.9 Removal of Scale and Other Tenaciously Adhering Materials

Perform sandblast cleaning or power wire brushing. The brush must be made of spark resistant bronze wire. After sandblasting or power wire brushing, clean the entire tank interior surfaces by brushing, blowing with dry compressed air, and vacuuming. Remove loose materials from the tank interior. Perform abrasive blasting in accordance with API RP 2027.

3.7.10 Disposal of Used Blasting Abrasive

Test used abrasive in accordance with 40 CFR 261 to determine if it is a hazardous waste using the EP toxicity test for metals. Handle and dispose of abrasive determined to be hazardous waste in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266. Dispose of abrasive which is not hazardous waste at a landfill off Government property in accordance with applicable regulations. The contract price will be adjusted if the used abrasive is determined to be hazardous waste. However, payment for disposal of hazardous waste will not be made until a completed manifest from the treatment or disposal facility is returned, and a copy furnished to the Government.

3.7.11 Special Instructions for Cleaning Tank Storage JP-5 Fuel

a. Comply with the precautions and procedures outlined above for cleaning petroleum storage tanks.

b. Use respiratory equipment specified for "Respiratory Protection" under paragraph EQUIPMENT, in this section, at all times, regardless whether or not combustible gas indicator indicates any vapors present in the tank. Wear the respiratory protective equipment continuously until the tank side and bottom has been thoroughly cleaned, washed and dried.

3.7.12 Lead-Hazard-Free Tests

In accordance with API Std 2015, perform lead-in-air tests to make sure that the tank is lead-hazard-free (CAUTION: Never perform lead-hazard-free tests before or during cleaning, only after).

3.8 FINAL CLEAN-UP

After the Contracting Officer has inspected and accepted the tank cleaning and before final inspection, accomplish the following work:

3.8.1 Stenciling Tank

Stencil on the tank in 3/4-inch letters adjacent to the manhole openings the following data:

Date Cleaned - [_____]

Contractor Name - [_____]

Address - [_____]

3.8.2 Restoration of Site to Original Condition

Do not reconnect pipelines until application of interior and exterior coatings specified in other sections of this specification, have been completed. Replace valves, piping, manhole covers, and similar items which were removed at the start of the job with new gasket material resistant to fuel not less than the thickness of the gasket removed. Pressure check valves and piping. Remove, from the site, debris, equipment and materials used for the cleaning operations. Restore the site to its original condition.

-- End of Section --

SECTION 33 05 23

TRENCHLESS UTILITY INSTALLATION
08/15, CHG 2: 08/16

PART 1 GENERAL

Provide utility installation using microtunneling boring and jacking techniques at locations indicated. The Contractor is responsible for all work related to the provision of utilities installed, including assessing surface, subsurface, and environmental (seasonal) conditions.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 5L	(2018; 46th Ed; ERTA 2018) Line Pipe
API Spec 13A	(2010; Errata 1 2014; Errata 2-3 2015) Specification for Drilling-Fluid Materials

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2017) Manual for Railway Engineering

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 27-00	(2000) Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction
ASCE 28-00	(2001) Standard Practice for Direct Design of Precast Concrete Box Sections for Jacking in Trenchless Construction
ASCE 36-15	(2015) Standard Design and Construction Guidelines for Microtunneling

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.5M/D1.5	(2020; Errata 1 2022) Bridge Welding Code

ASTM INTERNATIONAL (ASTM)

ASTM A139/A139M	(2016) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C76	(2020) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C150/C150M	(2021) Standard Specification for Portland Cement
ASTM C1091	(2003a; R 2013) Standard Test Method for Hydrostatic Infiltration Testing of Vitrified Clay Pipe Lines

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

1.2 DEFINITIONS

As used herein, the terms "shaft" and "pit" are synonymous.

1.2.1 Microtunneling

Unless otherwise specified or indicated, see ASCE 36-15 for definitions.

1.2.2 Jacking Precast Concrete Pipe

Unless otherwise specified or indicated, see ASCE 27-00 for definitions.

1.2.3 Jacking Precast Concrete Box Sections

Unless otherwise specified or indicated, see ASCE 28-00 for definitions.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Microtunneling Plan; G

Boring and Jacking Plan; G

Statement of Contractor Qualifications; G

SD-03 Product Data

Pipe casing and couplings; G

Lubricating Fluid for pipe exterior; G

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.

SD-05 Design Data

Design calculations for pipe casing; G

Access Shaft Construction Plan; G

SD-06 Test Reports

Monitoring Survey; G

SD-08 Manufacturer's Instructions

Installation procedures for pipe casing; G

Safety Data Sheets; G

SD-11 Closeout Submittals

Record Drawings; G

Daily Work Logs of installation operations, including records of the volume of materials removed, daily progress and grout volumes used, and as-built drawings of location and alignment of casing pipeline; G

1.4 PRE-CONSTRUCTION

No later than 45 days prior to commencement of the work, submit the following to the Contracting Officer for review and approval:

Microtunneling Plan

Boring and Jacking Plan

Access Shaft Construction Plan

Statement of Contractor Qualifications

Submit a complete list of all drilling fluids, additives, and mixtures to be used along with Safety Data Sheets.

1.5 QUALITY CONTROL

1.5.1 STATEMENT OF CONTRACTOR QUALIFICATIONS

Contractors are required to have proven and successful experience in microtunneling boring and jacking. The experience is the successful completion of similar projects to the tolerances indicated for the size of pipe and quantities shown on the plans, in the anticipated soil conditions indicated in the geotechnical report included in the contract documents. Submit a description of at least three such projects which include, at a minimum, a listing of the location(s), date of projects, owner with contact information, pipe type, size installed, length of installation, type, and manufacturer of equipment used, and other information relevant to the successful completion of the project.

1.5.2 RECORDS

1.5.2.1 DAILY WORK LOG

Maintain a work log of construction events and observations. Include the following information for each days work:

a. Hours worked.

b. Location of boring machine face or shield by station and progress made in advancing pipe.

c. Completed field forms, such as steering control logs, for checking line and grade of boring operation, showing achieved alignment relative to design alignment.

d. Maximum pipe jacking pressures per drive.

e. Ground water control operations and piezometric levels.

f. Descriptions of soil conditions encountered.

g. Any unusual conditions or events, including observed ground movement.

h. Reasons for operational shutdown in event drive is halted.

1.6 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes free of dirt and debris.

1.6.1 Handling

Handle pipe in a manner to ensure delivery to the excavation site in sound undamaged condition. Avoid damage to coatings and linings on pipe; make repairs if coatings or linings are damaged. Carry, do not drag pipe to the excavation site. Store jointing materials and rubber gaskets that are not to be installed immediately, under cover out of direct sunlight. Handle steel pipe with coal-tar enamel or coal-tar epoxy coating in accordance with the provisions for handling coal-tar enamel coated pipe in AWWA C203. Handling coal-tar epoxy coated steel is not permitted below 40 degrees F.

1.7 SAFETY

1.7.1 General

Provide procedures for safe conduct of the work in accordance with EM 385-1-1. When and where installations temporarily disrupt pedestrian use of sidewalk areas for periods exceeding two consecutive work days, provide an alternate route that meets current ABA Accessibility Standard for Department of Defense Facilities.

1.7.2 Equipment

Utilize equipment that employs a common grounding system to prevent electrical shock in the event of underground electrical cable strike. Ensure the grounding system connects all pieces of interconnecting machinery; the drill, mud mixing system, drill power unit, drill rod trailer, operators booth, worker grounding mats, and any other interconnected equipment to a common ground. Utilize equipment having an "electrical strike" audible and visual warning system that notifies the system operators of an electrical strike.

1.7.3 Sheeting, Shoring and Dewatering

Provide sheeting, shoring and dewatering as specified in Section 31 23 00.00 20, EXCAVATION AND FILL, and as specified herein.

1.7.4 Tunnel Bore

Unprotected mining of the tunnel bore is not permitted. Fully support the tunnel face and bore at all times.

1.8 QUALITY ASSURANCE

1.8.1 Microtunneling PlanBoring and Jacking Plan

Provide a plan prepared, signed and sealed by a licensed Professional Engineer and include the following:

1.8.1.1 Operational Layout

1.8.1.1.1 Layout Plan

Provide a plan location of the operation, discussing relationship of equipment, the method of construction and details for the following:

a. Access pits configurations and details, including equipment layout.

b. Location of intermediate jacking stations, if required.

c. Casing pipe with connection details.

1.8.1.1.2 Pedestrian Access Around Site

When and where installations disrupt pedestrian use of sidewalk areas for periods exceeding two consecutive days, provide an alternate route that meets current ADA requirements.

1.8.1.2 Method and Procedures

Provide an outline of the methods and procedures, including drawings, schedule of operations, specifications, and manufacturer's catalog data for products in lieu of specifications, methods of operation for microtunneling boring and jacking operations, and specifically the following:

a. Jacking Equipment and Methods: Provide drawings of the jacking frame, jacking head, reaction blocks, jacking installation, pipe guides, procedures for lubricating exterior of pipe during jacking (if applicable), maximum force that jacking equipment can deliver.

b. Boring Equipment and Methods: Provide a discussion of the methods of operation, design and specifications for boring operation, steerage control, line and grade control methods, proposed procedures for removing or clearing obstructions, and a description of proposed methods for ground stabilization and minimizing overexcavation and loss of ground. Submit safety data sheets for fluids, grout, or chemical products.

c. Casing Annulus and Interior Space Grouting: Identify casing insulators/spacers/centralizers/tiedowns (type, number, spacing and installation instructions,) grout materials and method of placement, description of equipment used and grout pressure employed.

d. Survey Alignment Control: Identify method and equipment to install pipe within specified tolerances.

e. Ground Stabilization: Discuss dewatering and grouting, identification of measures and methods used to stabilize face at heading (if necessary), narrative of equipment, procedure and grout mix, and identification of subcontractor who will perform any required stabilization grouting.

f. Excavation Support System Plan: Provide a plan and discussion of methods to be employed, including design drawings and calculations, sealed and signed by a licensed Professional Engineer.

g. Monitoring/Survey Plan: Develop and provide a discussion of the monitoring/survey plan to be employed to protect structures and utilities from settlement and/or heave, including the following. Incorporate into the plan any supplemental requirements specified in Part 3, paragraph entitled "Field Quality Control".

(1) Structures Assessment: Provide a discussion of structures and utilities to be protected, and measures to be employed for preconstruction and postconstruction assessment of critical structures, namely those located within the zone of active excavation from proposed pipe centerline. Include photographs or video of existing damage to structures in the vicinity of sewer alignment in assessment reports.

(2) Instrumentation Monitoring Plan: Describe of instrumentation design, layout of instrumentation points, equipment installation details, manufacturer's catalog literature, and monitoring report forms.

(3) Surface Settlement Monitoring Plan: Identify on a plan the location of settlement monitoring points, reference benchmarks, survey frequency and procedures, and reporting formats.

h. Contingency Plan: Provide a plan and discuss protection of pavements, adjacent structures, and utilities affected by adverse movements detected by instrumentation. As a minimum, include the following:

(1) Names, telephone numbers, and locations of persons responsible for implementation of contingency plans.

(2) Materials and equipment required to implement contingency plans. Identify the location of all required materials and equipment.

(3) Step-by-step procedure for performing work involved in

implementation of the contingency plans.

(4) Clear identification of the objectives of the contingency plans and methods to measure plan success.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The work includes providing labor, materials, and specialized equipment for the installation of utility pipelines utilizing the boring and jacking microtunneling methods of installation.

2.1.1 Design Requirements

2.1.1.1 Excavations

Design excavations, including access shaft walls, considering loadings from reaction blocks, traffic loads and any surcharge loads.

2.1.1.1.1 Highway Crossing Criteria

For loadings under highways use HS20 vehicle loading distribution in accordance with AASHTO.

2.1.1.1.2 Railway Crossing Criteria

For pipe crossings under railways use Cooper E-80 locomotive loading distributions in accordance with AREMA Eng Man specifications for culverts. Account for loading due to any multiple tracks.

2.1.1.2 Design Calculations of Pipe Casing

Submit design calculations for pipe casing demonstrating that the equipment used in installing the pipe will not distort or otherwise damage the pipe. Provide calculations of maximum allowable jacking force to be used based on pipe materials to be used. The calculations are to be sealed by a licensed Professional Engineer using soil properties derived from subsurface investigations performed along the utility route.

2.2 EQUIPMENT

2.2.1 Microtunneling System

2.2.1.1 General Requirements

Utilize a continuously monitored laser guided Microtunneling Boring Machine (MTBM) system matched to the expected subsurface conditions, a hydraulic jacking system to jack the pipeline, a process to remove the slurry from the slurry water, a guidance system to provide installation accuracy to within the indicated tolerances, excavation equipment, material handling equipment, a dewatering system, and sheeting/shoring required to provide the work indicated and meet the following minimum performance requirements:

a. Capable of providing positive face support both during excavation and during shutdown regardless of the MTBM type.

b. Capable of handling and removing materials of high water content from the machine head.

c. All functions are controlled remotely from a surface control unit.

d. Capable of controlling rotation utilizing a bidirectional drive on the cutter head or by using anti-roll fins or grippers.

e. Capable of injecting lubricant around the exterior of the pipe being jacked.

f. Capable of controlling heave and settlement.

g. Minimize overcut during the operation. Do not exceed 1 inch on the radius, unless approved by the Contracting Officer.

2.2.1.2 Control System

The main control system of the MTBM is to provide the following information to the operator, as the minimum, required for successful operation of the MTBM:

a. Deviation of the MTBM from the required line and grade of the pipeline (normally by reference to a laser beam).

b. Grade and roll of the MTBM.

c. Jacking load.

d. Torque and RPM of the cutter head.

e. Instantaneous jacking rate and total distance jacked.

f. Indication of steering direction.

g. Progress of pipe advancement via CCTV at the pipe head.

2.2.2 Boring and Jacking System

Utilize a continuously monitored boring and jacking system matched to the expected subsurface conditions, a hydraulic jacking system to jack the pipeline, an auger to remove boring spoils, a guidance system to provide installation accuracy within the indicated tolerances, excavation equipment, material handling equipment, a dewatering system, and sheeting/shoring required to provide the work indicated.

2.2.3 Pipe Jacking Equipment

Provide main jacking equipment with a capacity greater than the anticipated jacking load. Provide intermediate jacking stations when the total anticipated jacking force needed to complete the installation may exceed the capacity of the main jacks or the designed maximum jacking force for the pipe. The jacking system is to supply a uniform distribution of jacking forces on the end of the pipe by use of thruster rings and cushioning material.

2.3 MATERIALS

2.3.1 Pipe Casing

Provide straight wall pipe casing of reinforced concrete pipe (RCP) or steel pipe.

2.3.1.1 Reinforced Concrete Pipe

2.3.1.1.1 Pipe

Pipe, class and concrete strength shall as indicated and in accordance with ASTM C76.

2.3.1.1.2 Joints and Jointing Material

Form joints of concrete and as detailed in the Contract drawings. Utilize a rubber gasket or mastic to provide the seal. Incorporate an assembly of steel bands or steel bell ends and spigot rings and rubber gaskets in accordance with Contract drawings.

2.3.1.1.3 Internal Diameter

The internal diameter of 12 to 24 inch pipe cannot vary by more than plus 1/4 inch from the design diameter. 24 inch and larger pipe cannot vary from the design diameter by more than plus one percent or plus 3/8 inch, whichever is less.

2.3.1.1.4 Wall Thickness

At any location along the length of the pipe, or at any point around its circumference, the wall thickness cannot vary by more than plus five percent of the design diameter.

2.3.1.1.5 End Squareness

Ensure that each pipe end lies within two planes perpendicular to the longitudinal center line of the pipe, spaced at 3/8 inches apart. Square the tongue or spigot end to within 3/16 inches and the groove or bell end of the pipe to within 3/16 inches.

2.3.1.1.6 Roundness

Ensure that the outside diameter of the pipe does not vary from a true circle by more than one percent. Permissible out-of-round dimensions are one half the difference between the maximum and minimum outer diameter of the pipe at any one location along the barrel.

2.3.1.1.7 Length of Pipe

Do not deviate from the finished pipe design length by more than plus 1/8 inch per foot with a maximum variation of plus 1/2 inch in any length of pipe.

2.3.1.1.8 Length of Two Opposite Sides

Variations in laying length of two opposite sides of the pipe cannot exceed 1/4 inch for all sizes through 24 inches internal diameter 1/8 inch per foot for all sizes larger than 24 inches in internal diameter, with a maximum of 3/8 inches in any length of pipe.

2.3.1.2 Steel Pipe

2.3.1.2.1 Pipe

Provide steel pipe in conformance with ASTM A139/A139M, Grade B with a minimum yield strength of 35,000 psi. Weld steel pipe seamless, square cut with even lengths that complies with Articles 4.2, 4.3, and 4.4 of the API Spec 5L.

2.3.1.2.2 Joints

Accomplish the connection of adjacent pieces of microtunneling steel pipe by field buttwelding, internal weld sleeves, integral press fit connectors, by a certified welder, in compliance with AWS D1.1/D1.1M as long as loading and installation design criteria are met.

Grouting Plugs: On large pipe, (24-inch diameter or greater), provide pipe with 2-inch diameter tapped holes with threaded plugs for exterior grouting.

2.3.1.2.3 Roundness

The maximum difference between the major and minor outside diameters cannot exceed one percent of the specified nominal outside diameter or 0.25 inch, whichever is less. For pipe exceeding 48 inches in diameter, a maximum deviation of 1/2 inch is permitted provided the circumference tolerance is maintained within 1/4 inch.

2.3.1.2.4 Circumference

Ensure that the outside circumference is within plus one percent of the nominal circumference or within plus 0.50 inches, whichever is less.

2.3.1.2.5 Straightness

The maximum allowable straightness deviation in any 10 foot length cannot exceed 1/8 inch. For lengths over 10 feet, the maximum allowable deviation of the entire pipe length is computed by the following formula, but not to exceed 3/8 inch in any length exceeding 30 foot length: Maximum Allowable Deviation in inches equals (1/8) times (total length in feet) divided by 10.

2.3.1.2.6 Pipe Ends

Ensure that the end of the pipe is perpendicular to the longitudinal axis of the pipe and within 1/16 inch per foot of diameter, with a maximum allowable deviation of 1/4 inch measured with a square and straightedge across the end of the pipe.

2.3.2 Grout

Provide cement grout for pressure grouting to fill the voids around the casing and for filling the interior annular space between carrier pipe and the casing composed of Portland cement conforming to ASTM C150/C150M, Type II, and sand meeting requirements of ASTM C33/C33Mfor fine aggregate, sufficiently fluid to inject through the casing and fill voids, with prompt setting to control grout flow. Utilize a grout with a minimum compressive strength of 100 psi attained within 24 hours. Admixtures are to be free of chlorides, corrosive or other material detrimental to the materials the grout contacts.

2.3.3 CONCRETE

Provide 3000 psi concrete in accordance with Section 03 30 00 CAST-IN-PLACE

CONCRETE.

2.3.4 Lubricating Fluid (Bentonite or Polymer)

Provide material for lubricating the exterior of pipe. Provide bentonite machine requirements of API Spec 13A and having the capacity of mixing with water to form a stable and homogeneous suspension.

2.3.5 SOIL MATERIALS

Provide soil materials in accordance with the requirements specified in Section 31 00 00 EARTHWORK31 23 00.00 20 EXCAVATION AND FILL.

2.4 Incidental Materials

2.4.1 Casing Insulators/Bore Spacers

Provide carbon steel with polyvinyl chloride coating or stainless steel casing insulators/bore spacers 8 inches in length for pipe 12 inches and less in diameter, and 12 inches in length for pipe 14 inches and greater in diameter, having a 2 inch minimum runner width. Orient spacers to allow for grout to flow easily to completely fill the casing pipe with grout throughout its length.

2.4.2 End Closures/Bulkheads

Provide Temporary End Closures to contain grout used for filling the annular space between conduits and the casing. Provide Permanent End Closures as indicated consisting of brick and mortar (one part cement/two parts sand/water) to completely encapsulate the conduits transition into the casing. Center the closure on the casing pipe end.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Access Shaft and Pit Construction Plan

No later than 45 days prior to start of construction submit an Access Shaft Construction Plan. Include in the plan a discussion of the method of construction of access shafts used for microtunneling boring and jacking. Address the excavation methods, dewatering system, sheeting/shoring and bracing systems proposed for use, and any ground stabilization to be employed for the shaft work area or thrust block. Acceptable construction methods include the use of interlocked steel sheetpiling or precast circular concrete segments lowered in place during excavation.

3.1.1.1 Design Requirements

a. Construct shafts of a size commensurate with safe working practices at locations indicated. Coordinate shaft locations with the Contracting Officer. The Contractor may propose to relocate shafts to better suit the capabilities of the equipment/methods proposed, but may not alter either the indicated pipeline alignment or structures associated with the installed pipeline, nor result in additional claims for compensation.

b. To the extent possible, keep shaft locations clear of pavements and within a single traffic lane, in order to minimize disruption to the flow of traffic. Locate support equipment, spoil piles, and materials to minimize disruption to traffic.

c. Support all excavations and prevent movement of the soil, pavement, utilities or structures outside of the excavation. Furnish, place, and maintain sheeting, bracing, and lining required to support the sides of all shafts and to provide adequate protection of the work, personnel, and the general public. Provide a concrete floor in the jacking access shaft. Design loads on the sides of the jacking and receiving pit walls are dependent on the construction method and flexibility of the wall systems.

d. Consider the loading from boring or pipe jacking when preparing the design of the jacking and receiving pit supports as well as special provisions and reinforcement around the breakout location. Design the base of the pits to withstand uplift forces from the full design head of water, unless approved dewatering or other ground modification methods are employed.

e. Construct a thrust block to transfer jacking loads into the soil. Ensure that the backstop and the proposed pipe alignment are square to each other and are designed to withstand the maximum jacking pressure to be used with a factor of safety of at least 2.5. Also, design the thrust block to minimize excessive deflections in such a manner as to avoid disturbance of adjacent structures or utilities or excessive ground movement. Begin jacking operations only after concrete thrust block or treated soil has attained the required strength.

f. If tremie concrete sealing slabs are placed within the earth support system to prevent groundwater inflow when access shafts are dewatered, furnish and install sealing slabs of sufficient thickness to provide a minimum factor of safety of 1.2 against hydrostatic uplift in order to prevent bottom blowout when the excavation is completely dewatered.

3.2 CONSTRUCTION

3.2.1 Access Shafts

3.2.1.1 Construction Requirements

a. Provide ground stabilization in the work area and the thrust block as required to accomplish the work.

b. Construct a jacking access shaft to accommodate the installation of pipe casings, equipment and piping jacking device. Install thrust blocks(s) as required and consolidate the ground (grout) where the casings exit the shaft. Provide a dry jacking work area having a stable concrete floor that drains to a recessed sump pump to handle nuisance inflow. Groundwater inflows into the jacking shaft are not to exceed 5 gallons/minute; soil inflows are not to exceed a total volume of 2 cubic feet.

c. Construct a receiver shaft to accommodate the installation of pipe casings and the equipment used in the work. Consolidate the ground (grout) where the casings enter the shaft.

d. Furnish, install, and maintain equipment to keep the jacking shaft free of excess water. Provide surface protection during the period of construction to ensure that surface runoff does not enter shafts.

Adhere to the dewatering plan and do not affect surrounding soils or structures beyond the tolerances stated in paragraph entitled "Tolerances."

e. Provide security fence around all access shaft areas and provide shaft cover(s) when the shaft area is not in use.

f. Pit Backfill and Compaction: Upon completion of the pipe jacking and all tests or inspections are complete remove all equipment, debris, and unacceptable materials from the pits and commence backfilling operation. Complete backfilling, compaction, and pavement repairs in accordance with Section 31 00 00 EARTHWORK31 23 00.00 20 EXCAVATION AND FILL.

3.3 INSTALLATION

3.3.1 Installation of Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe in accordance with the American Public Works Association Uniform Color Code. Attach wire to top of pipe in such a manner that will not be displaced during construction operations.

3.3.2 Connections to Existing Lines

Schedule connections to existing lines with the Contracting Officer to cause a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped.

3.3.3 Advancing the Pipe

Jack each pipe casing section forward as the excavation progresses in such a way to provide complete and adequate, ground support at all times. Utilize a bentonite slurry applied to the external surface of the pipe to reduce skin friction. Provide a jacking frame for developing a uniform distribution of jacking forces around the periphery of the pipe. Place a plywood spacer on the outer shoulder of the pipe casing joint. Design and construct the thrust reaction backstop to withstand the jacking forces. Continuously maintain a square alignment between the backstop and pipe casing and support the maximum obtainable jacking pressure with a safety factor at least 2.0. Continuously monitor the jacking pressure and rate of cutter head advancement. Exercise special care when setting the pipe guard rails in the jacking pit to ensure correctness of the alignment, grade and stability.

3.3.3.1 Installation Requirements

a. Utilize boring equipment capable of fully supporting the face of the tunnel.

b. Maintain face pressure exerted at the heading by the MTBM as required to prevent loss of ground, groundwater inflows, and settlement or heave of the ground surface by balancing soils and groundwater pressures present.

c. Dewatering for groundwater control is allowed at the jacking and receiving pits only.

d. Do not jack pipe casing until the concrete thrust block and tremie seal (if selected), and grouted soil zone in jacking and receiving shafts have attained the required strength.

e. Jack the pipe into place without causing damage to the coatings, joints or completed pipe section.

f. After completion of the jacking operation between jacking and receiving shafts, displace the lubricate material from between the pipe casing exterior and the surrounding ground with a cement grout. Control pressure and the amount of grout to avoid pipe damage and displacement of the pipe and soil beyond the tolerances specified in paragraph "Tolerances." Grout within 48 hours after pipe installation has been completed to prevent any surface settlement due to movement of soil material into the void space or loosened zone around the pipe casing.

g. Replace pipe casings damaged during installation.

h. Ensure that the welds of steel pipe attain the full strength of the pipe and are watertight before jacking of the pipe section. Ensure that the inner face of the internal weld seam is flush with the pipe to facilitate the installation of the carrier pipe in the pipe casing.

i. Perform all welding in accordance with requirements for shielded metal arc welding of AWS D1.5M/D1.5 for bridges and AWS D1.1/D1.1M for buildings and other structures.

j. Provide a pipeline that has a consistent diameter across assembled joints.

k. Once the tunneling process has begun, continue with that process uninterrupted until the pipe reaches the receiving shaft. Continue to push any damaged pipe until that damaged pipe section is pushed into the receiving shaft and is removed. Notify the Contracting Officer immediately if any pipe is known to be or believed to be damaged.

3.3.4 Carrier Pipe or Conduit Installation

3.3.4.1 Cleaning

Clean the inside of the casing of all foreign matter by using a pipe cleaning plug.

3.3.4.2 Carrier Pipe or Conduit Joints

Bond all metallic conduit joints within the casing pipe. Inspect with the Contracting Officer, prior to backfilling trenches, the transition of carrier pipe or conduit within the casing to non-cased trenching.

3.3.4.3 Casing Insulators/Spacers

Install casing insulators/spacers in accordance with approved submittals and the drawings. On center spacing is not to exceed 4 feet.

3.3.4.4 End Closures/Bulkheads and Grouting of Casing Pipe

a. Closures: Seal ends of casing with brick and mortar.

b. After installing, inspecting and acceptance of the carrier pipe or conduit and spacers within the casing pipe, pressure fill the annular space between the carrier pipe or conduit and the casing pipe, with cement grout specified herein. Regulate pump pressures to refusal or in accordance with the approved grouting plan. Place grout in a sequence and manner that will preclude voids or pockets of entrapped air or water. Use a refusal pressure equal to 0.5 psf per foot of overburden.

3.3.5 Ventilation

Provide adequate ventilation for all tunnels and shafts, following confined space entry procedures. Include such factors as the volume required to furnish fresh air in the shafts, and the volume to remove dust that may be caused by the cutting of the face and other operations which may impact the laser guidance system. In the design of the ventilation system, the minimum amount of fresh air to be as required. Routinely test the air in areas accessed by workers in accordance with the most current OSHA methods and standards. The current OSHA allowable gas concentrations or those presented below, whichever are more stringent, shall be met:

Carbon Monoxide	≤0.005 percent
Methane	≤0.25 percent
Hydrogen Sulfide	≤0.001 percent
Oxygen	≥20.0 percent

3.3.6 Lighting

Provide adequate lighting for the nature of the activity being conducted by workers. Separate and insulate with ground fault interrupters power and lighting circuits. Comply with requirements with regards to shatter resistance and illumination requirements.

3.3.7 Spoil Transportation

Match the excavation rate with rate of spoil removal. Utilize a system capable of balancing groundwater pressures and adjustment to maintain face stability for the particular soil conditions of the project.

3.4 TOLERANCES

3.4.1 Tolerances

Maximum allowable lateral deviation is 5 inches; maximum allowable vertical deviation is [_____] inches in the position of every completed 300 foot section of jacked pipe casings. Water must be free draining between any two points at the pipe invert. Reverse grades are not permitted.

3.5 FIELD QUALITY CONTROL

Employ the monitoring/survey plan. Maintain daily records in accordance with the paragraph titled RECORDS.

3.5.1 Instrumentation/Survey

3.5.1.1 Mandatory Requirements

Include the following, as a minimum, to supplement Contractor Quality Control measures employed to monitor ground surface heave or settlement in the monitoring/survey plan.

a. Monitor ground movements associated with the project using established survey points and make changes in the construction methods that control ground movements and prevent damage or detrimental movement to the work and adjacent structures and pavements.

b. Record in the daily work log a summary of monitoring survey results. Clearly identify work not meeting specified requirements, out-of-tolerance results, and impacts on new or existing work from settlement or heave.

c. Install instrumentation and perform monitoring to determine ground settlement surrounding each jacking and receiving pit.

d. Prior to any excavation activities, perform a pre-construction survey of the areas in and surrounding excavations and along the proposed utility alignment to identify any structures, facilities, underground or above ground utilities to be protected within a radius of five times either the depth of any excavation or the depth of trenchless excavation.

3.5.1.2 Supplemental Requirements

a. Prior to the start of advancing the pipe or any dewatering operation, install surface settlement markers along the trenchless excavation centerline using the following guidelines:

(1) Locate surface settlement markers in a grid, spaced 10 feet by 10 feet extending not less than 30 feet on either side of the trenchless excavation centerline. Use wooden hubs in unpaved areas with the hubs driven flush with the surface and a tack driven in the top for level rod placement. Use temporary paint or other approved materials in pavement areas. Minimize the size of temporary markings to the greatest extent practical. Remove all markers and markings prior to completion of work.

b. Prior to the start of advancing the pipe or dewatering operations, survey all monitoring points a minimum of three times to establish baseline readings. Perform all surveys to an accuracy of 0.01 foot. Survey daily feet of casing pipe advancement. In addition, if settlement exceeds Limit Level 2 survey all monitoring points within 20 feet of the heading hourly when the heading is approaching or passing beneath the monitoring points.

c. Evaluate all monitoring survey data immediately to determine corrective or mitigation action should be taken using the following evaluation criteria:

TYPE OF MONITORING POINT	LIMIT LEVEL 1	LIMIT LEVEL 2
Surface - Unpaved	+/- 1/4 inch	+/- 3/4 inch

TYPE OF MONITORING POINT	LIMIT LEVEL 1	LIMIT LEVEL 2
Surface - Paved	+/- 1/4 inch	+/- 1/2 inch

d. If the survey readings indicate settlement or heave is greater than Limit Level 1 in the above table, provide notification to the Contracting Officer immediately and increase the monitoring frequency of the instruments as directed. Proceed with advancing the pipe after providing mitigating measures to limit additional movements.

e. If the survey readings indicate settlement or heave is greater than Limit Level 2 in the above table, cease work and provide notification to the Contracting Officer immediately and implement the Contingency Plan.

f. Perform all repairs and/or rebuilding of the pavement or adjacent structures to their condition existing prior to settlement/lifting.

g. Continue to monitor by the survey at two week intervals for a period of six weeks after tunneling. When the survey identifies that heave or settlement has occurred that is greater than Limit Level 2 values, make repairs to new or existing work that is affected. Discontinue topographic surveys when settlement is no longer detected.

3.5.2 Field Tests

Perform field tests, and provide labor, equipment, and incidentals required for testing Section. Submit test results, identifying any results that do not meet specified requirements, to the Contracting Officer within four days of test completion. Provide corrective action and retest pipe not meeting specified requirements. Provide corrective action as recommended by the pipe manufacturer and subject to approval by the Contracting Officer.

3.5.2.1 Pipe Casing

Inspect and verify that pipe material meets the dimensional tolerances specified prior to use. Record each days inspection results in the daily work log.

3.5.2.1.1 Testing Requirements for Gravity Mains

Perform low pressure air test of all gravity mains (structure to structure) in accordance with ASTM C1091 Standard Test method for Hydrostatic Infiltration testing of Vitrified Clay Pipe Lines.

3.5.2.1.2 Non-Standard Pipe Lengths

Cut non-standard joint lengths from full length pipe having satisfactorily passed the hydrostatic test.

3.5.2.1.3 Elevations

Prior to removal of MTBM equipment, sheeting, and backfilling of access shafts, collect invert information on pipeline installed. Confirm that the elevations meet stated tolerances.

3.5.3 Inspections

Prior to the removal of MTBM equipment, sheeting, and backfilling of access shafts, conduct CCTV inspection of the mains installed in accordance with Section 33 01 30.16 TV INSPECTION OF SEWER LINES.

3.6 CLEANUP AND FINAL CLOSEOUT

3.6.1 Site Cleanup

Immediately clean "blow holes" or "breakouts" of drilling fluid to the surface and fill depressions with satisfactory fill material. Dispose of all drilling fluids, soils, and separated materials in compliance with Federal, State, and local environmental regulations.

3.6.2 Drilling Fluid

Immediately upon completion of work of this section, remove all rubbish and debris from the job site. Remove all construction equipment and materials leaving the entire area involved in a neat condition equal to existing conditions prior to construction, unless indicated otherwise.

3.6.3 Record Drawings and Daily Work Logs

Submit an electronic copy and three hard copies of the record drawings to the Contracting Officer within five days after completing the work. Include in the record drawings a plan, profile, and all information recorded during the progress of the work. Clearly tie the record drawings to the project's survey control. Maintain and submit upon completion final Daily Work Logs of installation operations, signed by the superintendent.

3.7 DISPOSITION OF MATERIAL

. Remove from Government property surplus or other soil material not required or suitable for fill or backfilling.

Store or legally dispose of excavated material and fluids used in the boring process and shaft construction away from the construction site and in compliance with all permits and applicable Federal, State, and local regulations. Comply with Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS. Stockpiling is permitted on the construction site provided material is removed at regular intervals not exceeding 48 hours.

-- End of Section --

SECTION 33 05 23.13

UTILITY HORIZONTAL DIRECTIONAL DRILLING
11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2017) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C900	(2016) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
AWWA C906	(2021) Polyethylene (PE) Pressure Pipe and Fittings, 4 In. through 65 In. (100 mm Through 1,650 mm), for Waterworks

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI Z535.1	(2017) Safety Colors

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926.652	Safety and Health Regulations for Construction; Subpart P, Excavations; Requirements for Protective Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Statement of Qualifications and Records; G

Horizontal Directional Drilling Plan; G

SD-03 Product Data

Pipe; G

Drilling Fluids; G

Additives; G

Tracer Wire; G

SD-05 Design Data

Secondary Containment Plan; G

SD-06 Test Reports

Soil Test Data

SD-07 Certificates

Drill Rod

Fusion Technician Qualifications

SD-11 Closeout Submittals

Record Drawings

Complete Work Logs of Guided Directional Drill Operations

1.3 QUALITY CONTROL

1.3.1 Qualifications

Ensure that the field supervisor and workers assigned to this project are experienced in work of this nature and have successfully completed similar projects of similar length, pipe type, pipe size, and soil type using directional drilling in the last three (3) years. As part of the bid submission, submit project descriptions which include, at a minimum, a listing of the location(s), date of project(s), owner, pipe type and material, size installed, length of installation, manufacturer of equipment used, and other information relevant to the successful completion of the project.

1.3.2 Safety

Include in directional drilling equipment machine safety requirements a common grounding system to prevent electrical shock in the event of underground electrical cable strike. Ensure the grounding system connects all pieces of interconnecting machinery; the drill, mud mixing system, drill power unit, drill rod trailer, operator's booth, worker grounding mats, and any other interconnected equipment to a common ground. Equip the drill with an "electrical strike" audible and visual warning system that notifies the system operators of an electrical strike.

1.3.3 Horizontal Directional Drilling Plan

Provide a plan prepared, signed, and sealed by a licensed Professional Engineer. Submit supporting calculations, certifications, and material product data demonstrating the strength of the product pipes for acceptance before the beginning of the installation. Demonstrate that the proposed material satisfies the purpose of the utility and withstands the design and construction stresses and pressures. The HDD Plan shall include the following:

1.3.3.1 Layout Plan

Provide a plan location of the operation, including entry and exit points, discussing the relationship of the equipment, pipe assembly, and staging areas.

1.3.3.2 Utility Profile

Provide a profile of the utility plotted at a scale appropriate for the work.

1.3.3.3 Equipment List

Provide a directional drilling equipment list including: drilling rig, drill bit, back-reamer, mud mixing and pumping systems, down-hole tools, guidance system, and rig safety system. Provide calibration records for guidance system.

1.3.3.4 Drilling Fluid Management Plan

Provide a drilling fluid management plan to include drilling fluid types and specifications, cleaning and recycling equipment, estimated flow rates, procedures for minimizing drilling fluid escape, and the method/location for final disposal of waste drilling fluids. Provide a frac out control plan, including frac control materials that will be onsite and contact information for emergency personnel.

1.3.3.5 Pedestrian Access

When and where installations disrupt pedestrian use of sidewalk for periods exceeding two consecutive days, provide an alternate route that meets current ADA requirements.

1.3.3.6 Method and Procedures

Provide an outline of the methods and procedures, describing the pilot hole drilling procedure, the reaming operation, and the pullback procedure, including drawings, schedule of operations, specifications, and method of operation. Include pipe storage and handling details and pipeline assembly and installation procedures.

1.3.3.7 Safety Data Sheets

Submit safety data sheets for fluids and additives.

1.3.3.8 Revisions

If site conditions change and require modification to the HDD Plan, submit revised drilling plan to achieve successful installation. Explain, in the revised submittal, the anticipated and encountered conditions that mandated the change in plans.

1.3.4 Fusion Technician Qualifications

The fusion technician must be qualified by the fusion equipment manufacturer to thermally butt-fuse the size of pipe used at the time of fusion performance. Each joint must be datalogged, recorded, and submitted for review.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for damage. All materials found during inspection or during the progress of work to have cracks, flaws, surface abrasions, or other defects will be rejected. Remove defective materials from the job site.

Protect stored piping from moisture and dirt and place on level surface. Store plastic piping protected from direct sunlight.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Drill Rod

Select the appropriate drill rod to be used. Submit certified statement that the drill rod has been inspected and is in satisfactory condition for its intended use.

2.2 MATERIALS

2.2.1 Pipe

2.2.1.1 Fusible PVC

Use butt fusion jointing method for plain end PVC pipe. Comply with AWWA C900 for butt fusion joints.

2.2.1.2 HDPE

Use butt fusion jointing method for plain end HDPE pipe. Comply with AWWA C906 for butt fusion joints.

2.2.2 Drilling Fluids

Use a high quality bentonite drilling fluid to ensure hole stability, cuttings transport, bit and electronics cooling, and hole lubrication to reduce drag on the drill pipe and the product pipe. Use only fluid with a composition which complies with all Federal, State, and local environmental regulations.

2.2.3 Additives

Use admixtures as required to address soil conditions and water conditions such as water hardness, acidity, and alkalinity.

2.2.4 Tracer Wire

Use a continuous sheathed solid conductor copper wire line, minimum #12 AWG. Sheathing shall be color coded to match the utility.

PART 3 EXECUTION

3.1 EXAMINATION

a. Soil Test Data

Provide written documentation of conformance with AASHTO T 180.

3.2 INSTALLATION

Ensure all utilities are located and clearly marked prior to start of excavation or drilling.

3.2.1 Drill Set-Up

Design and construct the drill entrance and exit pits.

3.2.1.1 Drilling Fluids

Mix the bentonite drilling fluid with potable water (of proper pH) to ensure no contamination is introduced into the soil during the drilling, reaming, or pipe installation process. Make any required additive adjustments.

3.2.2 Drill Entrance and Exit Pits

Drill entrance and exit pits are required. Maintain at minimum size to allow only the minimum amount of drilling fluid storage prior to transfer to mud recycling or processing system or removal from the site.

Do not allow drilling mud to flow freely on the site or around the entrance or exit pits. Remove spilled mud and restore ground to original condition. Provide shore pits in compliance with OSHA Standards, 29 CFR 1926.652.

Drilling near wetlands or water courses requires secondary containment to prevent drilling fluids from entering the wetlands. Secure written approval of a secondary containment plan from the Contracting Officer.

3.2.3 Drill Entrance and Exit Angle

Ensure entrance and exit angles and elevation profile maintains adequate cover to reduce risk of drilling fluid breakouts and ground exit occurs as specified herein. Ensure that entrance and exit angles generate pullback forces that do not exceed 7.5 percent strain on the high density polyethylene or fusible polyvinyl chloride pipe.

3.2.4 Pilot Hole

The type and size of the pilot string cutting head and the diameter of the drill pipe are at the Contractor's discretion.

Drill the pilot hole along the path shown on the plan and profile drawings. Pilot hole tolerances are as follows:

a. Vertical Tolerance: Provide minimum cover below channel bottom as specified on the plans. Pilot hole may go deeper if necessary to prevent breakout.

b. Horizontal Tolerance: Plus or minus - 60 inches from the centerline of the product pipe.

c. Curve Radius: No curve is acceptable with a radius less than 1,000 feet.

d. Entry Point Location: Make pilot hole entry point within plus or minus

- 60 inches of the location shown on the drawings or as directed by the Contracting Officer in the field.

e. Exit Point Location: Make the exit point location within plus/minus - 60 inches of the location shown on the drawings or as directed by the Contracting Officer in the field.

f. Mandatory pipeline cover requirements are as shown on the drawings or as specified.

3.2.5 Guidance Systems

Walkover guidance systems are not acceptable for this project; use a magnetic survey tool locator installed behind the pilot string cutting head and an electric grid (tru-tracker) system for this project. Ensure proper calibration of all equipment before commencing directional drilling operation.

3.2.6 Reaming

Conduct reaming operations at the Contractor's discretion. Determine the type of back reamer to be utilized by the type of subsurface soil conditions that are encountered during the pilot hole drilling operation. The reamer type is at the Contractor's discretion.

3.2.7 Pull Back

Fully assemble the entire pipeline to be installed via direction drill prior to commencement of pull back operations. Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe in accordance with ANSI Z535.1. Attach wire to top of pipe in such a manner that it will not be displaced during construction operations.

Support the pipeline during pullback operations in a manner to enable it to move freely and prevent damage. Install the pipeline in one continuous pull.

Minimize torsion stress by using a swivel to connect the pull section to the reaming assembly.

Maximum allowable tensile force imposed on the pull section is not to exceed 90 percent of the pipe manufacturer's safe pull (or tensile) strength. If the pull section is made up of multiple pipe size or materials, the lowest safe pull strength value governs and the maximum allowable tensile force is not to exceed 90 percent of this value.

Minimize external pressure during installation of the pullback section in the reamed hole. Replace damaged pipe resulting from external pressure at no cost to the Government. Buoyancy modification is at the discretion of the Contractor.

3.2.8 Drilling Fluids Disposal

Collect drilling fluid returns in the entrance pit, exit pit, or spoils recovery pit. Immediately clean up any drilling fluid spills or overflows from these pits.

Dispose of fluids in a manner that is in compliance with all permits and applicable Federal, State, and local regulations. Disposal of the drilling fluids may occur on approved land owned by the Government subject to written approval from the Contracting Officer. Spread the drilling slurry over the Government-approved disposal area and plow into the soil.

Conduct disposal in compliance with all relative environmental regulations, right-of-way and work space agreements, and permit requirements.

3.2.9 Connection of Product Pipe to Pipeline

After the product pipe has been successfully installed, allow the product pipe to recover for 24 hours prior to connection of the pipeline. Ensure that a sufficient length of the product pipe has been pulled through the hole so that the pull-nose is not pulled back into bore hole due to stretch recovery of the product pipe.

3.3 FIELD QUALITY CONTROL

3.3.1 Daily Work Log

Maintain a work log of construction events and operations including, but not limited to, the following for each day's work:

a. Hours worked.

b. Log of each drill rod added or withdrawn during drilling, reaming, and pull back.

c. Groundwater control operations.

d. Description of soil conditions encountered.

e. Tools and equipment in use, drilling fluid, fluid pumping rate, and drilling head location.

f. Any unusual conditions or events.

g. Reasons for operational shutdown in event work is halted.

3.3.2 Drill Logs

Maintain drilling logs that accurately provide drill bit location (both horizontally and vertically) at least every 2 inches along the drill path. In addition, keep logs that record, as a minimum the following, every 15 minutes throughout each drill pass, back ream pass, or pipe installation pass:

a. Drilling Fluid Pressure

b. Drilling Fluid Flow Rate

c. Drill Thrust Pressure

d. Drill Pullback Pressure

e. Drill Head Torque

Make all instrumentation, readings, and logs available to the Contracting Officer at all times during operation.

3.3.3 Field Tests

Perform field tests and provide labor, equipment, and incidentals required for testing. Submit test results, identifying any results that do not meet requirements, to the Contracting Officer within four days of test completion. Provide corrective action and retest pipe not meeting requirements. Provide corrective action as recommended by the pipe manufacturer and subject to approval by the Contracting Officer.

3.4 CLOSEOUT ACTIVITIES

Immediately upon completion of work, remove all rubbish and debris from the job site. Remove all construction equipment and implements of service leaving the entire area involved in a neat condition acceptable to the Contracting Officer.

Immediately clean "blow holes" or "breakouts" of drilling fluid to the surface and return the surface area to its original condition. Dispose of all drilling fluids, soils, and separated materials in compliance with Federal, State, and local environmental regulations.

Provide a post-construction fusion report including the following data for each fusible connection:

a. Pipe Size and Thickness

b. Machine Size

c. Fusion Technician Identification

d. Job Identification

e. Fusion Joint Number

f. Fusion, Heating, and Drag Pressure Settings

g. Heat Plate Temperature

h. Time Stamp

i. Heating and Cool Down Time of Fusion

j. Ambient Temperature

Submit an electronic copy and three hard copies of the record drawings to the Contracting Officer within five days after completing the pull back. Include in the record drawings a plan, profile, and all information recorded during the progress of the work. Clearly tie the record drawings to the project's survey control. Maintain, and submit upon completion, signed complete work logs of guided directional drill operations.

-- End of Section --

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING
02/18, CHG 1: 02/22

PART 1 GENERAL

1.1 UNIT PRICES

Measurement and payment will be based on completed work performed in accordance with the drawings, specifications, and the Contract payment schedules.

1.1.1 Measurement

The length of water lines will be determined by measuring along the centerlines of the various sizes of pipe provided. Pipe will be measured from center of fitting to center of fitting, from center of water main to center of fire hydrant, and from center of water main to end of service connection. No deduction will be made for the space occupied by valves or fittings.

1.1.2 Payment

Payment will be made for water lines at the Contract unit price per linear foot for the various types and sizes of water lines, and will be full compensation for all pipes, joints, specials, and fittings, complete and in place. Payment for fire hydrants, valves, and valve boxes will be made at the respective Contract unit price each for such items complete and in place. Payment will include providing all testing, plant, labor, and material and incidentals necessary to complete the work, as specified and as shown.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B1.20.3	(1976; R 2013) Dryseal Pipe Threads (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.4	(2021) Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(2018) Hypochlorites
AWWA B301	(2018) Liquid Chlorine
AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	(2018) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast
AWWA C153/A21.53	(2019) Ductile-Iron Compact Fittings for Water Service
AWWA C200	(2012) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C205	(2018) Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied
AWWA C206	(2017) Field Welding of Steel Water Pipe

AWWA C207	(2018) Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in. (100 mm through 3600 mm)
AWWA C208	(2017) Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	(2019) Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fitting for Steel Water Pipelines
AWWA C210	(2015) Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C213	(2022) Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings
AWWA C219	(2017) Bolted Sleeve-Type Couplings for Plain-End Pipe
AWWA C500	(2019) Metal-Seated Gate Valves for Water Supply Service
AWWA C502	(2018) Dry-Barrel Fire Hydrants
AWWA C503	(2018) Wet-Barrel Fire Hydrants
AWWA C504	(2015) Standard for Rubber-Seated Butterfly Valves
AWWA C508	(2017) Swing-Check Valves for Waterworks Service, 2 In. Through 48-In. (50-mm Through 1,200-mm) NPS
AWWA C509	(2015) Resilient-Seated Gate Valves for Water Supply Service
AWWA C511	(2017) Reduced-Pressure Principle Backflow Prevention Assembly
AWWA C512	(2015) Air-Release, Air/Vacuum, and Combination Air Valves for Water and Wastewater Service
AWWA C515	(2020) Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
AWWA C550	(2017) Protective Interior Coatings for Valves and Hydrants
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C602	(2011) Cement-Mortar Lining of Water Pipelines in Place—4 In. (100 mm) and Larger

AWWA C604	(2011) Installation of Buried Steel Water Pipe—4 In. (100 mm) and Larger
AWWA C605	(2021) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings
AWWA C606	(2015) Grooved and Shouldered Joints
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C655	(2009) Field Dechlorination
AWWA C701	(2019) Cold-Water Meters - Turbine Type for Customer Service
AWWA C704	(2019) Propeller-Type Meters for Waterworks Applications
AWWA C800	(2021) Underground Service Line Valves and Fittings
AWWA C900	(2016) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
AWWA C901	(2020) Polyethylene (PE) Pressure Pipe and Tubing, 3/4 In. (19mm) Through 3 In. (76 mm), for Water Service
AWWA C906	(2021) Polyethylene (PE) Pressure Pipe and Fittings, 4 In. through 65 In. (100 mm Through 1,650 mm), for Waterworks
AWWA C909	(2016) Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In. (100 mm) and Larger
AWWA M6	(2012) Water Meters - Selection, Installation, Testing, and Maintenance
AWWA M9	(2008; Errata 2013) Manual: Concrete Pressure Pipe
AWWA M11	(2016) Steel Pipe: A Guide for Design and Installation
AWWA M23	(2020) Manual: PVC Pipe - Design and Installation - Third Edition
AWWA M41	(2009; 3rd Ed) Ductile-Iron Pipe and Fittings
AWWA M45	(2013; 3rd Ed) Fiberglass Pipe Design
AWWA M55	(2020; 2nd Ed) PE Pipe - Design and Installation

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B61	(2015; R 2021) Standard Specification for Steam or Valve Bronze Castings
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM C1433	(2020) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe

	Fittings, Schedule 80
ASTM D2683	(2020) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2774	(2021) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3035	(2015) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM F402	(2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F714	(2022) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
ASTM F1055	(2016a) Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX)Pipe and Tubing
ASTM F1290	(2019) Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings
ASTM F1483	(2017) Standard Specification for Oriented Poly(Vinyl Chloride), PVCO, Pressure Pipe
ASTM F1674	(2011) Standard Test Method for Joint Restraint Products for Use with PVC Pipe
ASTM F1962	(2020) Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit

	Under Obstacles, Including River Crossings
ASTM F2164	(2018) Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure
ASTM F2620	(2020a; E 2021) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
ASTM F3190	(2021) Standard Practice for Heat Fusion Equipment (HFE) Operator Qualification on Polyethylene (PE) and Polymide (PA) Pipe and Fittings

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies
FCCCHR Manual	(10th Edition) Manual of Cross-Connection Control

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 24	(2022) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 1961	(2013) Standard on Fire Hose

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2021) Plastics Piping System Components and Related Materials
NSF/ANSI 61	(2020) Drinking Water System Components - Health Effects

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-600-01	(2016; with Change 6, 2021) Fire Protection Engineering for Facilities

UNDERWRITERS LABORATORIES (UL)

UL 246	(2011; Reprint Jul 2020) UL Standard for Safety Hydrants for Fire-Protection Service
UL 262	(2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service

UL 312	(2022) UL Standard for Safety Check Valves for Fire-Protection Service

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-PUB-08	(2016) Tapping Guide for PVC Pressure Pipe

1.3 DEFINITIONS

1.3.1 Water Transmission Mains

Water transmission mains include water piping having diameters greater than 14 inch, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.3.2 Water Mains

Water mains include water piping having diameters 4 through 14 inch, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.3.3 Water Service Lines

Water service lines include water piping from a water main to a building service at a point approximately 5 feet from building or the point indicated on the drawings, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.3.4 Additional Definitions

For additional definitions refer to the definitions in the applicable referenced standard.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Connections; G

SD-03 Product Data

Pipe, Fittings, Joints and Couplings; G

Ball And Socket Joint; G

Valves; G

Valve Boxes; G

Fire Hydrants; G

Pipe Restraint; G

Tapping Sleeves; G

Corporation Stops; G

Backflow Preventer; G

Precast Concrete Thrust Blocks; G

Disinfection Procedures; G

Fusion Joining

SD-06 Test Reports

Backflow Preventer Tests; G

Bacteriological Samples; G

Post-Construction Fusion Report; G

Hydrostatic Sewer Test

Leakage Test

Hydrostatic Test

SD-07 Certificates

Pipe, Fittings, Joints and Couplings

Shop-Applied Lining and Coating

Lining

Lining for Fittings

Lining for Ductile Iron Fittings

Valves

Fire Hydrants

Backflow Prevention Training Certificate

Backflow Tester Certification

Backflow Certificate

Fusion Technician Qualifications; G

SD-08 Manufacturer's Instructions

Ductile-Iron Piping

PVC Piping

PVCO Piping

Polyethylene (PE) Pipe

Fiberglass Pipe, Fittings, Joints And Joint Materials

PVC Piping For Service Lines

Copper Pipe For Service Lines

Polyethylene (PE) Piping And Tubing For Service Lines

1.5 QUALITY CONTROL

1.5.1 Regulatory Requirements

Use NSF/ANSI 61 or NSF/ANSI 14 materials for potable water systems to comply with lead free content requirements as defined by the U.S. Safe Drinking Water Act effective January 2014.

Comply with NFPA 24 for materials, installation, and testing of fire main piping and components.

1.5.2 Qualifications

1.5.2.1 Backflow Preventers

1.5.2.1.1 Backflow Preventer Certificate

Certificate of Full Approval from FCCCHR List, University of Southern California, attesting that the design, size and make of each backflow preventer has satisfactorily passed the complete sequence of performance testing and evaluation for the respective level of approval. Certificate of Provisional Approval will not be acceptable.

1.5.2.1.1.1 Backflow Tester Certificate

Prior to testing, submit to the Contracting Officer certification issued by the State or local regulatory agency attesting that the backflow tester has successfully completed a certification course sponsored by the regulatory agency. Tester must not be affiliated with any company participating in any other phase of this Contract.

1.5.2.1.1.2 Backflow Prevention Training Certificate

Submit a certificate recognized by the State or local authority that states the Contractor has completed at least 10 hours of training in backflow preventer installations. The certificate must be current.

1.5.2.2 Fusion Technician Qualifications

Submit a certificate from the manufacturer of the fusible pipe that shows the fusion technician is fully qualified to install fusible pipe of the types and sizes being used. Qualification must be current as of the actual date of fusion performance on the project.

1.5.2.2.1 Fusion Technician Qualification on Polyethylene (PE) Pipe and Fittings

Provide certification for PE Pipe heat fusion in accordance with ASTM F3190.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Delivery and Storage

Inspect materials delivered to site for required pipe markings and damage. Unload and store with minimum handling and in accordance with manufacturer's instructions to prevent cuts, scratches and other damage. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, valves, fire hydrants, and other accessories free of dirt and debris or other contaminates.

1.6.2 Handling

Handle pipe, fittings, valves, fire hydrants, and other accessories in accordance with applicable AWWA standard, manufacturer's instructions and in a manner to ensure delivery to the trench in sound undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place other material, hooks, or pipe inside a pipe or fitting after the coating has been applied. Inspect the pipe for defects before installation. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. Clean the interior of pipe and accessories of foreign matter before being lowered into the trench and keep them clean during laying operations by plugging. Replace defective material without additional expense to the Government. Store rubber gaskets, not immediately installed, under cover or out of direct sunlight.

Handle ductile iron pipe, fittings, and accessories in accordance with AWWA C600 and AWWA M41. Handle PVC and PVCO pipe, fittings, and accessories in accordance with AWWA C605. Handle PE pipe, fittings, and accessories in accordance with AWWA M55. Handle fiberglass pipe, fittings, and accessories in accordance with AWWA M45. Handle steel pipe, fittings and accessories in accordance with AWWA C604.

PART 2 PRODUCTS

2.1 MATERIALS

All materials are intended for potable water use unless otherwise indicated. Comply with NSF/ANSI 61 or NSF/ANSI 14 for all potable water pipe, fittings and other applicable materials. Provide pipe, fittings and other applicable materials bearing NSF/ANSI 61 or NSF/ANSI 14 markings for potable water service.

Provide all materials in accordance with AWWA C800 and as indicated herein. Provide valves and fittings with pressure ratings equivalent to the pressure ratings of the pipe.

2.1.1 Pipe, Fittings, Joints And Couplings

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.

2.1.1.1 Ductile-Iron Piping

2.1.1.1.1 Pipe and Fittings

Pipe, AWWA C151/A21.51, . Fittings, AWWA C110/A21.10 or AWWA C153/A21.53; fittings with push-on joint ends are to meet the same requirements as fittings with mechanical-joint ends, except for the factory modified bell design. Provide fittings with pressure ratings equivalent to that of the pipe. Provide compatible pipe ends and fittings for the specified joints. Provide cement-mortar lining, AWWA C104/A21.4, twice the standard thickness on pipe and fittings.

2.1.1.1.2 Joints and Jointing Material

Provide push-on joints or mechanical joints for pipe and fittings unless otherwise indicated. Provide mechanical joints where indicated. Provide flanged joints where indicated. Provide mechanically coupled type joints using a sleeve-type mechanical coupling where indicated. Provide grooved or shouldered type joints where indicated. Provide insulating joints where indicated. Sleeve-type mechanical couplings in lieu of push-on joints are acceptable, subject to the limitations specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS. Utilize grooved or shouldered type joints in lieu of flanged joint or push-on joint, except where joint is buried.

a. Push-On Joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly as recommended in AWWA C111/A21.11.

b. Mechanical Joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets as recommended in AWWA C111/A21.11.

c. Flanged Joints: Bolts, nuts, and gaskets for flanged connections as recommended in Appendix A of AWWA C115/A21.15. Provide AWWA C115/A21.15 ductile iron flanges and conform to ASME B16.1, Class 125. Provide ASTM A536 epoxy coated steel set screw flanges. Gasket and lubricants for set screw flanges, in accordance with mechanical-joint gaskets specified in AWWA C111/A21.11.

d. Insulating Joints: Designed to prevent metal-to-metal contact at the joint between adjacent sections of piping. Provide flanged type joint with insulating gasket, insulating bolt sleeves, and insulating washers. Provide full face dielectric type gaskets, as recommended in the Appendix to AWWA C115/A21.15. Bolts and nuts, as recommended in the Appendix to AWWA C115/A21.15.

e. Sleeve-Type Mechanical Coupled Joints: As specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS.

f. Grooved and Shouldered Type Joints: Grooved and shouldered pipe ends and couplings, AWWA C606. Joint dimension as specified in AWWA C606 for rigid joints, joint dimensions as specified in AWWA C606 for flexible joints.

2.1.1.2 Plastic Piping

2.1.1.2.1 PVC and PVCO Piping

2.1.1.2.1.1 PVC Piping

AWWA C900 plain end or gasket bell end pipe meeting or exceeding ASTM D1784 cell class 12454, with a minimum Pressure Class , , 200 (DR21), , with ductile iron outside diameter (DIOD).

2.1.1.2.1.2 PVCO Piping

AWWA C909, ASTM F1483 plain end or gasket bell end pipe meeting or exceeding ASTM D1784 cell class 12454, Pressure Class 165 PVCO pressure pipe, with ductile iron outside diameter (DIOD).

2.1.1.2.1.3 Fittings for PVC and PVCO Pipe

Ductile iron fittings, AWWA C110/A21.10 or compact fittings in accordance with AWWA C153/A21.53, with cement-mortar lining for fittings, AWWA C104/A21.4, standard thickness. Fittings with push-on joint ends are to conform to the same requirements as fittings with mechanical-joint ends, except for the factory modified bell design compatible for use with PVC pipe as specified.

Fittings from material that meets or exceeds ASTM D1784 cell class 12454 and is the same material as the pipe with elastomeric gaskets, in conformance with AWWA C605 and AWWA C900.

2.1.1.2.1.4 Joints and Jointing Material for PVC and PVCO Piping

a. Push-on joints: Use jointing material in accordance with ASTM D3139 and AWWA C111/A21.11 between pipes, pipes and metal fittings, valves, and other accessories or compression-type joints/mechanical joints. Provide each joint connection with an elastomeric gasket compatible for the bell or coupling used. Gaskets for push-on joints for pipe, ASTM F477. Gaskets for push-on joints and compression-type joints/mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories, AWWA C111/A21.11, respectively, for push-on joints and mechanical joints.

b. Mechanical Joint: Use mechanically coupled joints having a sleeve-type mechanical coupling, as specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS, as an optional jointing method for plain-end PVC pipe, subject to the limitations specified for mechanically coupled joints using a sleeve-type mechanical coupling as specified for compression-type joints in ASTM D3139. Provide jointing material in accordance with AWWA C111/A21.11 between pipe and sleeve-type mechanical couplings.

2.1.1.2.2 PVC Piping for Service Lines

2.1.1.2.2.1 Pipe and Fittings

Provide ASTM D1784 cell class 12454 pipe and fittings of the same PVC material.

a. ASTM D1785, Schedule 40 with ASTM D2466 Schedule 40 or ASTM D2467

Schedule 80 fittings.

b. ASTM D2241 pipe and fittings with SDR as necessary to provide 150 psi minimum pressure rating with ASTM D2466 Schedule 40 or ASTM D2467 Schedule 80 fittings.

2.1.1.2.2.2 Joints and Connections

Fittings may be joined by the solvent-cement method or threading.

2.1.1.2.2.3 Solvent Joining

Provide solvent joints in accordance with ASTM D2855.

2.1.1.2.3 Polyethylene (PE) Pipe

AWWA C906, ASTM F714, PE4710, minimum cell class PE 445574C, oxidative resistance classification CC3 with a minimum Pressure Class 200 (DR11) and ductile iron outside diameter (DIOD).

2.1.1.2.3.1 Fittings For PE Pipe

Ductile iron fittings, AWWA C110/A21.10 or compact ductile iron fittings in accordance with AWWA C153/A21.53, with cement-mortar lining for ductile iron fittings, AWWA C104/A21.4, standard thickness. Fittings with push-on joint ends are to conform to the same requirements as fittings with mechanical-joint ends.

2.1.1.2.3.2 Joints and Jointing Materials

Mechanical Joint: AWWA C111/A21.11 DIOD Mechanical joint adapter and gaskets for mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories.

2.1.1.2.4 Polyethylene (PE) Piping and Tubing for Service Lines

2.1.1.2.4.1 PE Service Line Pipe And Tubing

AWWA C901, PE4710, ASTM D3035, ASTM D3350 minimum cell class PE 445574C, oxidative resistance classification CC3 with a minimum Pressure Class .

2.1.1.2.4.2 PE Service Line Fittings

AWWA C901, PE4710, ASTM D3350 minimum cell class PE 445574C, oxidative resistance classification CC3 with a minimum Pressure Class 250, molded ASTM D2683 caps, reducers, couplings, elbows, and tees or compatible fittings in accordance with this specification.

2.1.1.3 Steel Piping

2.1.1.3.1 Pipe and Fittings

Pipe, AWWA C200. Fittings, AWWA C208 and AWWA C200, with reference to the requirements specified therein for "Special Sections." Provide cement-mortar lining and cement-mortar coal-tar enamel coal-tar epoxy coating on pipe and fittings for underground lines in accordance with applicable AWWA standard. Provide cement-mortar lining on pipe and fittings for aboveground lines. Utilize pipe ends and fittings compatible for the joints and jointing materials used.

a. Utilize welded or seamless pipe with plain, or shouldered and grooved ends in accordance with AWWA C606 for use with mechanical couplings or bell-and-spigot ends with rubber gaskets. Provide bell-and-spigot ends for sizes less than 6 inches diameter in accordance with AWWA C200.

b. Provide fittings and specials made of the same material as the pipe. Use specials and fittings made of standard steel tube turns or segmentally welded sections, with ends to accommodate the type of couplings or joints specified for the pipe. Match the thickness rating of pipe fittings and specials to the thickness specified and the pressure rating calculated for the pipe with which they are used. Provide identical protective materials for fittings and specials as specified for the pipe. Hand wrap, line, or coat specials and fittings that cannot be mechanically wrapped, lined, or coated using the same material used for the pipe with the same number of applications of each material, smoothly applied.

2.1.1.3.2 Wall Thickness for Pipe and Fittings

The minimum metal thickness for steel pipe wall shall be as indicated.. Wall thickness of steel pipe and fittings shall be determined by the manufacturer of the pipe and calculated in the following manner. Design for the following minimum conditions:

Pressure rating	as specified
Earth cover	as specified
Water hammer	40 percent of pressure rating
Live load	AASHTO H 20 truck loading
Allowable deflection	2 percent of nominal pipe diameter

Ensure that the wall thickness of fittings is equal to or greater than that required for the pipe. Reinforce fittings in accordance with methods given in AWWA M11, Chapter 13, "Supplementary Design Data and Details" when necessary to meet the pressure test requirements.

2.1.1.3.3 Joints and Jointing Material

Provide rubber-gasketed pipe and fitting bell-and-spigot joints, welded joints, or the mechanically coupled type using a sleeve-type mechanical coupling, unless otherwise specified. Provide flanged joints where indicated. Provide mechanically coupled type joints using a sleeve type mechanical coupling where indicated. Provide grooved or shouldered type where indicated. Provide insulating joints where indicated. It is acceptable to use grooved or shouldered type joints in lieu of flanged joints.

a. Rubber-Gasketed Bell-and-Spigot Joints: Provide joints and pipe ends in accordance with the pipe manufacturer's standard for this type of joint, except that the joint is to also meet the requirements specified for rubber-gasketed joints and rubber gaskets in AWWA C200.

b. Welded Joints: Provide electrodes of the quality specified in AWWA C206.

c. Sleeve-Type Mechanical Coupled Joints: As specified in paragraph SLEEVE-TYPE MECHANICAL COUPLINGS.

d. Grooved and Shouldered Type Joints: Provide pipe ends grooved by roll grooving or with welded-on adapters and cut grooves. Provide grooves made by roll grooving with dimensions as recommended by the coupling manufacturer. Match dimensions for cut grooves in adapters to AWWA C606. Couplings and shouldered pipe ends, AWWA C606. Match the joint dimensions as specified in AWWA C606 for rigid joint , joint dimensions as specified in AWWA C606 for flexible joints.

e. Flanged Joints: Provide pipe ends with steel flanges, AWWA C207; Class D Class E. Bolts and nuts for flanged connections, AWWA C207. Rubber gaskets, AWWA C207; asbestos gaskets are not allowed.

f. Insulating Joints: Designed to prevent metal-to-metal contact at the joint between adjacent sections of piping. Provide flange type joints with insulating gasket, insulating bolt sleeves, and insulating washers. Provide dielectric type gaskets, full face, and in other respects as recommended in the Appendix to AWWA C115/A21.15. Bolts and nuts as recommended in the Appendix to AWWA C115/A21.15.

2.1.1.3.4 Lining and Coating

a. Cement-Mortar Lining: AWWA C205, shop-applied. Materials for cement mortar lining in place as specified in AWWA C602.

b. Cement-Mortar Coating: AWWA C205, shop-applied.

c. Coal-Tar Enamel Coating: Except as otherwise specified, prepare, prime, and coat piping with hot-applied coal-tar enamel and a bonded single layer of felt wrap in accordance with AWWA C203 double felt wraps in accordance with AWWA C203. Provide shop applied coating of fibrous-glass mat felt material as specified in Section 10 of AWWA C203. Do not use asbestos felt.

d. Coal-Tar Epoxy Coating: Clean, prime, and topcoat piping with coal-tar epoxy coating system in accordance with AWWA C210. Shop-apply coating.

2.1.1.3.5 Steel Piping for Service Lines

Pipe, ASTM A53/A53M, Standard Weight, zinc-coated. Fittings, ASME B16.4, Class 125, zinc coated; or ASME B16.3, Class 150, zinc coated, threaded.

Mechanically apply, in a factory or plant especially equipped for the purpose, the protective materials for steel pipe. Unless otherwise indicated, the materials consist of the following for the indicated pipe material and size:

Clean pipe and fittings less than 3 inches in diameter of foreign material by wire brushing and solvent cleaning, and apply one coat of coal-tar primer and two coats of coal-tar enamel matching the requirements of AWWA C203; protect threaded ends of pipe and fittings prior to coating.

2.1.1.4 Copper Pipe For Service Lines

2.1.1.4.1 Copper Tubing and Associated Fittings

Provide ASTM B88, Type K copper tubing. Provide AWWA C800 fittings. AWWA C800 includes ASME B1.20.3, ASME B1.20.1, ASME B16.18 solder-type joint fittings.

2.1.1.5 Trenchless Piping

2.1.1.5.1 PVC Pipe

AWWA C900 plain end meeting or exceeding ASTM D1784 cell class 12454, plastic formulated for fusing with a minimum Pressure Class 235 (DR18) 305 (DR 14) with ductile iron outside diameter (DIOD).

2.1.1.5.1.1 Butt Fusion

Use butt fusion jointing method for plain-end PVC pipe. Comply with AWWA C900 and AWWA C605 for butt fusion joints. No offset in alignment between adjacent pipe joints of fittings is permitted. The fusion technician must be qualified by the fusion equipment manufacturer to thermally butt-fuse the size of pipe used at the time of fusion performance. Each joint must be datalogged, recorded and submitted for review and meet the requirements of ASTM F1674.

2.1.1.5.2 PE Pipe and Tubing

Provide PE pipe in accordance with paragraphs POLYETHYLENE(PE) PIPE or POLYETHYLENE (PE) PIPING AND TUBING FOR SERVICE LINES in this specification. Submit fusion joining information including recommended fusion parameters, recommended product and environmental conditions for joining and documentation that these parameters and conditions have been validated by appropriate testing.

2.1.1.5.2.1 Butt and Socket Fusion Fittings

Use Provide PE pipe fittings in accordance with paragraphs FITTINGS FOR PE PIPE or PE SERVICE LINE FITTINGS in this specification. Use ASTM D3261, socket fusion caps, reducers, couplings, elbows, and tees.

2.1.1.5.2.2 Butt and Socket Fusion

Use ASTM F2620 butt or socket fusion jointing method for plain-end PE pipe. Comply with AWWA C906, ASTM F3190, and ASTM F2620 for Butt Fusion joints. No offset in alignment between adjacent pipe joints of fittings is permitted. The fusion technician must be qualified by the fusion equipment manufacturer to thermally butt-fuse the size of pipe used at the time of fusion performance. Each joint must be datalogged, recorded and submitted for review.

2.1.1.5.2.3 Electrofusion Fittings

Provide PE pipe fittings in accordance with paragraphs FITTINGS FOR PE PIPE or PE SERVICE LINE FITTINGS in this specification. Use ASTM F1055, socket fusion caps, reducers, couplings, elbows, and tees.

2.1.1.5.2.4 Electrofusion

Use AWWA M55 and ASTM F1290 electrofusion jointing method for PE pipe. No offset in alignment between adjacent pipe joints of fittings is permitted. The fusion technician must be qualified by the fusion equipment manufacturer to thermally butt-fuse the size of pipe used at the time of fusion performance. Each joint must be datalogged, recorded and submitted for review.

2.1.1.5.3 Ductile Iron Ball and Socket Joint

Use centrifugally cast ductile iron pipe meeting the applicable requirements of AWWA C151/A21.51 and in accordance with pipe manufacturer's instructions. The separately cast Ductile-Iron ball, bell and retainer ring conforms with the requirements of ASTM A536, Grade 70-50-05. Critical surfaces of the ball, bell socket and retainer ring are machined.

2.1.1.5.3.1 Fittings

Ductile iron bell, ball and retainer ring meeting the applicable requirements of AWWA C110/A21.10and in accordance with pipe manufacturer's instructions for ball and socket joint pipe.

2.1.2 Valves

Provide a protective interior coating in accordance with AWWA C550.

2.1.2.1 Gate Valves 3 Inch Size and Larger on Buried Piping

AWWA C500, AWWA C509, AWWA C515, or UL 262 and:

a. AWWA C500: nonrising stem type with double-disc gate and mechanical-joint ends or push-on joint ends compatible for the adjoining pipe

b. AWWA C509 or AWWA C515: nonrising stem type with mechanical-joint ends or resilient-seated gate valves 3 to 12 inches in size

c. UL 262: inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working pressure of 175 psi, and have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined.

Match materials for UL 262 gate valves to the reference standards specified in AWWA C500. Gate valves open by counterclockwise rotation of the valve stem. Stuffing boxes have 0-ring stem seals. Stuffing boxes are bolted and constructed so as to permit easy removal of parts for repair. Provide valve ends and gaskets for connection to cement piping or to sleeve-type mechanical couplings that conform to the requirements specified respectively for the joint or coupling. Provide all valves from one manufacturer.

2.1.2.2 Gate Valves 3 Inch Size and Larger in Valve Pit(s) and Aboveground Locations

AWWA C500, AWWA C509, AWWA C515, or UL 262 and:

a. AWWA C500: outside-screw-and-yoke rising-stem or nonrising stem type with double-disc or solid-wedge gates and flanged ends

b. AWWA C509 or AWWA C515: outside-screw-and-yoke rising-stem or nonrising stem type with flanged ends

c. UL 262: outside-screw-and-yoke or inside-screw type, with double-disc or split-wedge or solid or one-piece type gate and flanged ends, and designed for a hydraulic working pressure of 175 psi

Match materials for UL 262 gate valves to the reference standards specified in AWWA C500. Provide gate valves with handwheels that open by counterclockwise rotation of the valve stem. Bolt and construct stuffing boxes so as to permit easy removal of parts for repair. In lieu of flanged ends, provide valves with grooved or shouldered ends compatible with grooved or shouldered type joints, as specified in the paragraph DUCTILE-IRON PIPING. Provide all valves from one manufacturer.

2.1.2.3 Check Valves

Provide a protective interior coating in accordance with AWWA C550. Swing-check type, AWWA C508 or UL 312 and:

a. AWWA C508: Iron or steel body and cover and flanged ends

b. UL 312: Cast iron or steel body and cover, flanged ends, and designed for a minimum working pressure of 150 psi.

Materials for UL 312 check valves are to match the reference standards specified in AWWA C508. Provide check valves with a clear port opening. Provide grooved or shouldered ends grooved or shouldered type joints, as specified in the paragraph DUCTILE-IRON PIPING in lieu of flanged ends. Provide all check valves from one manufacturer.

2.1.2.4 Rubber-Seated Butterfly Valves

Provide rubber-seated butterfly valves and wafer type valves that match the performance requirements of AWWA C504. Wafer type valves not meeting laying length requirements are acceptable if supplied and installed with a spacer, providing the specified laying length. Meet all tests required by AWWA C504. Flanged-end valves are required in a pit. Provide a union or sleeve-type coupling in the pit to permit removal. Direct-bury mechanical-end valves 3 through 10 inches in diameter. Provide a valve box, means for manual operation, and an adjacent pipe joint to facilitate valve removal. Provide valve operators that restrict closing to a rate requiring approximately 60 seconds, from fully open to fully closed.

2.1.2.5 Pressure Reducing Valves

Maintain a constant downstream pressure regardless of fluctuations in demand. Using pressure reducing valves capable of providing high psi operating pressure on the inlet side, with outlet pressure set for normal range psi. Provide hydraulically-operated, pilot controlled, globe or angle type valves that are capable of being actuated either by diaphragm or piston. Provide diaphragm-operated, adjustable, spring-loaded type pilot controls made of lead-free bronze with stainless steel working parts, designed to permit flow when controlling pressure exceeds the spring setting. Construct the bodies of bronze, cast iron or cast steel with lead-free bronze trim; the valve stem of stainless steel; the seat of lead-free bronze; and the valve discs and diaphragms of synthetic rubber. Provide threaded or flanged ends.

2.1.2.6 Air Release, Air/Vacuum, and Combination Air Valves

Provide AWWA C512 air release , air vacuum and combination air valves that release air and prevent the formation of a vacuum. Provide valves with an iron body, lead-free bronze trim and stainless steel float that automatically releases air when the lines are being filled with water and admits air into the line when water is being withdrawn in excess of the inflow.

2.1.2.7 Water Service Valves

2.1.2.7.1 Gate Valves Smaller than 3 Inch in Size on Buried Piping

Gate valves smaller than 3 inch size on Buried Piping MSS SP-80, Class 150, solid wedge, nonrising stem, with flanged or threaded end connections, a union on one side of the valve, and a handwheel operator.

2.1.2.7.2 Gate Valves Smaller Than 3 Inch Size in Valve Pits

MSS SP-80, Class 150, solid wedge, inside screw, rising stem. Provide valves with flanged or threaded end connections, a union on one side of the valve, and a handwheel operator.

2.1.2.7.3 Check Valves Smaller than 2 Inch in Size

Provide check valves with a minimum working pressure of 150 psi or as indicated with a clear waterway equal to the full nominal diameter of the valve. Valves open to permit flow when inlet pressure is greater than the discharge pressure, and close tightly to prevent return flow when discharge pressure exceeds inlet pressure. Cast the size of the valve, working pressure, manufacturer's name, initials, or trademark on the body of each valve.

Provide valves for screwed fittings, made of lead-free bronze and in conformance with MSS SP-80, Class 150, Types 3 and 4 compatible for the application.

2.1.2.8 Valve Boxes

Provide a valve box for each gate valve on buried piping, except where indicator post is shown. Construct adjustable valve boxes manufactured from cast iron or precast concrete of a size compatible for the valve on which it is used. Provide cast iron valve boxes with a minimum cover and wall thickness of 3/16 inch and conforming to ASTM A48/A48M, Class 35B. Coat the cast-iron box with a heavy coat of bituminous paint. Provide a round head. Cast the word "WATER" on the lid. The minimum diameter of the shaft of the box is 5 1/4 inches. Provide ASTM C1433 precast concrete valve box. Provide precast concrete boxes installed in locations subjected to vehicular traffic to withstand AASHTO load designation as outlined in AASHTO HB-17. Manufacture precast concrete boxes in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION.

2.1.2.9 Valve Pits

Construct the valve pits at locations indicated or as required above and in accordance with the details shown.

2.1.3 Blowoff Valve Assemblies

Provide blowoff valve assemblies complete with all pipe, fittings, valve, valve box, riser box and lid, riser extension, discharge fitting and other materials required to connect to the water main. Provide blow off valve assemblies 4 inches or larger with AWWA C110/A21.10 or AWWA C153/A21.53 fittings. Provide a blowoff valve assembly with a removable riser.

2.1.4 Fire Hydrants and Hose Houses

2.1.4.1 Fire Hydrants

Provide fire hydrants where indicated. Paint fire hydrants with at least one coat of primer and two coats of enamel paint. Paint barrel and bonnet colors in accordance with UFC 3-600-01. Stencil fire hydrant number and main size on the fire hydrant barrel using black stencil paint.

2.1.4.1.1 Dry-Barrel Type and Wet-Barrel Type Fire Hydrants

Provide Dry-barrel type fire hydrants, AWWA C502 or UL 246, "Base Valve" with 6 inch inlet, 5 1/4 inch valve opening, one 4 1/2 inch pumper connection, and two 2 1/2 inch hose connections. Provide Wet-barrel type fire hydrants, AWWA C503 or UL 246, "Wet Barrel" with 6 inch inlet, one 4 1/2 inch pumper connection, and two 2 1/2 inch hose connections. Individually valve pumper connection and hose connections with independent nozzle gate valves.

Provide mechanical-joint end only inlet ; with end matching requirements for size and shape of operating nut, cap nuts, and threads on hose and pumper connections. Provide fire hydrants with frangible sections as mentioned in AWWA C502. Provide fire hydrant with special couplings joining upper and lower sections of fire hydrant barrel and upper and lower sections of fire hydrant stem that break from a force imposed by a moving vehicle.

2.1.4.1.2 Flush-Type Fire Hydrants

Provide flush-type fire hydrants that conform to the applicable requirements of AWWA C502, except that they are designed to permit placement of fire hydrant below surface of pavement. Provide 6 inch inlet, 4 1/4 inch minimum valve opening, one 4 1/2 inch pumper connection, and one 2 1/2 inch hose connection that have readily accessible hose and pumper connections and operating nuts enclosed in a cast iron box with a cast-iron cover set flush with the pavement. Provide flush lifting cover handle. Inlet has either mechanical-joint or push-on joint end . Size and shape of operating nut and cap nuts and threads on hose and pumper connections as specified in AWWA C502.

2.1.4.2 Fire Hydrant Hose Houses

Provide hose houses matching the requirements of NFPA 24 at each fire hydrant indicated on the drawings to have a fire hydrant hose house.

2.1.4.2.1 Additional Equipment

Provide the following equipment, in addition to that listed in NFPA 24, Hose Houses and Equipment, with each hose house:

a. 200 feet of 2-1/2 inch woven jacketed, rubber lined hose matching the requirements of NFPA 1961 with a minimum service test pressure of 300 psi; 100 feet of 1-1/2 inch woven jacketed, rubber lined hose matching the requirements of NFPA 1961 with a minimum service test pressure of 300 psi;

b. One gated 2-1/2 by 1-1/2 by 1-1/2 inch wye;

c. One playpipe for 2-1/2 inch hose with 1 inch shutoff nozzle tip;

d. One playpipe for 1-1/2 inch hose with 1/2 inch shutoff nozzle or combination nozzle;

e. Two adapter fittings, 2-1/2 to 1-1/2 inch;

f. Two spanners for 1-1/2 inch hose.

2.1.5 Meters

Submit certificates certifying all required and recommended tests set forth in the referenced standard and AWWA M6 have been performed and comply with all applicable requirements of the referenced standard and AWWA M6 within the past three years. Include certification that each meter has been tested for accuracy of registration and that each meter complies with the accuracy and capacity requirements of the referenced standard when tested in accordance with AWWA M6.

Include a register with all meters whether they are or are not connected to a remote reading system.

2.1.5.1 Turbine Type Meters

Provide AWWA C701 Class I Class II Advanced Metering Infrastructure (AMI) and Direct Digital Communication (DDC) compatible meter with a strainer screen. Main casing constructed of copper alloy containing not less than 75 percent copper cast iron or with protective coating in accordance with AWWA C213 or AWWA C550.

2.1.5.2 Propeller Type Meters

Provide AWWA C704 Advanced Metering Infrastructure (AMI) and Direct Digital Communication (DDC) compatible meter. Flow tubes or main cases constructed of cast iron or fabricated steel.

2.1.5.3 Meter Connections

Provide connections compatible with the type of pipe and conditions encountered.

2.1.5.4 Direct Digital Control System Interface

Provide all meters with the capability of providing pulse output to the DDC system provided in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

2.1.5.5 Meter Vaults

Provide meter vaults of sufficient size to completely enclose the meter and shutoff valve or service stop and in accordance with the details shown on the drawings. Provide a meter boxes or vaults with a height equal to the distance from invert of the service line to finished grade at the meter location.

2.1.5.5.1 Cast Iron

Provide ASTM A48/A48M, Class 25 cast iron meter box and lid. Provide a round lid with precast holes for remote electronic meter reading modules having the word "WATER" cast on the top surface.

2.1.5.5.2 Precast Concrete Meter Boxes or Vaults

Provide precast concrete meter boxes in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION. precast concrete meter boxes or vaults with ASTM A48/A48M, Class 25 cast iron lid. Provide a ASTM A48/A48M, Class 25 cast iron round lid having the word "WATER" cast on it. Provide meter boxes or vaults of sufficient size to completely enclose the meter and shutoff valve or service stop and in accordance with the details shown on the drawings.

2.1.5.5.2.1 Vault Access Door

Provide a single-leaf or double-leaf cast-in aluminum or painted steel diamond-plate access door.

Include stainless steel spring or pneumatic lift assist, type 316 stainless steel slam locking latch, automatic hold-open arm with a red release handle, and flush mounted retractable lifting handle. Door must have a minimum load rating for 15,000 lbs load. Center door over ladder and aligned with interior wall.

2.1.5.5.2.2 Fittings

Provide flanged fittings for pipe 3 inches and larger.

2.1.5.5.2.3 Vault Valves

Provide ball valves in meter vault.

2.1.5.5.3 Plastic Meter Boxes

Provide manufactured plastic boxes and lids meeting the following requirements:

a. One-piece molded construction

b. Vertical load rating for medium duty use of 15,000 lbs

c. Ultraviolet (UV) exterior surface protection

d. White interior surface

Provide a ASTM A48/A48M, Class 25 cast iron ring and round lid.

2.1.6 Backflow Preventers

Provide a bronze, cast iron or ductile iron AWWA C511 reduced pressure principle type backflow preventer.d. Flanged cast iron, bronze, brass or mounted gate valve

The particular make, model, and size of backflow preventers to be installed must be included in the latest edition of the List of Approved Backflow Prevention Assemblies issued by the FCCCHR List and be accompanied by a backflow certificate of full approval from FCCCHR List. Select materials for piping, strainers, and valves used in assembly installation that are galvanically compatible. Materials joined, connected, or otherwise in contact are to have no greater than 0.25 V difference on the Anodic Index, unless separated by a dielectric type union or fitting.

2.1.6.1 Backflow Preventer Enclosure

Provide an insulated enclosure.

2.1.7 Disinfection

Chlorinating materials are to conform to: Chlorine, Liquid: AWWA B301; Hypochlorite, Calcium and Sodium: AWWA B300.

2.2 ACCESSORIES

2.2.1 Pipe Restraint

2.2.1.1 Thrust Blocks

Use ASTM C94/C94M concrete having a minimum compressive strength of 3,000 psi at 28 days or use concrete of a mix not leaner than one part cement, two and one half parts sand, and five parts gravel, having the same minimum compressive strength.

2.2.1.2 Precast Thrust Blocks

Provide precast concrete thrust blocks.

2.2.1.3 Joint Restraint

Provide restrained joints in accordance with NFPA 24, Chapter 10 and in accordance with ASTM F1674.

Provide mechanical joint restraint restraint devices with gripper wedges incorporated into a follower gland and specifically designed for the pipe material and meeting the requirements of AWWA C110/A21.10 or metal harness fabricated by the pipe manufacturer.

2.2.2 Protective Enclosures

Provide Freeze-Protection Enclosures that are insulated and designed to protect aboveground water piping, equipment, or specialties from freezing and damage.

2.2.2.1 Housing

Reinforced and insulated aluminum or fiberglass construction; with anchoring devices for attaching housing to concrete base, access doors with locking devices, sized to allow access and service of the protected unit, drain openings, and an electric heating cable or heater with self-limiting temperature control.

2.2.3 Tapping Sleeves

Provide cast gray, ductile, malleable iron or stainless steel, split-sleeve type tapping sleeves of the sizes indicated for connection to existing main with flanged or grooved outlet, and with bolts, follower rings and gaskets on each end of the sleeve. Utilize similar metals for bolts, nuts, and washers to minimize the possibility of galvanic corrosion. Provide dielectric gaskets where dissimilar metals adjoin. Provide a tapping sleeve assembly with a maximum working pressure of 150 psi. Provide bolts with square heads and hexagonal nuts. Longitudinal gaskets and mechanical joints with gaskets as recommended by the manufacturer of the sleeve. When using grooved mechanical tee, utilize an upper housing with full locating collar for rigid positioning which engages a machine-cut hole in pipe, encasing an elastomeric gasket which conforms to the pipe outside diameter around the hole and a lower housing with positioning lugs, secured together during assembly by nuts and bolts as specified, pre-torqued to 50 foot-pound.

2.2.4 Sleeve-Type Mechanical Couplings

Use AWWA C219 couplings to join plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. The coupling consists of one middle ring flared or beveled at each end to provide a gasket seat; two follower rings; two resilient tapered rubber gaskets; and bolts and nuts to draw the follower rings toward each other to compress the gaskets. Provide true circular middle ring and the follower rings sections free from irregularities, flat spots, and surface defects; provide for confinement and compression of the gaskets. For ductile iron and PVC pipe, use ASTM A536 ductile iron. For steel piping, the middle ring is steel and the follower rings are steel. Steel is to have a strength not less than that of the pipe. Use gaskets for resistance to set after installation and to meet the requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Provide track-head type bolts ASTM A307, Grade A, with ASTM A563, Grade A nuts or round-head square-neck type ASME B18.5.2.2M or ASME B18.5.2.1M bolts with ASME B18.2.2 hex nuts. Provide 5/8 inch diameter bolts. Shape bolt holes in follower rings to hold fast to the necks of the bolts used. Do not use mechanically coupled joints using a sleeve-type mechanical coupling as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint. Provide a tight flexible joint with mechanical couplings under reasonable conditions, such as pipe movements caused by expansion, contraction, slight settling or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Match coupling strength to that of the adjoining pipeline.

2.2.5 Insulating Joints

Provide a rubber-gasketed insulating joint or dielectric coupling between pipe of dissimilar metals which will effectively prevent metal-to-metal contact between adjacent sections of piping.

2.2.6 Bonded Joints

For all ferrous pipe, provide a metallic bond at each joint, including joints made with flexible couplings, caulking, or rubber gaskets, of ferrous metallic piping to effect continuous conductivity. Provide Size 1/0 copper conductor thermal weld type bond wire designed for direct burial and shaped to stand clear of the joint.

2.2.7 Dielectric Fittings

Install dielectric fittings between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains to prevent metal-to-metal contact of dissimilar metallic piping elements and compatible with the indicated working pressure.

2.2.8 Tracer Wire for Nonmetallic Piping

Provide a continuous bare copper or aluminum wire not less than 0.10 inch in diameter in sufficient length over each separate run of nonmetallic pipe.

2.2.9 Water Service Line Appurtenances

2.2.9.1 Corporation Stops

Ground key type; lead-free bronze, ASTM B61 or ASTM B62; compatible with the working pressure of the system and solder-joint, or flared tube compression type joint. Threaded ends for inlet and outlet of corporation stops, AWWA C800; coupling nut for connection to flared copper tubing, ASME B16.26.

2.2.9.2 Curb or Service Stops

Ground key, round way, inverted key type; made of lead-free bronze, ASTM B61 or ASTM B62; and compatible with the working pressure of the system. Provide compatible ends for connection to the service piping. Cast an arrow into body of the curb or service stop indicating direction of flow.

2.2.9.3 Service Clamps

Provide single or double flattened strap type service clamps used for repairing damaged cast-iron, steel or PVC pipe with a pressure rating not less than that of the pipe being repaired. Provide clamps with a galvanized malleable-iron body with cadmium plated straps and nuts and a rubber gasket cemented to the body.

2.2.9.4 Goosenecks

Manufacture goosenecks from Type K copper tubing; provide joint ends for goosenecks compatible with connecting to corporation stop and service line. Where multiple gooseneck connections are required for an individual service, connect goosenecks to the service line through a compatible lead-free brass or bronze branch connection; the total clear area of the branches to be at least equal to the clear area of the service line.

2.2.9.5 Curb Boxes

Provide a curb box for each curb or service stop manufactured from cast iron, size capable of containing the stop where it is used. Provide a round head. Cast the word "WATER" on the lid. Factory coat the box with a heavy coat of bituminous paint.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Connections to Existing System

Perform all connections to the existing water system in the presence of the Contracting Officer.

3.1.2 Operation of Existing Valves

Do not operate valves within or directly connected to the existing water system unless expressly directed to do so by the Contracting Officer.

3.1.3 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL.

3.2 INSTALLATION

Install all materials in accordance with the applicable reference standard, manufacturers instructions and as indicated herein.

3.2.1 Piping

3.2.1.1 General Requirements

Install pipe, fittings, joints and couplings in accordance with the applicable referenced standard, the manufacturer's instructions and as specified herein.

3.2.1.1.1 Termination of Water Lines

Terminate the work covered by this section at a point approximately 5 feet from the building, unless otherwise indicated.

Do not lay water lines in the same trench with gas lines, fuel lines, electric wiring, or any other utility. Do not install copper tubing in the same trench with ferrous piping materials. Where nonferrous metallic pipe (i.e., copper tubing) crosses any ferrous piping, provide a minimum vertical separation of 12 inches between pipes.

3.2.1.1.2 Pipe Laying and Jointing

Remove fins and burrs from pipe and fittings. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition. Provide proper facilities for lowering sections of pipe into trenches. Under no circumstances is it permissible to drop or dump pipe, fittings, valves, or other water line material into trenches. Cut pipe cleanly, squarely, and accurately to the length established at the site and work into place without springing or forcing. Replace a pipe or fitting that does not allow sufficient space for installation of jointing material. Blocking or wedging between bells and spigots is not permitted. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at the design elevation and grade. Secure firm, uniform support. Wood support blocking is not permitted. Lay pipe so that the full length of each section of pipe and each fitting rests solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports for fastening work into place. Make provision for expansion and contraction of pipelines. Keep trenches free of water until joints have been assembled. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Do not lay pipe when conditions of trench or weather prevent installation. Provide a minimum of 2 1/2 feet depth of cover over top of pipe.

3.2.1.1.3 Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.2.1.1.4 Connections to Existing Water Lines

Make connections to existing water lines after coordination with the facility and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped and as indicated, except as otherwise specified, tap concrete pipe in accordance with AWWA M9 for tapping concrete pressure pipe.

3.2.1.1.5 Sewer Manholes

No water piping is to pass through or come in contact with any part of a sewer manhole.

3.2.1.1.6 Water Piping Parallel With Sewer Piping

Where the location of the water line is not clearly defined by dimensions on the drawings, do not lay water line closer than 10 feet, horizontally, from any sewer line.

a. Normal Conditions: Lay water piping at least 10 feet horizontally from sewer or sewer manhole whenever possible. Measure the distance from outside edge to outside edge of pipe or outside edge of manhole. When local conditions prevent horizontal separation install water piping in a separate trench with the bottom of the water piping at least 18 inches above the top of the sewer piping.

b. Unusual Conditions: When local conditions prevent vertical separation, construct sewer piping of AWWA compliant ductile iron water piping and perform hydrostatic sewer test, without leakage, prior to backfilling. When local conditions prevent vertical separation, test the sewer manhole in place to ensure watertight construction.

3.2.1.1.7 Water Piping Crossing Sewer Piping

Provide at least 18 inches above the top (crown) of the sewer piping and the bottom (invert) of the water piping whenever possible. Measure the distance edge-to-edge. Where water lines cross under gravity sewer lines, construct sewer line of AWWA compliant ductile iron water piping with rubber-gasketed joints and no joint located within 10 feet, horizontally, of the crossing. Lay water lines which cross sewer force mains and inverted siphons at least 2 feet above these sewer lines; when joints in the sewer line are closer than 3 feet horizontally from the water line relay the sewer line to ensure no joint closer than 3 feet.

a. Normal Conditions: Provide a separation of at least 18 inches between the bottom of the water piping and the top of the sewer piping in cases where water piping crosses above sewer piping.

b. Unusual Conditions: When local conditions prevent a vertical separation described above, construct sewer piping passing over or under water piping of AWWA compliant ductile iron water piping and perform hydrostatic sewer test, without leakage, prior to backfilling. Construct sewer crossing with a minimum 20 feet length of the AWWA compliant ductile iron water piping, centered at the point of the crossing so that joints are equidistant and as far as possible from the water piping. Protect water piping passing under sewer piping by providing a vertical separation of at least 18 inches between the bottom of the sewer piping and the top of the water piping; adequate structural support for the sewer piping to prevent excessive deflection of the joints and the settling on or damage to the water piping.

3.2.1.1.8 Penetrations

Provide ductile-iron or Schedule 40 steel wall sleeves for pipe passing through walls of valve pits and structures. Fill annular space between walls and sleeves with rich cement mortar. Fill annular space between pipe and sleeves with mastic.

3.2.1.1.9 Flanged Pipe

Only install flanged pipe aboveground or with the flanges in valve pits.

3.2.1.2 Ductile-Iron Piping

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the requirements of AWWA C600 for pipe installation, joint assembly, valve-and-fitting installation, and thrust restraint.

a. Jointing: Make push-on joints with the gaskets and lubricant specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly. Make mechanical joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11. Make flanged joints with the gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight; avoid undue strain on flanges, fittings, valves, and other equipment and accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; use of undersized bolts will not be permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange. When flanged pipe or fitting has dimensions that do not allow the making of a flanged joint as specified, replace it. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer. Make grooved and shouldered type joints with the couplings previously specified for this type joint connecting pipe with the grooved or shouldered ends specified for this type joint; assemble in accordance with the recommendations of the coupling manufacturer. Groove pipe in the field only with groove cutting equipment designed especially for the purpose and produced by a manufacturer of grooved joint couplings; secure approval for field-cut grooves before assembling the joint. Make insulating joints with the gaskets, sleeves, washers, bolts, and nuts previously specified for this type joint. Assemble insulating joints as specified for flanged joints, except that bolts with insulating sleeves are to be full size for the bolt holes. Ensure that there is no metal-to-metal contact between dissimilar metals after the joint has been assembled.

b. Allowable Deflection: Follow AWWA C600 and AWWA M41 for the maximum allowable deflection. If the alignment requires deflection in excess of the above limitations, provide special bends or a sufficient number of shorter lengths of pipe to achieve angular deflections within the limit set forth.

3.2.1.3 PVC and PVCO Water Main Pipe

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the requirements of AWWA C605 for laying of pipe, joining PVC pipe to fittings and accessories, setting of fire hydrants, valves, and fittings; and with the recommendations for pipe joint assembly and appurtenance installation in AWWA M23, Chapter 7, "Installation."

a. Jointing: Make push-on joints with the elastomeric gaskets specified for this type joint, using either elastomeric-gasket bell-end pipe or elastomeric-gasket couplings. For pipe-to-pipe push-on joint connections, use only pipe with push-on joint ends having factory-made bevel; for push-on joint connections to metal fittings, valves, and other accessories, cut spigot end of pipe off square and re-bevel pipe end to a bevel approximately the same as that on ductile-iron pipe used for the same type of joint. Use a lubricant recommended by the pipe manufacturer for push-on joints. Assemble push-on joints for pipe-to-pipe joint connections in accordance with the requirements of AWWA C605 for laying the pipe and the recommendations in AWWA M23, Chapter 7, "Installation," for pipe joint assembly. Assemble push-on joints for connection to fittings, valves, and other accessories in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories and with the requirements of AWWA C600 for joint assembly. Make compression-type joints/mechanical joints with the gaskets, glands, bolts, nuts, and internal stiffeners previously specified for this type joint; assemble in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories, with the requirements of AWWA C600 for joint assembly, and with the recommendations of Appendix A to AWWA C111/A21.11. Cut off spigot end of pipe for compression-type joint/mechanical-joint connections and do not re-bevel. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer using internal stiffeners as previously specified for compression-type joints.

b. Joint Offset: Construct joint offset in accordance AWWA C605. Do not exceed the minimum longitudinal bending as indicated by AWWA C605.

c. Fittings: Install in accordance with AWWA C605.

3.2.1.4 Steel Piping

Unless otherwise specified, install pipe and fittings in accordance with AWWA C604 and AWWA M11, Chapter 12, "Transportation, Installation, and Testing."

a. Jointing: Make rubber-gasketed bell-and-spigot joints with the gaskets previously specified for this type joint, using a lubricant recommended by the pipe manufacturer; assemble in accordance with the recommendations of the pipe manufacturer. Make welded joints in accordance with AWWA C206 and with the recommendations given for installation of pipe in AWWA M11, Chapter 12, "Transportation, Installation, and Testing." Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer. Make flanged joints with the gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight; avoid undue strain on flanges, fittings, valves, and other equipment and accessories. Align bolt holes for each flanged joint. Use full-size bolts for the bolt holes; use of undersized bolts is not permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without straining the flange. Replace flanged pipe or fittings with dimensions that do not allow the making of a flanged joint as specified. Make grooved type joints with the couplings specified for this type joint connecting pipe with roll-grooved ends or pipe with welded-on cut-grooved adapters, each with dimensions as previously specified for this type joint. Groove pipe ends in the field only with manufacturer recommended groove rolling equipment and manufacturer recommended groove adapters in the field only with manufacturer recommended groove cutting equipment; use groove rolling and groove cutting equipment especially for the purpose and produced by a manufacturer of grooved joint couplings. Obtain approval for field-cut grooves before assembling the joint. Make shouldered type joints with the couplings specified for this type joint connecting pipe with the shouldered ends specified for this type joint. Assemble grooved and shouldered type joints in accordance with the recommendations of the coupling manufacturer. Make insulating joints with the gaskets, sleeves, washers, bolts, and nuts specified for this type joint. Assemble insulating joints as specified for flanged joints, except that bolts with insulating sleeves are to be full size for the bolt holes. Ensure that there is no metal-to-metal contact between dissimilar metals after the joint has been assembled. Finish joints on piping with cement-mortar lining and on piping with cement-mortar coating as specified in Appendix on Field Joints in AWWA C205. Finish joints on piping with coal-tar enamel or coal-tar epoxy coating by cleaning, priming, coating, and wrapping with a cold-applied tape coating matching the requirements of, and applied in accordance with AWWA C209.

b. Allowable Offsets: For pipe with bell-and-spigot rubber-gasket joints, maximum allowable deflections from a straight line or grade, as required by vertical curves, horizontal curves, or offsets is 5 degrees unless a lesser amount is recommended by the manufacturer. Form short-radius curves and closures with short lengths of pipe or fabricated specials specified.

c. Cement Mortar Lining: AWWA C205, shop applied.

3.2.1.5 Metallic Piping for Service Lines

Install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the applicable requirements of AWWA C600 for pipe installation, unless otherwise specified.

3.2.1.5.1 Screwed Joints

Make screwed joints up tight with a stiff mixture of graphite and oil, inert filler and oil, or graphite compound; apply to male threads only or with PTFE Tape, for use with threaded pipe. Threads are to be full cut; do not leave more than three threads on the pipe exposed after assembling the joint.

3.2.1.5.2 Joints for Copper Tubing

Cut copper tubing with square ends; remove fins and burrs. Replace dented, gouged, or otherwise damaged tubing with undamaged tubing. Make solder joints using ASTM B32, 95-5 tin-antimony or Grade Sn96 solder. Use solder and flux containing less than 0.2 percent lead. Before making joint, clean ends of tubing and inside of fitting or coupling with wire brush or abrasive. Apply a rosin flux to the tubing end and on recess inside of fitting or coupling. Insert tubing end into fitting or coupling for the full depth of the recess and solder. For compression joints on flared tubing, insert tubing through the coupling nut and flare tubing.

3.2.1.5.3 Flanged Joints

Make flanged joints up tight, avoid undue strain on flanges, valves, fittings, and accessories.

3.2.1.5.4 Protection of Buried Steel Service Line Piping

Unless otherwise specified, prepare, prime, and coat exterior surface of zinc-coated steel pipe and associated fittings to be buried with hot-applied coal-tar enamel with a bonded single layer of felt wrap in accordance with AWWA C203. For the felt wrap material, use fibrous-glass mat as specified in AWWA C203; use of asbestos felt will not be permitted. Use solvent wash only to remove oil, grease, and other extraneous matter from zinc-coated pipe and fittings.

3.2.1.6 Plastic Service Piping

Install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the applicable requirements of ASTM D2774 and ASTM D2855, unless otherwise specified. Handle solvent cements used to join plastic piping in accordance with ASTM F402.

3.2.1.6.1 Jointing

Make solvent-cemented joints for PVC piping using the solvent cement previously specified for this material; assemble joints in accordance with ASTM D2855. Make plastic pipe joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.2.1.6.2 Plastic Pipe Connections to Appurtenances

Connect plastic service lines to corporation stops and gate valves in accordance with the recommendations of the plastic pipe manufacturer.

3.2.1.7 Trenchless Piping

3.2.1.7.1 Butt Fusion

Fusible pipe will be fused by qualified fusion technicians, as required by manufacturer of the fusion equipment. Record and log each fusion joint by an electronic monitoring device (data logger) connected to the fusion machine. Log fusion data and create Post-Construction Fusion Report with software specifically developed for the pipe material being fused. Software must record the parameters required by the fusion equipment manufacturer and these specifications. Manual log data not logged by the data logger and be included in the Post-Construction Fusion Report. Assemble fusible PVC and PE pipe lengths in the field with butt-fused joints. Follow the manufacturer's fusion equipment procedures.

3.2.1.7.1.1 PVC Pipe

For butt fused PVC Pipe, provide joints meeting the requirements of ASTM F1674.

3.2.1.7.1.2 Polyethylene Pipe

Install butt fused PE Pipe in accordance with AWWA M55 and ASTM F1962.

3.2.1.7.2 Post-Construction Fusion Report

Include the following data for each fusible connection in the report:

a. Pipe Size and Thickness

b. Machine Size

c. Fusion Technician Identification

d. Job Identification

e. Fusion Joint Number

f. Fusion, Heating, and Drag Pressure Settings

g. Heat Plate Temperature

h. Time Stamp

i. Heating and Cool Down Time of Fusion

j. Ambient Temperature

3.2.1.7.3 Installation Ductile Iron Ball and Socket Joint

Install pipe and fittings in accordance with AWWA C600 and AWWA M41 for pipe installation, joint assembly, and thrust restraint.

a. Allowable Deflection: Meet the applicable requirements of AWWA C600, AWWA M41 and in accordance with pipe manufacturer's instructions for the maximum allowable deflection.

b. Exterior Protection: Completely encase buried ductile iron pipelines using Method A or B, with polyethylene film, in accordance with AWWA C105/A21.5.

3.2.1.8 Fire Protection Service Lines for Sprinkler Supplies

Connect water service lines used to supply building sprinkler systems for fire protection to the water main in accordance with NFPA 24.

3.2.1.9 Water Service Piping

3.2.1.9.1 Location

Connect water service piping to the building service where the building service has been installed. Where building service has not been installed, terminate water service lines approximately 5 feet from the building line at the points indicated; close such water service lines with plugs or caps.

3.2.1.9.2 Water Service Line Connections to Water Mains

Connect water service lines to the main by a corporation stop and gooseneck and install a service stop below the frostline . Connect water service lines 2 inch size to the main with a rigid connection or a corporation stop and gooseneck and install a gate valve on service line below the frostline . Connect water service lines to the main with a rigid connection and install a gate valve on service line below the frostline . Connect water service lines to ductile-iron water mains in accordance with AWWA C600 for service taps. Connect water service lines to PVC water mains in accordance with UBPPA UNI-PUB-08 and the recommendations of AWWA M23, Chapter 9, "Service Connections." Connect water service lines to concrete water mains in accordance with the recommendations of AWWA M9, "Tapping Concrete Pressure Pipe." Connect water service lines to steel water mains in accordance with the recommendations of the steel water main pipe manufacturer and with the recommendations for special and valve connections and other appurtenances in AWWA M11, Chapter 13, "Supplementary Design Data and Details."

3.2.2 Meters

Install meters and meter boxes or vaults at the locations shown on the drawings. Center meters in the boxes or vaults to allow for reading and ease of removal or maintenance. Set top of box or vault at finished grade.

3.2.3 Backflow Preventers

Install backflow preventers of type, size, and capacity indicated a minimum of 12 inch and a maximum of 36 inch above concrete base. Include valves and test cocks. Install according to the manufacturers requirements and the requirements of plumbing and health department and authorities having jurisdiction. Support NPS 2 1/2 inch and larger backflow preventers, valves, and piping near floor with 12 inch minimum air gap, and on concrete piers or steel pipe supports. Do not install backflow preventers that have a relief drain in vault or in other spaces subject to flooding. Do not install by-pass piping around backflow preventers.

3.2.3.1 Backflow Preventer Enclosure

Install a level concrete base with top of concrete surface approximately 2 inches inches above grade. Install protective enclosure over valve and equipment. Anchor protective enclosure to concrete base.

3.2.4 Disinfection

Prior to disinfection, provide disinfection procedures, proposed neutralization and disposal methods of waste water from disinfection as part of the disinfection submittal. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Disinfect new water piping using the AWWA C651 continuous-feed method of chlorination . Ensure a free chlorine residual of not less than 10 parts per million after 24 hour holding period and prior to performing bacteriological tests.

3.2.5 Flushing

Perform bacteriological tests prior to flushing. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 parts per million, the residual chlorine content of the distribution system, or acceptable for domestic use. Use AWWA C655 neutralizing chemicals.

3.2.6 Pipe Restraint

3.2.6.1 Concrete Thrust Blocks

Install concrete thrust blocks where indicated.

3.2.6.2 Restrained Joints

Install restrained joints in accordance with the manufacturer's instructions where indicated. For metal harness use tie rods and clamps as shown in NFPA 24. Provide structural welded, skip welded, clamp type harness, bell bolt harness, snap ring harness for pipe anchorage. Provide metal harness fabricated by the pipe manufacturer and furnished with the pipe.

3.2.7 Valves

3.2.7.1 Gate Valves

Install gate valves, AWWA C500 and UL 262, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500. Install gate valves, AWWA C509 or AWWA C515, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C509 or AWWA C515. Install gate valves on PVC and PVCO water mains in accordance with the recommendations for appurtenance installation in AWWA M23, Chapter 7, "Installation." Make and assemble joints to gate valves as specified for making and assembling the same type joints between pipe and fittings.

3.2.7.2 Check Valves

Install check valves in accordance with the applicable requirements of AWWA C600 for valve-and-fitting installation. Make and assemble joints to check valves as specified for making and assembling the same type joints between pipe and fittings.

3.2.7.3 Air Release, Air/Vacuum, and Combination Air Valves

Install pressure vacuum assemblies of type, size, and capacity indicated. Include valves and test cocks. Install according to the requirements of plumbing and health department and authorities having jurisdiction. Do not install pressure vacuum breaker assemblies in vault or other space subject to flooding.

3.2.8 Blowoff Valve Assemblies

Install blowoff valve assemblies as indicated on the drawings or in accordance with the manufactures recommendations. Install discharge fitting on the end of riser pipe to direct the flow of water so as to minimize damage to surrounding areas.

3.2.9 Fire Hydrants

Install fire hydrants in accordance with AWWA C600 for fire hydrant installation and as indicated. Make and assemble joints as specified for making and assembling the same type joints between pipe and fittings. Provide metal harness as specified under pipe anchorage requirements for the respective pipeline material to which fire hydrant is attached. Install fire hydrants with the 4 1/2 inch connections facing the adjacent paved surface. If there are two paved adjacent surfaces, install fire hydrants with the 4 1/2 inch connection facing the paved surface where the connecting main is located.

3.3 FIELD QUALITY CONTROL

3.3.1 Tests

Notify the Contracting Officer a minimum of five days in advance of hydrostatic testing. Coordinate the proposed method for disposal of waste water from hydrostatic testing. Perform field tests, and provide labor, equipment, and incidentals required for testing, except that water needed for field tests will be furnished as set forth in paragraph AVAILABILITY AND USE OF UTILITY SERVICES in Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS. Provide documentation that all items of work have been constructed in accordance with the Contract documents.

3.3.1.1 Hydrostatic Test

Test the water system in accordance with the applicable AWWA standard specified below. Where water mains provide fire service, test in accordance with the special testing requirements given in the paragraph SPECIAL TESTING REQUIREMENTS FOR FIRE SERVICE. Test ductile-iron water mains in accordance with the requirements of AWWA C600 for hydrostatic testing. The amount of leakage on ductile-iron pipelines with mechanical-joints or push-on joints is not to exceed the amounts given in AWWA C600; no leakage will be allowed at joints made by any other methods. Test PVC and PVCO plastic water systems made with PVC pipe in accordance with the requirements of AWWA C605 for pressure and leakage tests. The amount of leakage on pipelines made of PVC water main pipe is not to exceed the amounts given in AWWA C605, except that at joints made with sleeve-type mechanical couplings, no leakage will be allowed. Test PE pipe in accordance with the requirements of AWWA M55 for hydrostatic testing. Test concrete water mains in accordance with the recommendations in AWWA M9, "Hydrostatic Testing and Disinfection of Mains." The amount of leakage on concrete pipelines is not to exceed 20 gallons per 24 hours per inch of pipe diameter per mile of pipeline. Test steel water mains in accordance with applicable requirements of AWWA C600 for hydrostatic testing. The amount of leakage on steel pipelines with rubber-gasketed bell-and-spigot joints is not to exceed 20 gallons per 24 hours per inch of pipe diameter per mile of pipeline; no leakage will be allowed at joints made by any other method. To stop leakage, repair welded joints only by welding. Test water service lines in accordance with requirements of AWWA C600 for hydrostatic testing. No leakage will be allowed at copper pipe joints, copper tubing joints (soldered, compression type, brazed), plastic service pipe joints, flanged joints, and screwed joints. Do not backfill utility trench or begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least 7 days after placing of the concrete.

3.3.1.2 Hydrostatic Sewer Test

The hydrostatic pressure sewer test will be performed in accordance with the applicable AWWA standard for the piping material or AWWA C600.

3.3.1.3 Leakage Test

For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

For PE pipe perform leak testing in accordance with AWWA M55, ASTM F2164.

3.3.1.4 Bacteriological Testing

Perform bacteriological tests in accordance with AWWA C651 Option A . For new water mains use Option A and obtain two sets of samples for coliform analysis, each sample being collected at least 16 hours apart. Take samples every 1,200 ft plus one set from the end of the line and at least one from each branch greater than one pipe length. Analyze samples by a certified laboratory, and submit the results of the bacteriological samples.

3.3.1.5 Backflow Preventer Tests

After installation conduct Backflow Preventer Tests and provide test reports verifying that the installation meets the FCCCHR Manual Standards.

3.3.1.6 Special Testing Requirements for Fire Service

Test water mains and water service lines providing fire service or water and fire service in accordance with NFPA 24. The additional water added to the system must not exceed the limits given in NFPA 24

3.3.1.7 Tracer Wire Continuity Test

Test tracer wire for continuity after service connections have been completed and prior to final pavement or restoration. Verify that tracer wire is locatable with electronic utility locating equipment. Repair breaks or separations and re-test for continuity.

3.4 SYSTEM STARTUP

Water mains and appurtenances must be completely installed, disinfected, flushed, and satisfactory bacteriological sample results received prior to permanent connections being made to the active distribution system. Obtain approval by the Contracting Officer prior to the new water piping being placed into service.

3.5 CLEANUP

Upon completion of the installation of water lines and appurtenances, remove all debris and surplus materials resulting from the work.

-- End of Section --

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SECTION 33 11 23

NATURAL GAS AND LIQUID PETROLEUM PIPING
11/09, CHG 1: 08/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.1 (2000) Diaphragm Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)

AGA ANSI B109.2 (2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)

AGA ANSI B109.3 (2019) Rotary-Type Gas Displacement Meters

AGA ANSI B109.4 (2016) Self-Operated Diaphragm-Type Natural Gas Service Regulators for Nominal Pipe Size 1¼ inches (32 mm) and Smaller with Outlet Pressures of 2 psig (13.8 kPa) and Less

AGA XR0603 (2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.41/CSA 6.9 (2014; R 2019) Quick-Disconnect Devices for Use with Gas Fuel Appliances

ANSI Z21.45 (1995) Flexible Connectors of Other Than All-Metal Construction for Gas Appliances

ANSI Z21.69/CSA 6.16 (2015; R 2020) Connectors for Movable Gas Appliances

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25-16 (2016) Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1 (2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.3 (2021) Malleable Iron Threaded Fittings,

	Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.33	(2012; R 2017) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psi, (Sizes NPS 1/2 - NPS 2)
ASME B16.38	(2012; R 2017) Large Metallic Valves for Gas Distribution Manually Operated, NPS 2 1/2 (DN 65) to NPS 12 (DN 300), 125 psig 8.6 bar) Maximum
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.40	(2019) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.8	(2018; Supplement 2018) Gas Transmission and Distribution Piping Systems
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM D2513	(2018a) Standard Specification for Polyethylene (PE) Gas Pressure Pipe,

Tubing, and Fittings

ASTM D2683	(2020) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
NFPA 58	(2020; TIA 20-1; TIA 20-2; TIA 20-3) Liquefied Petroleum Gas Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
49 CFR 195	Transportation of Hazardous Liquids by Pipeline

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Valve Box

Pressure Regulator

Gas Equipment Connectors

Valves

Warning and Identification Tape

Risers

Transition Fittings

Gas meter

[LPG Containers and Accessories]

SD-07 Certificates

Welder's Qualifications

PE Welder's Qualifications

Welder's Identification Symbols

SD-08 Manufacturer's Instructions

PE Pipe and Fittings

Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart.

1.4 QUALITY ASSURANCE

1.4.1 Welder's Qualifications

Comply with ASME B31.8. The steel welder shall have a copy of a certified ASME B31.8 qualification test report. The PE welder shall have a certificate from a PE pipe manufacturer's sponsored training course. Contractor shall also conduct a qualification test. Submit each welder's identification symbols, assigned number, or letter, used to identify work of the welder. Affix symbols immediately upon completion of welds. Welders making defective welds after passing a qualification test shall be given a requalification test and, upon failing to pass this test, shall not be permitted to work this contract.

1.4.2 PE Welder's Qualifications

Prior to installation, Contractor shall have supervising and installing personnel trained by a PE pipe manufacturer's sponsored course of not less than one week duration, or present proof satisfactory to the Contracting Officer that personnel are currently working in the installation of PE gas distribution lines.

1.4.3 Safety Standards

49 CFR 192 [and 49 CFR 195].

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap pipe ends during transportation or storage to minimize dirt and moisture entry. Do not subject to abrasion or concentrated external loads. Discard PE pipe sections and fittings that have been damaged.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Conform to NFPA 54 and with requirements specified herein. Supply piping to appliances or equipment shall be at least as large as the inlets thereof.

2.2 PIPE AND FITTINGS

2.2.1 Aboveground and Within Buildings and Vaults

a. Pipe: Black steel in accordance with ASTM A53/A53M, Schedule [40] [80], threaded ends for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.

b. Threaded Fittings: ASME B16.3, black malleable iron.

c. Socket-Welding Fittings: ASME B16.11, forged steel.

d. Butt-Welding Fittings: ASME B16.9, with backing rings of compatible material.

e. Unions: ASME B16.39, black malleable iron.

f. Flanges and Flanged Fittings: ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1. Flange faces shall have integral grooves of rectangular cross sections which afford containment for self-energizing gasket material.

2.2.2 Underground Polyethylene (PE)

PE pipe and fittings are as follows:

a. Pipe: ASTM D2513, 100 psig working pressure, Standard Dimension Ratio (SDR), the ratio of pipe diameter to wall thickness, 11.5 maximum.

b. Socket Fittings: ASTM D2683.

c. Butt-Fusion Fittings: ASTM D2513, molded.

2.2.3 Risers

Manufacturer's standard riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide [remote bolt-on or bracket] [or] [wall-mounted] riser supports [as indicated].

2.2.4 Transition Fittings

[a. Steel to Plastic (PE): As specified for "riser" except designed for steel-to-plastic with tapping tee or sleeve. Coat or wrap exposed steel pipe with heavy plastic coating.

][b Plastic to Plastic: [Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support, O-ring seals, and rated for 150 psig gas service.] [Manufacturer's standard fused tapping (PE-to-PE) tee assembly with shut-off feature.]

]2.3 SHUTOFF VALVES, BELOW GROUND

[2.3.1 Metallic Ball Valves

[ASME B16.33] [or] [ASME B16.38] corrosion-resisting steel, with threaded or flanged ends. Provide polytetrafluoroethylene (PTFE) seats.

][2.3.2 PE Ball or Plug Valves

ASME B16.40 and ASTM D2513, Class C materials (PE 2306 or PE 3406), strength rating of Class [1 location with class factor of 0.32] [2 location with class factor of 0.25] [3 location with class factor of 0.25] [4 location with class factor of 0.20], and SDR matching PE pipe dimensions and working pressure.

]2.4 VALVES, ABOVEGROUND

[Provide lockable valves where indicated.

]2.4.1 Shutoff Valves, Sizes Larger Than 2 Inches

[[Cast-iron] [or] [steel] body ball valve with flanged ends in accordance with ASME B16.38. Provide PTFE seats.

][Cast-iron body plug valve in accordance with ASME B16.38, nonlubricated, wedge-mechanism or tapered lift plug, and flanged ends.

]2.4.2 Shutoff Valves, Sizes 2 Inches and Smaller

[[Bronze] [Steel] body ball valve in accordance with ASME B16.33, full port pattern, reinforced PTFE seals, threaded ends, and PTFE seat.

][[Bronze] [Steel] body plug valve in accordance with ASME B16.33, straightway, taper plug, regular pattern with a port opening at least equal to the internal pipe area or round port full bore pattern, non-lubricated, PTFE packing, flat or square head stem with lever operator, 125 psig rating, threaded ends.

]2.4.3 Line Appliance Pressure Regulator and Shutoff Valve

Provide regulators conforming to [ANSI Z21.18/CSA 6.3 for appliances] [ANSI Z21.78/CSA 6.20 for combination gas controls for gas appliances] [, and ANSI Z21.80/CSA 6.22 for line pressure regulators]. Provide shutoff valves conforming to [ANSI Z21.15/CSA 9.1 for manually controlled gas shutoff valves] [and] [ANSI Z21.21/CSA 6.5 for automatic shutoff valves for gas appliances].

2.4.4 Service Regulators

a. Provide ferrous bodied pressure regulators for individual service lines, capable of reducing distribution line pressure to pressures required for users. Provide service regulators conforming to

AGA ANSI B109.4 CGA-6.18-M95 with full capacity internal relief[and overpressure shutoff]. Set pressure relief at a lower pressure than would cause unsafe operation of any connected user.

b. Adjust regulators for liquified petroleum gas to 10 to 12 inches of water column, with pressure relief set a 16 inches of water column.

c. Provide regulator(s) having a single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas flow rate at the regulator inlet pressure. Provide regulator valve vent of resilient materials designed to withstand flow conditions when pressed against the valve port, capable of regulating downstream pressure within limits of accuracy and limiting the buildup of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Provide a self-contained service regulator, and pipe not exceeding exceed 2 inch size.

2.4.5 Earthquake Automatic Gas Shutoff Valve

ASCE 25-16 and UL listed or AGA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The valve may be either pendulum or ball construction with [remote [, pneumatic] [electronic] [or] [electric]] actuator.

2.5 GAS METER

[AGA ANSI B109.1] [AGA ANSI B109.2] [AGA ANSI B109.3] [pipe] [pedestal] mounted, [diaphragm] or [bellow] [style], [cast-iron] [enamel coated steel] [aluminum] case. [Provided with a strainer immediately upstream]. Provide [diaphragm-type meter conforming to AGA ANSI B109.1 for required flow rates less than 500 cfh, or AGA ANSI B109.2, for flow rates 500 cfh and above] [rotary-type displacement meter conforming to AGA ANSI B109.3] as required by local gas utility supplier. Provide combined [odometer-type] register totalizer index, UV-resistant index cover, water escape hole in housing, and means for sealing against tampering. Provide temperature-compensated type meters sized for the required volumetric flow rate and suitable for accurately measuring and handling gas at pressures, temperatures, and flow rates indicated. Provide meters with over-pressure protection as specified in 49 CFR 192 and ASME B31.8. Provide meters that are tamper-proof [with] [frost protection] [fungus protection][seismic protection].Provide meters with a pulse switch initiator capable of operating up to speeds of 500 maximum pulses per minute with no false pulses and requiring no field adjustments. Provide not less than one pulse per 100 cubic feet of gas. Minimum service life shall be 30,000,000 cycles.

2.5.1 Utility Monitoring and Control System (UMCS) / Energy Monitoring and Control (EMCS) or Automatic Meter Reading Interfaces

Provide gas meters capable of interfacing the output signal, equivalent to volumetric flow rate, with the existing UMCS / EMCS for data gathering in units of cubic meters cubic feet. Provide meters that do not require power to function and deliver data. Output signal shall be either a voltage or amperage signal that can be converted to volumetric flow by using an appropriate scaling factor.

2.5.2 Measurement Configuration

For buildings that already have a gas meter with a pulse output, ensure that the pulse output is connected to a data gathering device (i.e.

electric meter). For buildings where a natural gas meter already exists but does not have a pulse output, add a pulse kit to the existing meter and tie the output to a data gathering device. If the existing gas meter will not accept a pulse kit or if no meter exists a new natural gas meter shall be installed, also requiring a pulse output to a data gathering device. Ensure the pulse frequency and electronic characteristics are compatible with the existing data gathering device, if any.

2.6 GAS EQUIPMENT CONNECTORS

a. Flexible Connectors: ANSI Z21.45.

b. Quick Disconnect Couplings: ANSI Z21.41/CSA 6.9.

c. Semi-Rigid Tubing and Fittings: ANSI Z21.69/CSA 6.16.

2.7 VALVE BOX

Provide [street valve box with cast-iron cover and two-piece 5 1/4 inch shaft-slip valve box extension] [rectangular concrete valve box, sized large enough for removal of valve without removing box]. Cast the word "Gas" into the box cover. Use valve box for areas as follows:

a. Roads and Traffic Areas: Heavy duty, cast iron cover.

b. Other Areas: Standard duty, concrete cover.

[c. Airfields and Special Loadings: As detailed.

]2.8 CASING

Where indicated at railroad or other crossing, provide ASTM A53/A53M, galvanized pipe, Schedule 40 [, with extruded polyethylene coating].

2.9 BURIED UTILITY WARNING AND IDENTIFICATION TAPE

Provide detectable aluminum-foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inch minimum width, color-coded yellow for natural gas, with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED GAS PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2.10 HANGERS AND SUPPORTS

MSS SP-58, as required by MSS SP-69.

2.11 WELDING FILLER METAL

ASME B31.8.

2.12 PIPE-THREAD TAPE

Antiseize and sealant tape of polytetrafluoroethylene (PTFE).

2.13 BOLTING (BOLTS AND NUTS)

Stainless steel bolting; ASTM A193/A193M, Grade B8M or B8MA, Type 316, for bolts; and ASTM A194/A194M, Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts shall conform with ASME B18.2.1and ASME B18.2.2 with coarse threads conforming to ASME B1.1, with Class 2A fit for bolts and studs and Class 2B fit for nuts. Bolts or bolt-studs shall extend through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Bolts shall have American Standard regular square or heavy hexagon heads; nuts shall be American Standard heavy semifinished hexagonal.

2.14 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.15 IDENTIFICATION FOR ABOVEGROUND PIPING

MIL-STD-101 for legends and type and size of characters. For pipes 3/4 inch od and larger, provide printed legends to identify contents of pipes and arrows to show direction of flow. Color code label backgrounds to signify levels of hazard. Make labels of plastic sheet with pressure-sensitive adhesive suitable for the intended application. For pipes smaller than 3/4 inch od, provide brass identification tags 1 1/2 inches in diameter with legends in depressed black-filled characters.

[2.16 (LIQUEFIED PETROLEUM GAS) LPG CONTAINERS AND ACCESSORIES

NFPA 58, [DOT] [or] [ASME] containers with appurtenances, system working pressure, minimum design pressure, that is LPG vapor pressure at 100 degrees F, and water capacity as indicated. Provide containers with piping and fittings, [fuse plugs], [hose and flexible hose connectors], [gas-air mixer], strainer, and marking conforming to NFPA 58.

]PART 3 EXECUTION

3.1 INSTALLATION

Install gas piping, appliances, and equipment in accordance with NFPA 54. [Install distribution piping in accordance with ASME B31.8.] [Install and store liquefied petroleum gas piping, appliances, and equipment in accordance with NFPA 58.]

3.1.1 Excavating and Backfilling

Perform excavating and backfilling of pipe trenches as specified in Section 31 00 00 EARTHWORK. Place pipe directly in trench bottom and cover with minimum 3 inches of sand to top of pipe. If trench bottom is rocky, place pipe on a 3 inch bed of sand and cover as above. Provide remaining backfilling. Coordinate provision of utility warning and identification tape with backfill operation. Bury utility warning and identification tape with printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

3.1.2 Piping

Cut pipe to actual dimensions and assemble to prevent residual stress. [Provide supply connections entering the buildings as indicated.] Within buildings, run piping parallel to structure lines and conceal in finished spaces. Terminate each vertical supply pipe to burner or appliance with tee, nipple and cap to form a sediment trap. To supply multiple items of gas-burning equipment, provide manifold with inlet connections at both ends.

3.1.2.1 Cleanliness

Clean inside of pipe and fittings before installation. Blow lines clear using 80 to 100 psig clean dry compressed air. Rap steel lines sharply along entire pipe length before blowing clear. Cap or plug pipe ends to maintain cleanliness throughout installation.

3.1.2.2 Aboveground Steel Piping

Determine and establish measurements for piping at the job site and accurately cut pipe lengths accordingly. For 2 inch diameter and smaller, use threaded or socket-welded joints. For 2 1/2 inch diameter and larger, use flanged or butt-welded joints.

a. Threaded Joints: Where possible use pipe with factory-cut threads, otherwise cut pipe ends square, remove fins and burrs, and cut taper pipe threads in accordance with ASME B1.20.1. Provide threads smooth, clean, and full-cut. Apply anti-seize paste or tape to male threads portion. Work piping into place without springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed. Use unions for connections to [valves] [meters] for which a means of disconnection is not otherwise provided.

b. Welded Joints: Weld by the shielded metal-arc process, using covered electrodes and in accordance with procedures established and qualified in accordance with ASME B31.8.

c. Flanged Joints: Use flanged joints for connecting welded joint pipe and fittings to valves to provide for disconnection. Install joints so that flange faces bear uniformly on gaskets. Engage bolts so that there is complete threading through the nuts and tighten so that bolts are uniformly stressed and equally torqued.

d. Pipe Size Changes: Use reducing fittings for changes in pipe size. Size changes made with bushings will not be accepted.

e. Painting: Paint new ferrous metal piping, including supports, in accordance with Section 09 90 00 PAINTS AND COATINGS. Do not apply paint until piping tests have been completed.

f. Identification of Piping: Identify piping aboveground in accordance with MIL-STD-101, using adhesive-backed or snap-on plastic labels and arrows. In lieu of labels, identification tags may be used. Apply labels or tags to finished paint at intervals of not more than 50 feet. Provide two copies of the piping identification code framed under glass and install where directed.

3.1.2.3 Buried Plastic Lines

Provide totally PE piping. Prior to installation, obtain printed instructions and technical assistance in proper installation techniques from pipe manufacturer.[When joining new PE pipe to existing pipe line, ascertain what procedural changes in the fusion process is necessary to attain optimum bonding.]

a. Jointing Procedures: Use jointing procedures conforming to AGA XR0603 and 49 CFR 192 that have been qualified by test in accordance with 49 CFR 192.283 and proven to make satisfactory joints. Personnel make joints in plastic pipe shall be qualified in accordance with 49 CFR 192.285, under the submitted and approved procedure by making a satisfactory specimen joint that passes the required inspection and test. Joints in plastic pipe shall be inspected by a person qualified by 49 CFR 192.287 under the applicable procedure. Certificates that qualify the applicable procedures, joining personnel, and inspectors shall be submitted and approved and shall be on file with the Contracting Officer prior to making these joints.

b. PE Piping: Prior to installation, Contractor shall have supervising and installing personnel, certified in accordance with paragraph WELDER'S QUALIFICATIONS. Provide fusion-welded joints except where transitions have been specified. Use electrically heated tools, thermostatically controlled and equipped with temperature indication. (Where connection must be made to existing plastic pipe, contractor shall be responsible for determination of compatibility of materials and procedural changes in fusion process necessary to attain maximum integrity of bond.)

c. Laying PE Pipe: Bury pipe 24 inches below finish grade [or deeper when indicated]. Lay in accordance with manufacturer's printed instructions.

3.1.2.4 Connections to Existing Pipeline

When making connections to live gas mains, use pressure tight installation equipment operated by workmen trained and experienced in making hot taps. For connections to existing underground pipeline or service branch, use transition fittings for dissimilar materials.

3.1.2.5 Wrapping

Where connection to existing steel line is made underground, tape wrap new steel transition fittings and exposed existing pipe having damaged coating. Clean pipe to bare metal. Initially stretch first layer of tape to conform to the surface while spirally half-lapping. Apply a second layer, half-lapped and spiraled as the first layer, but with spirals perpendicular to first wrapping. Use 10 mil minimum thick polyethylene tape. In lieu of tape wrap, heat shrinkable 10 mil minimum thick polyethylene sleeve may be used.

3.1.3 Valves

Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally. [Provide support for valves to resist operating torque applied to PE pipes.]

3.1.3.1 Stop Valve and Shutoff Valve

Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

3.1.4 Gas Service Installation

[Gas service line, service regulator and gas company meter shall be installed in accordance with Section 33 51 15 NATURAL-GAS / LIQUID PETROLEUM GAS DISTRIBUTION PIPELINES.]Installations shall be in accordance with 49 CFR 192 and ASME B31.8. Contractor shall submit and use only tested and approved work procedures. Contractor shall use only welders and jointers who have been recently qualified by training and test for joining and installing the gas pipe material used on this job. The finished product shall be inspected by a person qualified to inspect joints made by the particular procedures used to make joints.

[3.1.4.1 Service Line

Install service line, branch connection to the main, and riser in accordance with 49 CFR 192 and ASME B31.8. Provide a minimum of 18 inches cover or encase the service line so that it is protected. Install service line so that no undue stress is applied to the pipe, connection, or riser. Install approved riser and terminate with an approved isolation valve, EFV and automatic shutoff device. After laying of pipe and testing, backfill the trench in accordance with Section 31 00 00 EARTHWORK.

Where steel pipe is used as service line, install corrosion prevention coating and cathodic protect for the steel service line. Where connected to an existing cathodically protected steel pipe, ensure electrical continuity from the riser to the branch connection to the main. Install a dielectric fitting on the riser to prevent electrical continuity to the above ground piping.

Where plastic pipe is used as the service line, make joints in accordance with procedures qualified by test. Personnel joining plastic pipe shall be qualified by making a satisfactory specimen joint that passes the required inspection and test listed in 49 CFR 192.285. Inspection shall be made by inspectors qualified in evaluating joints made under the specific joining procedure, as required by 49 CFR 192.287.

3.1.4.2 Service Regulator

Install service regulator in accordance with 49 CFR 192 and ASME B31.8 and this specification ensuring that the customer's piping is protected from over pressurization should the service regulator fail. A 3/8 inch tapped fitting equipped with a plug shall be provided on both sides of the service regulator for installation of pressure gauges for adjusting the regulator. For inside installations, route the regulator vent pipe through the exterior wall to the atmosphere, and seal building penetrations for service line and vent. Terminate the regulator vent so that it is protected from precipitation and insect intrusion, so that it is not submerged during floods, and so that gas escaping will not create a hazard or enter the building through openings.

3.1.4.3 Gas Meter

Install shutoff valve, meter set assembly, and service regulator on the service line [outside the building] [inside the building, a minimum of 3 feet from any potential ignition source], 18 inches above the [ground] [finished floor] on the riser. An insulating joint (dielectric connection) shall be installed on the inlet side of the meter set assembly and service regulator and shall be constructed to prevent flow of electrical current.

]3.1.5 Pipe Sleeves

[Comply with Section 07 84 00 FIRESTOPPING.]Where piping penetrates concrete or masonry wall, floor or firewall, provide pipe sleeve poured or grouted in place. Make sleeve of steel or cast-iron pipe of such size to provide 1/4 inch or more annular clearance around pipe. Extend sleeve through wall or slab and terminate flush with both surfaces. Pack annular space with oakum, and caulk at ends with silicone construction sealant.

3.1.6 Piping Hangers and Supports

Selection, fabrication, and installation of piping hangers and supports shall conform with MSS SP-69 and MSS SP-58, unless otherwise indicated. [Provide seismic restraints in accordance with SMACNA 1981.]

3.1.7 Final Connections

Make final connections to equipment and appliances using rigid pipe and fittings, except for the following:

3.1.7.1 Domestic Water Heaters

Connect with AGA-Approved semi-rigid tubing and fittings.

3.1.7.2 Kitchen Equipment

Install AGA-Approved gas equipment connectors. Connectors shall be long enough [to permit movement of equipment for cleaning] [and] [to afford access to coupling].

3.2 FIELD QUALITY CONTROL

3.2.1 Metal Welding Inspection

Inspect for compliance with [NFPA 54] [and] [ASME B31.8] and 49 CFR 192. Replace, repair, and then re-inspect defective welds.

3.2.2 PE Fusion Welding Inspection

Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect 100 percent of all joints and reinspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

3.2.3 Pressure Tests

Use test pressure of 1 1/2 times maximum working pressure, but in no case less than 50 psig. Do not test until every joint has set and cooled at least 8 hours at temperatures above 50 degrees F. Conduct testing before backfilling; however, place sufficient backfill material between fittings to hold pipe in place during tests. Test system gas tight in accordance with [NFPA 54] [or] [ASME B31.8]. Use clean dry air or inert gas, such as nitrogen or carbon dioxide, for testing. Systems which may be contaminated by gas shall first be purged as specified. Make tests on entire system or on sections that can be isolated by valves. After pressurization, isolate entire piping system from sources of air during test period. Maintain test pressure for at least 8 hours between times of first and last reading of pressure and temperature. Take first reading at least one hour after test pressure has been applied. Do not take test readings during rapid weather changes. Provide temperature same as actual trench conditions. There shall be no reduction in the applied test pressure other than that due to a change in ambient temperature. Allow for ambient temperature change in accordance with the relationship PF + 14.7 = (P1 + 14.7) (T2 + 460) / T1 + 460), in which "T" and "PF" represent Fahrenheit temperature and gage pressure, respectively, subscripts "1" and "2" denote initial and final readings, and "PF" is the calculated final pressure. If "PF" exceeds the measured final pressure (final gage reading) by 1/2 psi or more, isolate sections of the piping system, retest each section individually, and apply a solution of warm soapy water to joints of each section for which a reduction in pressure occurs after allowing for ambient temperature change. Repair leaking joints and repeat test until no reduction in pressure occurs. In performing tests, use a test gage calibrated in one psi increments and readable to 1/2 psi.

3.2.4 System Purging

After completing pressure tests, and before testing a gas contaminated line, purge line with nitrogen at junction with main line to remove all air and gas. Clear completed line by attaching a test pilot fixture at capped stub-in line at building location and let gas flow until test pilot ignites. Procedures shall conform to [NFPA 54] [and] [ASME B31.8].

-CAUTION-
Failure to purge may result in explosion within line when air-to-gas is at correct mixture.

-- End of Section --

SECTION 33 16 15

WATER STORAGE STEEL TANKS
11/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318	(2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7-9 2017) Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2021) Gray Iron Threaded Fittings; Classes 125 and 250
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(2018) Hypochlorites
AWWA B301	(2018) Liquid Chlorine
AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	(2018) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C150/A21.50	(2014) Thickness Design of Ductile-Iron Pipe
AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast
AWWA C500	(2019) Metal-Seated Gate Valves for Water Supply Service
AWWA C504	(2015) Standard for Rubber-Seated Butterfly Valves
AWWA C508	(2017) Swing-Check Valves for Waterworks Service, 2 In. Through 48-In. (50-mm Through 1,200-mm) NPS
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C652	(2019) Disinfection of Water-Storage Facilities
AWWA D100	(2021) Welded Steel Tanks for Water Storage
AWWA D103	(2019) Factory-Coated Bolted Steel Tanks for Water Storage

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.3/D1.3M	(2018) Structural Welding Code - Sheet Steel

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 22	(2022) Standard for Water Tanks for Private Fire Protection

NSF INTERNATIONAL (NSF)

NSF/ANSI 61	(2020) Drinking Water System Components - Health Effects

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC 150/5345-43	(2019; Rev J) Specification for Obstruction Lighting Equipment

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Manufacturer's Qualifications; G[, [_____]]

SD-02 Shop Drawings

Detail Drawings; G[, [_____]]

Tank Installation; G[, [_____]]

Piping and Valve Installation; G[, [_____]]

SD-03 Product Data

Manufacturer's Technical Literature; G[, [_____]]

System Description; G[, [_____]]

Foundations; G[, [_____]]

Heating System; G[, [_____]]

Alarm System; G[, [_____]]

Disinfection Procedures; G[, [_____]]

Valves; G[, [_____]]

Pipe, Fittings, Joints and Couplings; G[, [_____]]

Joint Sealants and Gaskets; G[, [_____]]

SD-05 Design Data

Manufacturer's Design Analysis; G[, [_____]]

Foundation Design Analysis; G[, [_____]]

SD-06 Test Reports

Tank Installation; G[, [_____]]

Testing of Valves and Piping; G[, [_____]]

Hydrostatic Test; G[, [_____]]

Leak Test; G[, [_____]]

SD-07 Certificates

Tank Coating System; G[, [_____]]

Pipe Lining and Coating; G[, [_____]]

SD-08 Manufacturer's Instructions

Shipping, Handling, and Storage; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 Manufacturer's Qualifications

The manufacturer and installer must demonstrate a minimum 10 years of experience in the manufacturing and construction of [elevated] [standpipe] [reservoir] steel water storage tanks. Manufacturer must be able to demonstrate experience through the design and construction of at least 5 completed projects of similar type and size with references with current position, address, and contact information.

Provide certified manufacturer's design analysis, detail drawings, and foundation design analysis by an authorized licensed engineer in the geographical area where construction will take place, having a minimum 4 years of experience as an engineer knowledgeable in design and analyses of steel storage tanks and its foundations. Submit a certificate signed by a registered professional engineer, providing the following information:

a. Description of the structural design loading conditions used for the design of entire tank including the foundation.

b. Description of the structural design method and codes used in establishing the allowable stresses and safety factors applied in the design.

c. A statement verifying that the structural design has been checked by experienced engineers specializing in hydraulic structures.

d. A statement verifying that the detail drawings have been checked by experienced engineers specializing in hydraulic structures to determine that they agree with the design calculations in member sizes, dimensions, and fabricating process as prescribed by applicable AWWA, ACI, and other applicable standards.

1.3.2 Welding Qualifications

Qualification of welding procedures, welders, and welding operators must be in accordance with Section 8.2 of AWWA D100 or AWWA D103 and AWS D1.1/D1.1M and AWS D1.3/D1.3M.

1.3.3 Tank Coating System Certifications

Coating materials for interior applications and all other materials which will be in normal contact with potable water must conform to NSF/ANSI 61. Certification by an independent third-party organization that all interior coatings and materials that come in contact with potable water must comply with NSF/ANSI 61 must be provided.

1.4 SHIPPING, HANDLING, AND STORAGE

Deliver paint in unopened containers with unbroken seals and labels showing designated name, specification number, color, directions for use, manufacturer, and date of manufacture, legible and intact at time of use. Handle and store water storage tank systems, components, and parts to prevent distortions and other damage that could affect their structural, mechanical, or electrical integrity. Replace damaged items that cannot be restored to original condition. Store items subject to deterioration by exposure to elements, in a well-drained location, protected from weather, and accessible for inspection and handling.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Design Requirements

The design, fabrication, and erection of the [elevated] [standpipe] [reservoir] steel water storage tank must be in accordance with the requirements of AWWA D100 or AWWA D103 and ASCE 7-16. Submit design analyses and manufacturer's technical literature.

The following data and information are supplied as a basis for design and erection of the tank and appurtenances:

Tank Capacity and Dimensions

a. Top Capacity Level (TCL) [_____]
b. Bottom Capacity Level (BCL) [_____]
c. Head Range [_____]
d. Diameter [_____]
e. Tank Height [_____]
f. Top of Foundation Elevation [_____]

Seismic Design Criteria

a. Seismic Use Group [_____]
b. Seismic Importance Factor, IF [_____]
c. Site Class [_____]
d. Ss [_____]
e. S1 [_____]

Design Wind Loading

a. Design Wind Speed, V [_____]
b. Gust Factor, G [_____]
c. Importance Factor [_____]
d. Exposure Category [_____]

Roof Design Loading

a. Roof Live Load [_____]
b. Ground Snow Load [_____]

2.1.2 Elevated Tank

Sizing and design of welded steel elevated tank must be in accordance with Section 4 of AWWA D100 and AISC 325. The tank must be a [multi-column] [pedosphere] [fluted column] of [double ellipsoidal type] [double-cone type] [spherical type] [spheroidal type] [the style shown] [or as approved]. [The welded steel tower supporting the tank must be constructed of structural shapes of the open type, or of tubular sections, to permit inspection and painting. The tower must be thoroughly braced with horizontal struts and diagonal ties. The tower columns may be vertical or inclined as the design may require. Main column splices must be as few as possible and must be located as near as practicable to the intersection of the centerline of the struts. Splice plates must be welded so as to hold the members in line and transmit any tension or shearing stresses to which the members may be subjected. The connections of the tank, with the columns must be made to distribute the load properly over the column sections and over the shell of the tank.] [The single-pedestal supporting the tank must be all welded steel, cylindrical column with the transition at the top and bottom of the pedestal in accordance with manufacturer standard.]

2.1.3 [Standpipe][Reservoir]

The [standpipe] [reservoir] must have such standard shell height and diameter that will meet the requirements for the selected standard capacity and for the high-water level specified. The range between high and low water levels will be approximately [_____] feet. The [standpipe] [reservoir] must have [column supported cone roof] [clear span self-supporting [cone roof,] [toriconical roof,] [umbrella roof,] [dome roof, or] [ellipsoidal roof,] [aluminum dome roof,] as approved]. The [standpipe] [reservoir] must be of welded or bolted construction designed in accordance with AWWA D100 or AWWA D103 and AISC 325.

2.1.4 Foundation

Foundation design and construction must be in accordance with [Section 12 of AWWA D100] [Section 13 of AWWA D103] and ACI 318. The foundation design must be based on recommendations provided in the Geotechnical investigation included with the Contract Documents. Recommendations for the foundation type, foundation depth, and design soil-bearing pressure are defined in this report.

2.2 MATERIALS

Provide materials conforming to the following requirements:

2.2.1 Steel

Comply with design requirements of Section 2 of AWWA D100 or Section 2 of AWWA D103 and AISC 325.

2.2.2 Shop Fabrication

Section 9 of AWWA D100 or Section 7 of AWWA D103.

2.2.3 Ductile-Iron Pipe

Pipe, fittings, joints and couplings for fluid conductors, except for overflow pipe, must be ductile-iron pipe and must be either of the following:

2.2.3.1 Bell-and-Plain End Pipe

AWWA C150/A21.50 and AWWA C151/A21.51, for not less than 150 psi working pressure, unless otherwise shown or specified. Joints must be push-on or mechanical-joint conforming to AWWA C111/A21.11 with pressure rating equivalent to that of the pipe. Provide standard thickness cement mortar lined in accordance with AWWA C104/A21.4.

2.2.3.2 Flanged Pipe

Flanged pipes must conform to the applicable portions of AWWA C110/A21.10, AWWA C115/A21.15 and AWWA C151/A21.51, for not less than 150 psi working pressure, unless otherwise shown or specified. Pipe must have flanged ends in accordance with AWWA C115/A21.15. Provide standard thickness cement mortar lining in accordance with AWWA C104/A21.4.

2.2.4 Specials and Fittings (except for overflow pipe)

2.2.4.1 Ductile-Iron with Bell-and-Plain End

AWWA C110/A21.10 and AWWA C151/A21.51 for not less than 150 psi working pressure, unless otherwise shown or specified. Provide standard thickness cement mortar lining in accordance with AWWA C104/A21.4.

2.2.4.2 Ductile-Iron with Flanged Ends

AWWA C110/A21.10 and AWWA C151/A21.51 for not less than 150 psi working pressure unless otherwise shown or specified. Fittings must have flanged ends in accordance with AWWA C110/A21.10. Provide standard thickness cement mortar lining in accordance with AWWA C104/A21.4.

2.2.4.3 Steel Piping

Pipe, ASTM A53/A53M, Standard Weight, zinc-coated for not less than 150 psi working pressure unless otherwise shown or specified. Fittings, ASME B16.4, Class 125, zinc coated; or ASME B16.3, Class 150, zinc coated, threaded.

2.2.4.4 Joints Inside Valve Chamber

All joints inside the valve chamber must be flanged.

2.2.5 Valves

Provide all valves from one manufacturer.

2.2.5.1 Gate Valves

Gate valves must be opened by turning counterclockwise. Valves 3 inches and larger must be stem type with joint ends compatible for the adjoining pipe conforming to AWWA C500. Valves smaller than 3 inches must be all bronze and must conform to MSS SP-80, Type 1, class 150. Valves 3 inches or larger located in valve chambers must be equipped with hand-operating wheels and must be flanged.

2.2.5.2 Rubber-Seated Butterfly Valves

Rubber-seated butterfly valves must be opened by turning counterclockwise. Valves must conform to AWWA C504. Body and disc must be cast iron, conforming to ASTM A48/A48M. Shaft must be 18-8 stainless steel. Resilient seat must be bonded to the valve body. Butterfly valves must be stainless steel to rubber seated, tight closing type. Flanged-end valves are required in valve chamber. Provide a union or sleeve-type coupling in the chamber to permit removal.

2.2.5.3 Check Valves

Check valves must conform to AWWA C508 and be of the horizontal swing-check type, suitable for the purpose and the operating conditions. The body must be cast iron with flanged ends with pressure rating equivalent to that of the connecting pipe.

2.2.5.4 Altitude Valve

The supply to the [elevated tank] [standpipe] [reservoir] must be controlled by a one-way [_____] inch altitude valve, automatic in operation and accurately set to prevent overflow of the [elevated tank] [standpipe] [reservoir]. The valve must have flanged ends and a heavy cast iron body, must be bronze fitted with renewable cups and seats, and must be designed without metal-to-metal seats. The valve must be cushioned when opening and closing to prevent water hammer or shock. Valves must be provided with a travel indicator to determine operating position. All necessary repairs and/or modifications other than replacement of the main valve body must be made possible without removing the valve from the pipeline.

2.2.6 Pressure Gauge

Pressure gauge of the direct-reading type, equipped with a shutoff cock, must be provided, in the valve chamber, on the tank side and on the discharge side of the check or altitude valve. Gauges must have 6 inch dials, must be stem mounted, and must conform to ASME B40.100. Accuracy of gauges must be Grade A or better. Gauges must be calibrated in psi in not more than 2 psi increments from 0 to 50 psi in excess of the normal operating pressure at the tank.

2.2.7 Joint Sealants and Gaskets

The lap joint sealant must be a one component, moisture cured, polyurethane compound in accordance with Section 4.10 of AWWA D103. The sealant must be suitable for contact with potable water must comply with NSF/ANSI 61. Neoprene gaskets and tape type sealer must not be used in liquid contacting surfaces.

2.3 ASSEMBLIES

2.3.1 Tank Accessories

Section [5][7] of AWWA D100 or Section 7 of AWWA D103 and as specified. Additional requirements for accessories are as follows:

2.3.1.1 Steel Riser

Center steel riser must conform to Section 5.1 of AWWA D100 must not be less than [_____] inches in diameter. A safety grill must be provided at the top of the riser with an 18 inch by 18 inch hinged door. [A minimum 18 x 24 inch elliptical access manhole must be provided approximately 3 feet above the base of the wet riser. The hatch must open inward.]

2.3.1.2 Roof Hatches

Provide two access hatches 180 degrees apart on the roof of the tank. One hatch must be 30 inch diameter and allow access from the roof to the interior of the tank. The hatch will be hinged and equipped with a hasp for locking. The hatch cover must have a 2 inch downward edge. The second hatch will be 24 inch diameter and flanged with a removable cover so constructed that an exhaust fan may be connected for ventilation during inspection, maintenance, painting, and cleaning operations. The openings must have a minimum 4 inch curb

2.3.1.3 Tank Vent

Clog resistant tank vent must be centrically located on the tank roof above the maximum weir crest elevation. The vent must conform to Section 5.5 or 7.5 of AWWA D100 or Section 7.7 of AWWA D103. The tank vent must have an intake and relief capacity sufficient to ensure that excessive pressure or vacuum, either entering or leaving the tank, will not be developed during maximum flow rate. The vent will be tank manufacturer's standard mushroom type constructed with corrosion resistant screen to prevent the ingress of wind driven debris, insects, birds and animals. The vent must be designed to ensure fail-safe operation in the event that screen frosts over or otherwise clogged and the bottom of the screen must be sufficiently elevated for snow consideration in the area

2.3.1.4 Overflow

The overflow for the tank must consist of an overflow weir box and [stub overflow] [outside drop pipe, adequately supported and] capable of discharging at a rate of [_____] gpm with [_____] inches of head [, without the water level exceeding [_____]]. [The top of the weir must be [_____] inches below [_____].] [The weir must be located as indicated.] The [stub overflow must be steel, ASTM A53/A53M or equal, must project at least 12 inches from the shell, and must be fitted with a screen] [overflow pipe must be steel, ASTM A53/A53M or equal, and must terminate 1 to 2 feet above grade not to be obstructed by snow or ground clutter and must be fitted with a flapper valve or course corrosion-resistant screen to prevent ingress of animals and insects].

2.3.1.5 Shell Access Manholes

Number, type, location, and size of manholes must be as shown on the drawings.

2.3.1.6 Pipe Connections

Number, type, location, load, and size of pipe connections must be as shown on the drawings. Inlet pipe connections to extend [_____] inches above tank bottom and must be provided with deflectors as shown on the drawings. Outlet pipe connections to extend [_____] inches above tank bottom and must be provided with vortex breakers as shown on the drawings. Pipe connections to the tank must include a flexible coupling outside the tank to allow for differential movement. Pipe connections through the shell must include protection from freezing and vandalism. Piping must allow for differential movement when the tank is filled and drained. Special flexible, extendable connections must be provided for tanks subject to seismic loads.

2.3.1.7 Ladders, Platforms, and Safety Devices

Ladders, platforms, and safety devices must be provided in accordance with Sections 7.4 of AWWA D100 or Sections 7.4 and 7.5 of AWWA D103. Location of ladders must be as shown on the drawings. Sections 7.4 of AWWA D100 and Sections 7.4 and 7.5 of AWWA D103 represent the minimum requirement. In addition, safety cage, rest platforms, roof platforms, roof ladder handrails, and other safety devices must be provided as required by federal or local laws or regulations.

2.3.1.8 Balconies

Provide a balcony a minimum of 2 feet wide with a standard guard railing. Provide a structural steel railing with a top rail 42 inches above balcony platform with an intermediate rail halfway between. Guard rail must be capable of withstanding a force of 200 pounds applied in any direction. Install a steel toe board with minimum height of 4 inches. Bottom of toe board must be a maximum 1/4 inch from platform top. Extend guard rail and toe board entire length of balcony except where access openings are required. For balcony floors use diamond plates a minimum of 1/4 inch thick, punched or drilled for drainage. [Equip access openings in guard rail with a gate which closes automatically.] Hatches through balcony floor must be counterbalanced or otherwise arranged to open from below.

2.3.2 Valve Chamber

Valve chamber must be sufficiently large to house all control valves and fittings; and allow for unobstructed maintenance and replacement. Pipes, valves, and fittings must be supported on concrete blocks where necessary. The valve chamber must be constructed to provide not less than [_____] feet of cover over the pipes. The valves and fittings must extend from the [standpipe] [reservoir] [riser pipe] connection to a point one length of pipe outside the valve chamber walls on the main or feed line to the [elevated tank] [standpipe] [reservoir]; the drain line will be carried to an outlet as indicated on the drawings. The access manhole must be not less than 30 inches in diameter.

2.3.3 Anchors for [Standpipe] [Reservoirs]

The following requirements must be met:

a. An adequate number of anchors designed to prevent overturning for the maximum design uplift forces on the [standpipe] [reservoir] must be installed. If anchor bolts are used, the nominal diameter must not be less than one inch, plus a corrosion allowance of at least 1/4 inch on the diameter. If anchor straps are used, they must be pre-tensioned before welding to the tank shell.

b. The anchor bolts must be a right angle bend, hook, or plate washer, while anchor straps must have only a plate welded to the bottom. The anchors must be inserted into the foundation to resist the computed uplift.

c. Attachment of anchors to the shell must not add significant localized stresses to the shell. The method of attachment must consider the effects of deflection and rotation of the tank shell. Anchors must not be attached to the tank bottom. Attachment of the anchor bolts to the shell must be through stiffened chair-type assemblies or anchor rings of adequate size and height.

2.3.4 High and Low Water Level Alarm System

Provide high and low level devices for alarm monitoring and an intermediate device for tank water level status. All three water levels must be indicated by their respective pilot lights; green for high, amber for intermediate and red for low water levels, and a buzzer for low and high water levels. Buzzer and the respective pilot lights at high and low water levels must be energized while the high or low water level pilot device is actuated. Depressing a silencing button must silence the buzzer indicating the water level and must remain in OFF condition. The pilot light must remain energized. Resetting the pilot light must de-energize the pilot light and release the buzzer from its sealed-off condition.

2.3.5 Heating System

Provide tank heating to comply with NFPA 22 and with capacity to maintain 42 degrees F at all times including coldest temperatures and lowest consumption.

2.4 COATINGS

2.4.1 Tank Coating System for Welded Tanks

Provide exterior coating systems conforming to Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURES and interior coating systems conforming to Section 09 97 13.16 INTERIOR COATING OF WELDED STEEL WATER TANKS.

2.4.2 Tank Coating System for Bolted Tanks

As supplied by the manufacturer.

2.5 CONCRETE WORK

Concrete work must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.6 CHLORINE

AWWA B300 for hypochlorites or AWWA B301 for liquid chlorine, mixed with water to give the solutions required in AWWA C652.

PART 3 EXECUTION

3.1 FOUNDATIONS

Foundations for the [standpipe] [reservoir] [tank columns and riser] and for the valve chamber must be constructed of concrete, reinforced where necessary, and designed in accordance with Sections 12 and 13.7 of AWWA D100 or Sections 13 and 14.5 of AWWA D103 for earth with a bearing value of [_____] psf, at elevation [_____], and constructed in conformance with the applicable requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE, except as shown or specified herein. A Type 1 or Type 2 foundation per AWWA D100 or AWWA D103 must be provided for the [standpipe] [reservoir].

3.2 EXCAVATING, FILLING, AND GRADING

Excavating, filling, and grading must conform to the applicable requirements of Section 31 00 00 EARTHWORK.

3.3 CATHODIC PROTECTION

Cathodic protection must be provided, conforming to Section 26 42 15 CATHODIC PROTECTION SYSTEM FOR THE INTERIOR OF STEEL WATER TANKS.

3.4 LIGHTNING PROTECTION

Lightning protection must be provided, conforming to Section 26 41 00 LIGHTNING PROTECTION SYSTEM.

3.5 OBSTRUCTION LIGHTING

Obstruction lighting must be provided and installed as shown, and must conform to Section 26 56 20 AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS and FAA AC 150/5345-43.

3.6 TANK INSTALLATION

Submit detailed erection drawings, before proceeding with any fabrication. Complete drawings with details of steel, piping and valve installation, and concrete work, and of the assembling of items required for the total installation. Use standard welding symbols in accordance with AWS D1.1/D1.1M and AWS D1.3/D1.3M. Details of welded joints referenced on the drawings must be included. Tank installation must be in accordance with the following requirements:

3.6.1 Welding

Section 8 of AWWA D100 or AWWA D103 and AWS D1.1/D1.1M and AWS D1.3/D1.3M.

3.6.2 Erection

Section 10 of AWWA D100 or AWWA D103 and in accordance with manufacturer's procedures using factory trained and certified erectors.

3.6.3 Inspections and Testing

Tank inspection and testing must be in accordance with Section 11 of AWWA D100 AWWA D103. Mill and shop inspections [are not required] [are required and must be performed by an approved commercial inspection agency]. Perform the radiographic inspections of the welded tank shell, the hydrostatic test and the vacuum box leak test of the tank bottom. Final hydrostatic and leak tests must be performed before painting of welded tanks.

3.7 PIPING INSTALLATION (EXCEPT FOR OVERFLOW PIPING)

3.7.1 General Guidelines

Where details of fabrication or installation are not shown on the drawings, installation must conform to Section 1 and 4 of AWWA C600.

3.7.2 Testing of Valves and Piping

After the [elevated tank] [standpipe] [reservoir] has been erected and the valves and piping installed, and before field painting is begun, the valves and piping must be hydrostatically tested in accordance with Section 5 of AWWA C600. Submit each coating manufacturer's technical data, application instructions, Safety Data Sheets (SDS), and certificate for compliance for VOC content. Submit copies of the following test results:

a. Manufacturer's mill test reports for plate material.

b. Mill and shop inspections by a commercial inspection agency.

c. After acceptance of the structure, the radiographic film and test segments.

At the conclusion of the work, a written report covering the hydrostatic test and certifying that the work was inspected in accordance with Section 11.2.1 of AWWA D100.

Replace with sound material any defective material disclosed by the pressure test; the test must be repeated until the test results are satisfactory.

3.7.3 Pipe Lining and Coating of Underground Ductile-Iron Piping

Polyethylene encasement in accordance with AWWA C105/A21.5 of underground ductile-iron piping must be provided in addition to cement-mortar lining.

3.7.4 Plugging Ends

Cap or plug pipe ends left for future connections as directed.

3.8 PAINTING AND COATING OF TANK

Each coating manufacturer's tank coating system technical data, application instructions, SDS, and certificate for compliance for VOC content must be submitted to the Contracting Officer. Application, curing time, mixing and thinning of the coating materials must be in strict accordance with the manufacturers instructions. The use of thinners must not alter the required minimum dry thickness or adversely affect the VOC content.

3.8.1 Exterior Surfaces (Welded Tanks)

Provide an exterior coating system conforming to Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURES.

3.8.2 Interior Surfaces (Welded Tanks)

Provide an interior coating system conforming to Section 09 97 13.16 INTERIOR COATING OF WELDED STEEL WATER TANKS.

3.8.3 Bolted Tanks

The surfaces of both the interior and exterior of the tank must be coated in accordance with [Section 12.3, Galvanized Coatings][Section 12.4, Glass Coatings][Section 12.5, Thermoset Liquid Suspension Coatings][Section 12.6, Thermoset Powder Coatings] of AWWA D103. Color must be [as indicated] [as approved]. Coating damage during transportation and construction must be repaired per manufacturer's recommendations.

3.9 DISINFECTION

The [elevated tank] [standpipe] [reservoir] and connecting lines thereto must be disinfected with chlorine before being placed in operation.

3.9.1 Tank

[After coating system has been cured, inspected, and approved cured, rinse tank with potable water.] After flushing, the [elevated tank] [standpipe] [reservoir] must be disinfected in accordance with [AWWA C652] [Method 1] [Method 2] [or] [Method 3]. After the chlorination procedure is completed and before the storage facility is placed in service, the Contracting Officer will collect samples of water in properly sterilized containers for bacteriological testing from the full facility in accordance with Section 5 of AWWA C652. The tank will not be accepted until satisfactory bacteriological results have been obtained.

3.9.2 Piping

The valves and piping must be disinfected in accordance with Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

-- End of Section --

SECTION 33 26 00.00 10

RELIEF WELLS
04/08

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Relief Wells

1.1.1.1 Payment

Payment will be made for costs associated with relief wells, which price shall constitute full compensation for construction of relief wells. Wells ordered abandoned by the Contracting Officer before installation of well screen and riser due to no fault of the Contractor will be paid for at [_____] percent of the contract unit price per linear foot, for Bid Item No. [_____] "Relief Wells". Wells ordered abandoned by the Contracting Officer due to no fault of the Contractor will be paid for at the full contract unit price for Bid Item No. [_____] "Relief Wells". No payment will be made for placement or replacement of temporary casings or repair of damage resulting from Contractor operations. No separate payment will be made for relief well screen, riser, check valves, gravel pack, development, backfill, discharge or outfall pipes. No payment will be made for any wells that, in the opinion of the Contracting Officer, are abandoned due to Contractor fault or neglect.

1.1.1.2 Measurement

Relief wells will be measured for payment by the linear foot of completed well between ground surface and 1 foot below the bottom of the [well screen][tail pipe]. Wells ordered abandoned by the Contracting Officer, due to no fault of the Contractor, will be measured for payment.

1.1.1.3 Unit of measure

Unit of measure: linear foot.

1.1.2 Pump Tests

1.1.2.1 Payment

Payment will be made for costs associated with pump test, which price shall constitute full compensation to perform a satisfactory pump test as specified. No payment will be made for pump test not successfully completed.

1.1.2.2 Measurement

Pump tests will be measured for payment for each hour, measured to the nearest 15 minutes, of pump test successfully performed as specified in paragraph PUMP TEST, and as otherwise directed. Testing time will not include time required to place and remove testing and pump equipment.

1.1.2.3 Unit of measure

Unit of measure: per hour.

1.1.3 Pump Installation/Removal

1.1.3.1 Payment

Payment will be made for costs associated with installation and removal of the pumps used in pay item "Pump Tests". No payment will be made for pump installation removal where pump test was not successfully completed.

1.1.3.2 Measurement

Pump installation/removal for pump test will be measured for payment on the base of the applicable contract unit price per relief well pump tested.

1.1.3.3 Unit of measure

Unit of measure: each.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B31.9 (2020) Building Services Piping

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M (2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A312/A312M (2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

ASTM C33/C33M (2018) Standard Specification for Concrete Aggregates

ASTM C94/C94M (2021b) Standard Specification for Ready-Mixed Concrete

ASTM C136/C136M (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C387/C387M (2017) Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar

ASTM D75/D75M (2019) Standard Practice for Sampling Aggregates

ASTM D297 (2015; R 2019) Rubber Products - Chemical Analysis

ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D1056	(2020) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G[, [_____]]

SD-03 Product Data

Well Screen; G[, [_____]]

Filter Pack; G[, [_____]]

Cement Grout Mixture Proportion; G[, [_____]]

SD-06 Test Reports

Tests

1.4 QUALITY ASSURANCE

The [state statutory and regulatory] [_____] requirements listed herein form a part of this specification to the extent referenced: [_____].

1.4.1 Shop Drawings

Show details of the proposed methods for drilling, coupling well screen and riser sections together, placement of centralizers, installing the well screen and riser, and limit(s) of backfilling. Show on the shop drawings the type of screen and size; [perforation size] [or] [slot size], shape and pattern; [bottom plug] [tailpipe] material; and installation detail. The riser pipe, check valve(s) and well discharge details shall also be shown on the shop drawings. Any Contractor-proposed substitutes or alternates in material construction details or methods must be presented in the shop drawings. No phase of the work shall be initiated until all shop drawings concerning that activity have been approved.

1.4.2 Depth of Well

[The length of well screen, length of riser pipe and the well discharge elevation shall conform to the [schedule shown] [elevations established in the field by the Contracting Officer].] [The depth of wells as indicated on the drawings is approximate. Penetration of [bedrock] [impervious layer] might be required. The maximum well depth will not exceed [_____] feet. Whenever the depth to [bedrock] [impervious layer] is less than the maximum well depth, the bottom elevation of each well shall be as determined by the Contracting Officer after drilling of a pilot boring or the well boring.]

1.4.3 Well Design

From data obtained from exploratory drilling, the Contracting Officer will determine the diameter of the well screen, size of openings, the lengths and positions of the screens, and the gradation of the material for the filter pack which is to be installed around the well screen.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Location

The exact location of each well, [with respect to the toe of the embankment] [or] [with respect to distance from structure centerline], will be determined in the field by the Contracting Officer. The total number of wells and spacings may be modified by the Contracting Officer as the work proceeds.

1.5.2 Obstructions Encountered

If obstructions are encountered in the foundation which, in the opinion of the Contracting Officer, render it impracticable to complete the well to the directed depth, the Contracting Officer may adjust the depth. Alternatively, the Contracting Officer may direct the Contractor to abandon the well, plug the hole by backfilling with approved material by an approved procedure, and construct another well at an adjacent site.

PART 2 PRODUCTS

2.1 WELL SCREEN

[The Contractor may, as an option, furnish and install well screen of any of the alternate types specified.] [Well screen shall be of the type and dimensions indicated.] Submit the proposed well screen prior to installation. Screen openings shall be uniform in size and pattern, and shall be spaced approximately equally around the circumference of the pipe.

2.1.1 PVC Pipe Screen

Pipe, fittings, and screen shall be of the size and types [specified][shown.] Pipe, fittings, and screen shall conform to ASTM D1784, ASTM D1785, ASTM D2466, or ASTM D2467. All joints in the PVC pipe shall include couplings and shall be glued with a solvent cement conforming to ASTM D2564. The PVC pipe strength properties shall be equivalent to PVC 1120 Schedule [40] [80] unthreaded plastic pipe. [The well screen, pipe, and fittings shall have a minimum collapse strength of [_____].] [The screen, pipe, and fittings shall have a clear inside diameter of [_____].]

2.1.1.1 Couplings

Couplings shall be [bonded socket][threaded][certilock] type. Fittings shall be produced of the same material and equal quality as specified for plastic pipe screen. Socket type fitting connections of pipe sections shall be bonded with solvent cement. The determination of the proportions and preparation of adhesives, the method of application, and the procedure used for making and curing the connections shall be the responsibility of the Contractor. The system for making joints at the relief well site shall provide a curing period adequate to develop the ultimate strength of the solvent cement. Self-tapping screws or other devices for holding pipe in the couplings during the setting period may be utilized as long as the screws do not penetrate the inside of the pipe. In no case shall a newly-made joint in the casing be stressed, lowered into the relief well, or be submerged in water prior to complete curing of the solvent cement adhesive.

2.1.1.2 Perforations

The PVC well screen shall be [mill slot][continuous wire wrapped rod base] [continuous wire wrapped rod base on perforated pipe] [continuous wire wrapped on perforated pipe screen] [similar to that manufactured by [_____] Johnson Well Equipment, Inc., Pensacola, FL, telephone (904) 453-3131]. All well screen shall have smooth, sharp-edged openings free of burns, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. [The [_____] inch diameter well screen shall have a number [_____] slot, [0.0_____] inch open slot.] [The length of the slots measured on the inside of the pipe shall be [_____] inches.] There shall be a total open area of not less than [_____] square inches per linear foot of [_____] inch diameter well screen. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot, [parallel to,] [normal to,] [or] [diagonal with] the axis of the pipe.

2.1.2 Fiberglass Pipe Screen

Fiberglass pipe screen and fittings shall be manufactured from thermosetting epoxy resins and glass fiber by either a centrifugal casting process or by a filament winding process. Glass fiber used shall be continuous filament, electrical glass with a finish compatible with epoxy resins. Each glass fiber or filament shall be thoroughly impregnated with epoxy resin. The resins used shall be diglycidyl ether of bisphenoa A or cycloaliphatic diepoxides, or blends of the two. Curing agents for these resins shall be aromatic diamines, polycarboxylic acid anhydrides and eutectics therefrom. Curing of the resin system shall be at a temperature over 300 degrees F for a minimum of one hour. Fiberglass pipe wall thickness, strength and durability requirements shall be equivalent to [_____][the Fiberglass/Epoxy pipe produced by Fiberglass Resources Corporation of Farmingdale, New York or Burgess Well Company, Inc., Minden, Nebraska, telephone (308) 832-1642]. All fiberglass pipe and fittings shall be round and straight, of uniform quality and workmanship, and free from all defects including indentation, delamination, bends, cracks, blisters, porosity, dry spots, resin segregation and resin-starved areas. The inside of the pipe and fittings shall be smooth and uniform. The impregnation of the glass fiber with resin shall be such that when the pipe is cut or slotted, no fraying or looseness of glass fiber occurs. [The well screen, pipe, and fittings shall have a minimum collapse strength of [_____].] [The screen, pipe, and fittings shall have a clear inside diameter of [_____].]

2.1.2.1 Couplings

Couplings for fiberglass pipe sections shall be socket threaded or mechanical key-type couplings. The couplings shall be manufactured of the same materials used for the fiberglass pipe specified herein and may be either cast integrally with the pipe sections or as separate components for attachment to the pipe in the manufacturers plant. Every coupling attached to the pipe section as a separate component shall be proof tested in the manufacturer's plant with a tensile load of 2000 lbs. Key-type couplings shall consist of male and female halves designed for joining and locking together by means of a key strip inserted in grooves in the coupling halves. The minimum wall thickness remaining at any grooved section shall not be less than the minimum thickness specified for pipe. Key strips and locking strips shall be of fiberglass, plastic or other non-corrosive material capable of withstanding shearing and bearing stresses equivalent to the design load for the coupling. Socket type fitting connections of the pipe sections shall be bonded with epoxy adhesive. The epoxy materials and bonding agents shall be as recommended by the pipe manufacturer. The determination of the proportions and preparation of adhesives, the method of application, and the procedures used for the making and curing of the joints shall be the responsibility of the Contractor. The pot life, initial setting time and external heating requirements for curing of the adhesive shall be suitable for the procedure and climatic and other conditions and shall be varied as required to suit changes in climatic and other conditions. The system for making joints at the relief well site shall provide a curing period adequate to develop the ultimate strength of the adhesive. Self-tapping screws or other devices for holding adhesive-joined pipe in the couplings during the curing period may be utilized. In no case shall a newly-made joint in the casing pipe be lowered into the relief well, or be submerged in water prior to complete curing of the adhesive.

2.1.2.2 Perforations

All fiberglass well screen shall be [mill slot][continuous wire wrapped rod base]. All relief well screen shall have smooth, sharp-edged openings free of burrs, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. [The [_____] inch diameter well screen shall have a number [_____] slot, [0.0__] inch open slot.] [The length of the slots measured on the inside of the pipe shall be [_____] inches.] There shall be a total open area not less than [_____] square inches per linear foot of [_____] inch diameter well screen. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot [parallel to,] [normal to,] [or] [diagonal with] the axis of the pipe.

2.1.3 Steel Pipe Screen

Steel well screen shall consist of perforated or slotted sections of steel pipe conforming to the requirements of ASTM A53/A53M, Type [_____], Class [_____]. [The well screen, pipe, and fittings shall have a minimum collapse strength of [_____].] [The screen, pipe, and fittings shall have a clear inside diameter of [_____].]

2.1.3.1 Couplings

Couplings for steel pipe screen shall be welded joints or threaded couplings. Welding shall be performed in accordance with requirements in ASME B31.9. Couplings shall meet the material requirements specified for steel pipe screen, except perforations shall be omitted. All threaded pipe and fittings shall be threaded in accordance with ASME B1.20.1. All threaded pipe sections may be field connected. Couplings shall be given the same protection against corrosion as specified for the well screen pipe. Protective coatings damaged while making couplings shall have the areas recoated.

2.1.3.2 Perforations

All steel pipe to be used as relief well screen shall be provided with perforations which shall consist of either machine-cut slots; drilled or punched openings. The slots shall have a width of [_____] inch with a tolerance of plus or minus [_____] inch. The length of the slots measured on the inside of the pipe shall be [_____] inches with a tolerance of plus or minus [_____] inch. For slotted openings there shall be a total open area not less than [_____] square inches per linear foot of [_____] inch diameter relief well. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot [parallel to,] [normal to,] [or] [diagonal with] the axis of the pipe. Drilled or punched openings shall be [_____] inch in diameter and shall provide a total open area not less than [_____] square inches per linear foot of [_____] inch diameter well screen. The pattern of the openings shall be uniformly spaced around the periphery of the pipe.

2.1.4 Stainless Steel Well Screen

The well screen and fittings shall be fabricated entirely from stainless steel conforming to ASTM A312/A312M, Type 304, 304-L, 316 or 316-L. The well screen shall be of stainless steel with a keystone wire-wrapped continuous slot strainer equivalent to [_____] [that manufactured by [Howard Smith Screen Company, Houston, TX, telephone (713) 869-5771] [Johnson Screens, St. Paul, MN 55164, telephone (612) 636-3900]]. [The well screen, pipe, and fittings shall have a minimum collapse strength of [_____].] [The screen, pipe, and fittings shall have a clear inside diameter of [_____].]

2.1.4.1 Couplings

Couplings for the stainless steel well screen shall consist of the same material as the well screen and shall be threaded, flanged, and/or fitted with a welding ring. The couplings shall conform in design to the couplings recommended by the manufacturer of the well screen.

2.1.4.2 Perforations

The [_____] inch diameter well screen shall have a number [_____] slot, [0.0_____] inch open slot. There shall be a total opening of not less than [_____] square inches per foot of [_____] inch diameter well screen.

2.1.5 Tailpipe for Well Screen

The tailpipe for each well screen shall be made of the same material and at least the same minimum thickness as the riser pipe and shall include a bottom plug. Tailpipes shall be a minimum of [3] [_____] feet in length and fastened to the bottom of the screen in an approved manner.

2.2 RISER PIPE

The relief well riser pipe material and method of manufacture shall conform to the requirements specified in paragraph WELL SCREEN, except that the screen perforations or opening shall be omitted. The relief well riser pipe diameter and discharge details shall be as shown. Couplings to the well screen and between riser pipe sections shall be as specified in paragraph COUPLING.

2.3 FILTER PACK

Submit proposed filter pack material and its gradation, before it is placed. Material for the filter pack around the riser pipes and screens shall be a [washed gravel] [washed sand] [dry processed sand] composed of hard, tough, and durable particles free from adherent coating. The filter pack shall not be crushed stone. The filter pack material shall contain no detrimental quantities of organic matter nor soft, friable, thin, or elongated particles in accordance with the quality requirements in ASTM C33/C33M, Table 1 and Table 3, Class 5S, and in ASTM E11, Table 1. The filter pack shall meet the following gradation requirements:

U.S. STANDARD U.S. STANDARD	PERCENT PASSING BY WEIGHT
[_____]	[_____]
[_____]	[_____]

2.4 CHECK VALVES

a. [The check valve shall be a one piece reinforced all rubber (neoprene) check valve with an integral elastomer flange similar and equal to the Red Valve Series [35][_____], Size [6][_____] inch, manufactured by Red Valve Company, Inc., 700 North Bell Ave., Pittsburgh, PA 15106, telephone (412) 279-0044. The check valve shall be designed to withstand a maximum back pressure of [15][_____] psi. The backup ring for the check valve shall be stainless steel. Stainless steel bolts, washers, and nuts shall be used to fasten the valves onto the flanged end of the pipes. The check valve shall be installed with the flared end duck bill in a vertical position.]

b. [Fabricate check valves of [brass][stainless steel][aluminum] plate, threaded fasteners and rods as detailed on the drawings. Fabricate sealing disc of [3/8][_____] inch silicone sponge rubber free of porous areas, foreign materials, and visible defects.]

c. Silicone sponge rubber shall meet the following specifications:

PHYSICAL TEST	TEST VALUE		ASTM TEST METHOD
	SOFT	MEDIUM	
Compression Deflection (compressed 25 percent at room temperature)	2 to 7 psi	6 to 14 psi	ASTM D1056
Tensile Strength	50 psi (min)	75 psi (min)	ASTM D412
Elongation at break	75 percent (min)	100 percent (min)	ASTM D412
Compression Set (Compressed 50 percent for 22 hours at 212 F	15 percent (max)	5 percent (min)	ASTM D297
Density	0.012 pci (min)	0.017 pci (min)	ASTM D297 Hydrostatic Method

d. Workmanship and metalwork fabrication of check valves shall be in accordance with the details shown. Install check valves accurately vertically and adjust to the required elevation.

2.5 CONCRETE

Concrete shall conform to [the requirements specified in Section [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE] [_____]] [ASTM C94/C94M, Option A, with a [3/4][_____] inch Nominal Maximum Size of Aggregate, a maximum slump of 5 inches, air content of [5] [_____] percent, and a compressive strength of [2500][_____] psi] [packaged normal weight concrete conforming to ASTM C387/C387M].

PART 3 EXECUTION

3.1 DRILLING

Wells may be drilled by the reverse rotary circulation method or other method approved, which will insure proper placement of the well screen, riser pipe, and filter pack. Methods which involve radical displacement of the formation, or which may reduce the yield of the well, will not be permitted. Excavated material shall be disposed of as directed.

3.1.1 Reverse Circulation Method

If the reverse circulation method is used for drilling wells, remove all of the drilling fluid from the filter pack and the natural pervious formation. If in the opinion of the Contracting Officer the walls of the hole above the top of the filter pack require support during development operations, place a temporary casing similar to that specified in paragraph TEMPORARY CASING. The diameter of the hole shall be such as will permit the placement of the minimum thickness of filter pack as specified in paragraph FILTER PACK PLACEMENT. The drilling fluid shall be a suspension of fine grained soil or shall be a commercial product of a recognized manufacturer, shall be approved by the Contracting Officer, and shall have the characteristic of being readily removable from the filter pack and the walls of the formation by development as specified in paragraph DEVELOPMENT. The use of bentonite will not be permitted.

3.1.2 Temporary Casing

Temporary well casing of either iron or steel of sufficient length to case to the bottom of all borings shall be available at the construction site. The Contracting Officer will direct the use of a temporary casing to the bottom of the boring during drilling and placement of screen, riser, and filter pack when he believes it is necessary to provide adequate support to the sides of the hole. When the walls of the boring will require support only during development operations a temporary casing will be required to extend only to a depth 3 feet below the top of the filter pack. The temporary casing, shall have an inside diameter of not less than [_____] inches, shall have sufficient thickness to retain its shape and maintain a true section throughout its depth, and may be in sections of any convenient length. The temporary casing shall be such as to permit its removal without disturbing the filter pack, riser, or well screen. The setting of temporary casing shall be such that no cavity will be created outside of it at any point along its length. In the event the temporary casing should become unduly distorted or bent it should be discarded and a new casing should be used during installation of any additional relief wells.

3.2 INSTALLATION OF RISER PIPE AND SCREEN

3.2.1 Assembly

All riser pipe and screen shall be in good condition before installation and all couplings and other accessory parts shall be securely fastened in place. The successive lengths of pipe shall be arranged to provide accurate placement of the screen sections in the bore hole. [The riser-pipe shall be provided with an approved cap and a flanged top section, the top of which shall be set at the elevation directed or shown.] Centralizers shall be attached to the assembled riser pipe and screen in such numbers and of a type that they will satisfactorily center the riser pipe and screen in the well and will hold it securely in position while the filter pack material is being placed.

3.2.2 Joints

Sections of relief well pipe shall be joined together as specified in paragraph COUPLINGS. Joints shall be designed and constructed to have the strength of the pipe and where possible a strength capable to support the weight of the relief well stem as it is lowered into the hole. When not practicable to construct joints that will support the weight of the relief well stem, the stem shall be supported at the lower end by any approved means that will assure that the joints do not open while being lowered into place in the well.

3.2.3 Installation

The assembled riser pipe and screen shall be placed in the bore hole in such manner as to avoid jarring impacts and to insure that the assembly is centered and not damaged or disconnected. The screen should be suspended in the hole and not resting on the bottom of the hole. After the screen and riser pipe have been placed, a filter pack shall be constructed around the screen section as specified in paragraph FILTER PACK PLACEMENT and the well developed as specified in paragraph DEVELOPMENT. The top of the riser pipe shall be held at the designated elevation during placement of the filter pack.

3.2.4 Check for Plumbness and Alignment

[Each well shall be sufficiently straight and plumb, such that a cylinder [10][20][40] feet in length and with an outside diameter 1/2 inch smaller than the inside diameter of the well may be lowered for the full depth of the well and withdrawn without binding against the sides of the well. Furnish the dummy cylinder and perform the alignment check and plumbness check in the presence of the Contracting Officer. A variation of [6][_____] inches per 100 feet of depth will be permitted in the plumbness of well from a plumb line at the top of the well; however, this will not relieve the Contractor of the responsibility of maintaining adequate clearance for installation of the surging and pumping equipment required for testing and pumping the wells. At least one plumbness check and alignment check shall be performed on each well after placement of the filter pack. Additional tests may be made during the performance of the work at the option of the Contractor.]

[The well shall be constructed and all casing set round, plumb, and true. Perform the following tests after the installation of the well but prior to backfilling, and before its acceptance. Additional tests may be made during the performance of the work at the option of the Contractor. Should the Contractor fail to correct, at no additional cost to the Government, any faulty alignment or plumbness disclosed as a result of these tests, the Contracting Officer may refuse to accept the well. If in the judgement of the Contracting Officer the Contractor has exercised all possible care in constructing the well and the defect is due to circumstances beyond the Contractor's control or if the utility of the completed well is not materially affected or if the cost of necessary remedial measures will be excessive, the requirements for plumbness may be waived. In no event will the provisions with respect to alignment be waived.]

3.2.4.1 Plumbness

Test plumbness by use of a plumb line. The plummet shall be a short cylinder with an outside diameter approximately 1/4 inch smaller than the inside of the well and/or temporary casing. It shall be suspended from a small diameter wire rope and its point of suspension shall be in the exact center of the plummet. The plummet shall be sufficiently heavy to stretch the wire rope taut. The wire rope shall pass over a guide sheave which shall be positioned at least 10 feet above the top of the well and adjusted horizontally so that the plummet hangs in the center of the well. Displacement of the wire rope during the plumbness check shall be measured by means of a transparent plastic sheet on which a number of concentric circles shall be scribed or drawn, and which is centered on the top of the well. The exact center of these circles shall be marked, and then a slot, slightly larger than the plumb line and extending from this center to the edge, shall be cut in the plastic sheet. As the plummet is lowered, any out-of-plumb condition of the well will be indicated by the wire rope tending to drift away from the center, and the plastic sheet shall be rotated until the slot is oriented in the direction of this drift, while at all times maintaining the center of the concentric circles coincident with the center of the well. Measurement of the amount of drift shall be made along the edge of the slot for each increment by which the plummet is lowered into the well. Drift at any depth shall be determined by multiplying the measured plumb line displacement by the total length of the plumb line and dividing the result by the fixed distance between the guide sheave and the top of the well. If desired, alignment may be calculated from the plumbness data in lieu of the alignment check described in paragraph ALIGNMENT. Should the well vary from the vertical in excess of [6][_____] inches per 100 feet of depth, the plumbness of the well shall be corrected by the Contractor at no additional cost to the Government.

3.2.4.2 Alignment

Test the alignment by lowering into the well a section of cylinder [10][20][40] feet long or a dummy of the same length. The outside diameter of cylinder shall be not more than 1/2 inch smaller than the inside diameter of the well. Should the cylinder fail to move freely throughout the length of the well, the alignment of the well shall be corrected at no additional expense to the Government.

3.3 FILTER PACK PLACEMENT

After the well screen and riser pipe have been installed, the filter pack material shall be placed by tremie, when using a well graded material, in an approved manner such that segregation will not occur. When using a uniform graded filter material, the material may be poured around the well screen at a rate that will prevent bridging of the material. The material should be placed around all sides of the screen to assure that the screen is not pushed against the side of the bore hole causing the screen to come in contact with foundation material or prevent the proper thickness of filter from being placed uniformly around the screen. The filter pack shall have a minimum thickness of [_____] inches between the outside of the well screen and the natural formation. The filter pack shall be placed at a constant rate from the start of placement until it has reached the elevation [shown], [directed] [a minimum of 2 feet above the top of the well screen]. If a tremie is required, a double string of tremie pipe shall be used. The pipes shall be placed on opposite sides of the screen and/or casing, that is, 180 degrees apart, and shall be guided in such a manner that they will remain in this position throughout the placing process. The tremie pipes shall be set in place, filled completely with filter pack prior to being lifted off the bottom of the hole. The filter pack in the tremie pipe shall be kept a minimum of 1 foot above the water surface in the well throughout the placing process. In no case shall the gradation of the filter pack fall outside of the range specified in paragraph FILTER PACK.

3.4 DEVELOPMENT

Following placement of filter pack materials, develop the relief well by jetting, surging, intermittent pumping, or other approved methods as may be necessary to give the maximum yield of water per foot of drawdown. At the time of development of any relief well, the well shall be free of drawdown or surcharge effects due to pump testing, developing or drilling at another location. The Contractor is responsible for maintaining at the relief well the needed access and work area and clearance in the relief well necessary to accomplish development. Furnish, install, or construct the necessary discharge line and troughs to conduct and dispose of the discharge a sufficient distance from the work areas to prevent damage. Development shall be conducted to achieve a stable well of maximum efficiency and shall be continued until a satisfactory sand test, as specified in paragraph SAND TEST, is obtained. As development proceeds, filter pack material shall be added to the annular space around the screen to maintain the top elevation of the filter pack to the specified elevation. Provide an open tube or other approved means for accurately determining the water level in the well under all conditions. If, at any time during the development process it becomes apparent in the opinion of the Contracting Officer that the well may be damaged, development operations shall be immediately terminated. The Contracting Officer may require a change in method if the method selected does not accomplish the desired results. The Contracting Officer may order that wells which continue to produce excessive amounts of fines after development for 6 hours be abandoned, plugged, and backfilled, and may require the Contractor to construct new wells nearby. All materials pulled into the well by the development process shall be removed prior to performing the pumping test.

3.4.1 Jetting

Perform using either a single or double ring jet. If a double ring jet is used the rings should be 2 feet apart. The jetting tool shall be constructed of high-strength material and conservatively designed and proportioned so that it will withstand high pressures. The jetting tool shall have [two [3/16] [1/4][3/8] inch diameter hydraulically balanced nozzles spaced 180 degrees] [four [3/16][1/4][3/8] inch diameter holes spaced 90 degrees] apart and which shall exert the jetting force horizontally through the screen slots. The rings shall be constructed such that the tips of the jets shall be within 1/2 inch from the inner surface of the well screen. The pump used in conjunction with the jetting tool shall be capable of providing [pressures up to [250][_____] psi.] [a minimum jetting fluid exit velocity of 150 feet per second.] Prior to commencing jetting, and following each jetting cycle, all sand and/or other materials shall be removed from inside the screen. The jetting process shall start at the bottom of the screen and consist of rotating the jetting tool [slowly] [1 cycle per 30 seconds] [[_____] cycles per [_____] seconds] while rotating the pipe [180][90] degrees for two minutes at each location then raising the pipe [6][_____] inches. All wells, more than 4 inches in diameter, shall be pumped during the jetting cycle to remove incoming sand and other material. Such pumping shall be at a rate not less than 115 percent of the rate at which fluid is introduced through the jetting tool. This will allow a flow of material into the well as it is being developed. Water used for development shall be free of sand. The contracting officer may require other means of developing the well such as intermittent pumping method, variation of the intermittent pumping method, or surge block if it appears that the development of the well is not producing the desired results.

3.4.2 Intermittent Pumping

Perform by pumping the well at a capacity sufficient to produce a rapid drawdown of approximately [_____] feet stopping the pump (backflow through pump will not be permitted) to permit the water surface to rise to its former elevation, and repeating this procedure. Cycle time for this procedure will vary as directed but will not be more than 3 cycles per minute. A pump discharge in excess of [_____] gpm will be required. A deep well turbine pump, or electric submersible pump with check valve, shall be used with any attachment necessary to accomplish rapid starting and stopping for intermittent pumping. The intake shall be set at least 10 feet below the maximum expected drawdown in the well. Prior to commencing intermittent pumping, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. The amount of drawdown may be decreased if, in the opinion of the Contracting Officer, the efficiency of the well might otherwise be impaired.

3.4.3 Surging

Use a circular block which is approximately 1 inch smaller in diameter than the inside diameter of the relief well and is constructed of a material which will not damage the screen if the block comes in contact with the screen, and a bailer or pump to remove materials drawn into the well. The surging shall be continued for a period of approximately one hour or until little or no additional material from the foundation or filter pack can be pulled through the screen. The surge block shall be moved by a steady motion up and down the full length of the well screen. Prior to commencing surging, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. Remove all materials pulled into the well by the surging process.

3.5 BACKFILLING

[After the well has been developed, additional filter pack should be added if necessary to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the annular space above the filter pack, shall be backfilled by first placing a 12 inch minimum layer of concrete sand on the filter pack and then filling the remainder of the space up to the [finished ground surface] [well pit] with grout or concrete. The concrete backfill shall be placed to a depth at least equal to the existing impervious blanket, but in no case less than [_____] feet.] [For PVC riser pipe, after the well has been developed, additional filter pack should be added if necessary for it to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the remaining annular space above the filter pack shall be backfilled by first placing a 12 inch minimum layer of concrete sand on the filter pack and then filling the remainder of the space up to the [finished ground surface] [well pit] with bentonite.] The temporary casing, if used, shall be withdrawn in increments as the backfill is placed. Fill with impervious material, to original grade, all pits such as those incidental to the reverse rotary circulation method of drilling.

3.6 PLUGGING OF ABANDONED WELLS

[The Contractor has the option of attempting to remove the well screen. If the well screen can be removed, grout the bore hole starting from the bottom of the hole to within 3 feet of ground surface. The grouting shall start at the elevation of the bottom of the tailpipe of the well. If the well screen could not be removed or broke off during the removal attempt, the Contractor is still responsible for grouting the well from the bottom of the tailpipe to within 3 feet of ground surface. Either of the above abandonment procedures may require the Contractor to redrill the hole so that the bore hole can be grouted.][The well shall be grouted from the bottom of the tailpipe to within 3 feet of ground surface. After the grout has setup the riser pipe shall be cutoff 3 feet below ground. Then the hole shall be backfilled.] The cement grout mixture proportion to be used shall be submitted for approval.

3.7 TESTS

Submit sampling and testing reports for each relief well, logs of the borings, well screen and riser pipe, backfill material, and pump tests. Register each well with the state as required by the state in which the well is installed.

3.7.1 Pump Test

Upon completion but before acceptance, each well shall be subjected to a pump test of which a sand test will form a part. Provide a [deep well turbine] pump, capable of producing the specified drawdowns over periods of time sufficient to satisfactorily perform the pump test specified herein. The intake shall be set 10 feet below the maximum expected drawdown in the well. The amount of sand should be measured after each test. The pump shall be complete with either gasoline, diesel, or electric motor of adequate size. In case an electric motor is used, provide, without additional cost to the Government, the electric power and the necessary wiring. Provide an open tube or other approved means for accurately determining the water level in the well. Furnish and install an orifice meter of approved design or other approved equipment for the purpose of measuring the discharge from the well during the pumping test. Furnish, install, or construct the necessary pipe discharge line, troughs, or ditches necessary to dispose of the pumping test discharge a sufficient distance from the work area to prevent damage. The tests will be conducted under the direction of the Contracting Officer and may be made as soon as each well is completed [and adjacent Government installed piezometer tubes are operational]. Test data will be recorded by Government personnel. Test each well by pumping continuously for a minimum of [6] [_____] hours. Prior to starting the pump test all material shall be removed from the bottom of the well. The pumping shall be at a rate [of [_____] gpm][sufficient to produce approximately [_____] feet of draw-down]. If the test is interrupted, other than by order of the Contracting Officer, prior to the completion of the specified period of continuous operation, the test shall be re-run. In addition to the required pumping test, the Contracting Officer may direct the Contractor to perform additional pump tests. Such additional testing shall conform in general to the requirements specified herein except that the duration of the tests and the approximate draw-down will be determined by the Contracting Officer. In the event that sand or other material collects in the well as a result of the pump test, accurate measurements shall be taken as to the quantity of material in the well and all such material shall be removed. Upon completion of the pump test, remove all equipment, discharge lines, electrical lines, lumber, and debris, and shall backfill any excavated areas with impervious material.

3.7.2 Sand Test

As part of each Pump Test or at the end of each intermittent pumping a determination of the amount of sand (filter pack and/or foundation material) a well is producing shall be performed. Prior to starting the sand test all material shall be removed from the bottom of the tailpipe. Test each well by pumping at a rate [of [_____]gpm] [sufficient to produce approximately [_____] feet of draw-down]. After the pump is at the desired pumping rate the flow from the discharge shall be diverted [into a container that will collect all the sand being carried by the water][through a Rossum Sand Tester]. Development of the well is satisfactory if the amount of sand collected is less than 1 pint per 25,000 gallons of water pumped at the specified rate. Upon completion of the test the amount of sand in the tailpipe shall be determined to verify that no material is being deposited in the bottom of the well.

3.7.3 Filter Pack Sampling and Testing

Verify that all materials conform to the specifications before delivery to the project. The particle size distribution of the filter pack shall be sampled and tested in accordance with ASTM C136/C136M and ASTM D75/D75M. [Prior to delivery to the project site, at least two samples of material should be collected and tested for every 750 tons (2000 lb) produced under this contract.] [Within 48 hours before being placed in the relief well to be back-filled, the filter pack shall be sampled from the material stockpiled at the project site. There shall be at least one particle size distribution test on the filter pack for [each well] [every [_____] wells].] A pump test shall be performed in accordance with technical provisions herein specified.

3.7.4 Reports

Include in the reports for each relief well, logs of the boring, elevations of the well screen, top of riser pipe, bottom of the tailpipe, filter pack gradation, quantity of filter pack added during development, pump test, sand test, and report of backfilling. The elevation of changes between materials on these logs shall be to the nearest 0.1 foot. The log of backfill material shall include the filter pack particle size distribution test data, and notes concerning installation and development of the relief well. The pump test log shall include the duration of the test and rate of flow in gpm, and the draw-down response data with time in the pumped well, in adjacent wells, and in nearby piezometers. The relief well log and the pump test log shall be submitted to the Contracting Officer as part of the weekly quality control report specified in Section 01 45 00.00 10 QUALITY CONTROL. Also submit a report of the well installation to the appropriate public agency and in the form required by state statutory and/or regulatory requirements specified in paragraph REGULATORY REQUIREMENTS.

-- End of Section --

SECTION 33 30 00

SANITARY SEWERAGE
05/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE PIPE ASSOCIATION (ACPA)

ACPA 01-102	(2000) Concrete Pipe Handbook
ACPA 01-103	(2000) Concrete Pipe Installation Manual

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2017) Manual for Railway Engineering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	(2018) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges

AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast
AWWA C153/A21.53	(2019) Ductile-Iron Compact Fittings for Water Service
AWWA C302	(2016) Reinforced Concrete Pressure Pipe, Noncylinder Type
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C605	(2021) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings
AWWA C606	(2015) Grooved and Shouldered Joints
AWWA C900	(2016) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
AWWA M9	(2008; Errata 2013) Manual: Concrete Pressure Pipe

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A746	(2018) Standard Specification for Ductile Iron Gravity Sewer Pipe
ASTM C12	(2022) Standard Practice for Installing Vitrified Clay Pipe Lines
ASTM C14	(2020) Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe

ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C76	(2020) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C94/C94M	(2021b) Standard Specification for Ready-Mixed Concrete
ASTM C150/C150M	(2021) Standard Specification for Portland Cement
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C270	(2019a; E 2019) Standard Specification for Mortar for Unit Masonry
ASTM C361	(2016) Standard Specification for Reinforced Concrete Low-Head Pressure Pipe
ASTM C425	(2021) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C700	(2018) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C828	(2011; R 2021) Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C923	(2008; R 2013; E 2016) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C969	(2019) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C972	(2000; R 2011) Compression-Recovery of Tape Sealant

ASTM C990	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C1214	(2013) Standard Test Method for Concrete Pipe Sewerlines by Negative Air Pressure (Vacuum) Test Method
ASTM C1227	(2013) Standard Specification for Precast Concrete Septic Tanks
ASTM C1244	(2020) Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
ASTM C1644	(2006; R 2017) Standard Specification for Resilient Connectors Between Reinforced Concrete On-Site Wastewater Tanks and Pipes
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D624	(2000; R 2020) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2412	(2021) Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2464	(2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2015) Standard Specification for

	Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D2997	(2015) Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3262	(2020) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe
ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3753	(2019) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM D3840	(2014) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Nonpressure Applications
ASTM D4101	(2017) Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials
ASTM D4161	(2014) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F667/F667M	(2016; R 2021) Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings
ASTM F714	(2022) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

ASTM F758	(2014) Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
ASTM F794	(2021) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F894	(2019) Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings
ASTM F1417	(2011a; E 2020) Standard Practice for Installation Acceptance of Plastic Non-pressure Sewer Lines Using Low-Pressure Air
ASTM F2736	(2013; E 2014) Standard Specification for 6 to 30 in. (152 To 762 mm) Polypropylene (PP) Corrugated Single Wall Pipe And Double Wall Pipe
ASTM F2764/F2764M	(2019) Standard Specification for 6 to 60 in. [150 to 1500 mm] Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO Z1000	(2013) Prefabricated Septic Tanks

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.27	(Nov 2016) Scaffolds and Roope Descent Systems

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6	(1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor's License; G[, [_____]]

SD-02 Shop Drawings

Installation Drawings; G[, [_____]]

SD-03 Product Data

Precast Concrete Manholes

Frames, Covers, and Gratings

Gravity Pipe

Pressure Pipe

Precast Concrete Septic Tanks; G[, [_____]]

SD-06 Test Reports

Precast Concrete Sewer Manhole Test; G[, [_____]]

Hydrostatic Sewer Test; G[, [_____]]

Infiltration Tests And Exfiltration Tests; G[, [_____]]

Negative Air Pressure Test; G[, [_____]]

Low-Pressure Air Tests; G[, [_____]]

Tests For Pressure Lines; G[, [_____]]

Deflection Testing

Concrete Pipe Test; G[, [_____]]

SD-07 Certificates

Portland Cement

Gaskets

Pre-Installation Inspection Request; G

Post-Installation Inspection; G

1.3 QUALITY CONTROL

1.3.1 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Verify installing Contractor's License is current and state certified or state registered.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.4.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

[1.4.1.2 Cement, Aggregate, and Reinforcement

As specified in Section [03 30 00 CAST-IN-PLACE CONCRETE][03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE].

]1.4.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. [Take special care not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs.] Carry, do not drag, pipe to trench. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe in accordance with the manufacturer's recommendation and discard those materials if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Sanitary Sewer Gravity Pipeline

[Provide [mains and laterals] [[_____] inch lines] of [clay pipe] [concrete pipe] [ductile-iron pipe] [polypropylene pipe] [or] [polyvinyl chloride (PVC) plastic pipe]. Provide building connections [[_____] inch lines] of [clay pipe] [concrete pipe] [or] [polyvinyl chloride (PVC) plastic pipe].] [Provide new and modify existing exterior sanitary gravity sewer piping and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer system includes equipment, materials, installation, and workmanship as specified herein more than 5 feet outside of building walls.]

2.1.2 Sanitary Sewer Pressure Lines

Provide pressure lines of [ductile iron pressure pipe] [concrete pressure pipe] [or] [polyvinyl chloride (PVC) plastic pressure pipe].

2.2 MATERIALS

Provide materials conforming to the respective specifications and other requirements specified below. Submit manufacturer's product specification,standard drawings or catalog cuts.

2.2.1 Gravity Pipe

2.2.1.1 Clay Piping

2.2.1.1.1 Clay Pipe and Fittings

ASTM C700, [standard strength] [extra strength] [bell-and-spigot piping only].

2.2.1.1.2 Clay Piping Jointing Materials

Use ASTM C425.

2.2.1.2 Concrete Gravity Sewer Piping

2.2.1.2.1 Concrete Gravity Pipe and Fittings

Provide [nonreinforced concrete pipe conforming to ASTM C14, Class [_____]][reinforced concrete pipe conforming to ASTM C76, Class [_____]]. Provide circular pipe with elliptical reinforcement having a readily visible line at least 12 inches long painted or otherwise applied on the inside and outside of the pipe at each end so that when the pipe is laid in the proper position, the line will be at the center of the top of the pipe. Provide fittings and specials conforming to the applicable requirements specified for the pipe including the strength of the pipe. [Use pipe and fittings containing [Type II] [Type V] [low alkali cement] cement conforming to ASTM C150/C150M.]

2.2.1.2.2 Jointing Materials for Concrete Gravity Piping

Provide gaskets and pipe ends for rubber gasket joint conforming to ASTM C443. Use gaskets suitable for use with sewage.

Submit certificates of compliance stating that the fittings or gaskets used for waste drains or lines designated on the plans as [_____] are [oil] [_____] resistant.

2.2.1.3 Ductile Iron Gravity Sewer Pipe and Associated Fittings

2.2.1.3.1 Ductile Iron Gravity Pipe and Fittings

Provide ductile iron pipe conforming to ASTM A746 with cement-mortar lining in conforming to AWWA C104/A21.4, Pressure Class [_____]. Provide push-on joints conforming to AWWA C111/A21.11.

2.2.1.4 PVC Gravity Sewer Piping

2.2.1.4.1 PVC Gravity Pipe and Fittings

[ASTM D3034, SDR 35, or ASTM F949 with ends suitable for elastomeric gasket joints.] [ASTM F794, Series 46, for ribbed sewer pipe with smooth interior, size 8 inch through 48 inch diameters.]

2.2.1.4.2 PVC Gravity Joints and Jointing Material

Provide joints conforming to ASTM D3212. Gaskets are to conform to ASTM F477.

2.2.2 Pressure Pipe

2.2.2.1 Concrete Pressure Piping

2.2.2.1.1 Concrete Pressure Pipe and Fittings

Provide pipe conforming to [AWWA C302 or to] ASTM C361. Design pipe for hydrostatic head of [100] [125] feet and external loading of [5] [10] [15] [20] feet of earth cover. Provide circular pipe with elliptical reinforcement having a readily visible line at least 12 inches long painted or otherwise applied on the inside and outside of the pipe at each end so that when the pipe is laid in the proper position, the line will be at the center of the top of the pipe. [Use [Type II] [Type V] [low alkali] cement conforming to AWWA C302 in manufacturing pipe and fittings] Provide fittings.

2.2.2.1.2 Jointing Materials for Concrete Pressure Piping

Provide gaskets as specified in [the referenced specification for the pipe] [ASTM C361] and are suitable for use with sewage.

2.2.2.2 Ductile Iron Pressure Piping

2.2.2.2.1 Ductile Iron Pressure Pipe and Fittings

Provide [push-on-joint] [mechanical joint] [flanged] ductile-iron pipe conforming to AWWA C151/A21.51, [Pressure Class [_____]] [Thickness Class [_____]]. Provide fittings conforming to AWWA C110/A21.10 or AWWA C153/A21.53. [Provide fittings with push-on joint ends conforming to AWWA C111/A21.11.] Use fittings which have a pressure rating at least equivalent to that of the pipe. Pipe and fittings are to have cement-mortar lining conforming to AWWA C104/A21.4, standard thickness.

2.2.2.2.2 Ductile Iron Pressure Joints and Jointing Materials

a. Joints, general: Use [push-on joints] [or] [mechanical joints]for pipe and fittings except as otherwise specified in this paragraph. [Use mechanical-joints where indicated.] [Use flanged joints where indicated.] [Joints made with sleeve-type mechanical coupling may be used in lieu of push-on joint.] [[Grooved] [or] [shouldered] type joints may be used in lieu of push-on joint [or flanged joint], except where joint is buried.]

b. Push-on joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly are to conform to AWWA C111/A21.11.

c. Mechanical joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets are to conform to AWWA C111/A21.11.

d. Flanged joints: Provide bolts, nuts, and gaskets for flanged connections as recommended in the Appendix to AWWA C115/A21.15. Provide flange for setscrewed flanges of ductile iron, ASTM A536, Grade 65-45-12, and conforming to the applicable requirements of ASME B16.1, Class 250. Provide 190,000 psi tensile strength, heat treated, and zinc-coated steel setscrews for setscrewed flanges. Conform gasket for setscrewed flanges to the applicable requirements for mechanical-joint gaskets specified in AWWA C111/A21.11. Design of setscrewed gasket are to provide for confinement and compression of gasket when joint to adjoining flange is made.

e. Joints made with sleeve-type mechanical couplings: Provide couplings designed to couple plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. Provide couplings consisting of one middle ring flared or beveled at each end to provide a gasket seat, two follower rings, two resilient tapered rubber gaskets, and bolts and nuts to draw the follower rings toward each other to compress the gaskets. The middle ring and the follower rings are to be true circular sections free from irregularities, flat spots, and surface defects; the design is to provide for confinement and compression of the gaskets. The middle ring is to be of cast-iron [or steel], and the follower rings are to be of malleable iron or ductile iron. Cast iron couplings are to conform to ASTM A48/A48M and not be less than Class 25. Malleable iron couplings are to conform to ASTM A47/A47M. Ductile iron couplings are to conform to ASTM A536. [Steel is to have a strength not less than that of the pipe.] Gaskets are to be designed for long life and resistance to set after installation and meet the applicable requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Bolts are to be track-head type; bolts and nuts are to be either of the following: bolts conforming to the tensile requirements of ASTM A307, Grade A, with nuts conforming to the tensile requirements of ASTM A563, Grade A; or round-head square-neck type bolts conforming to ASME B18.5.2.1M and ASME B18.5.2.2M with hex nuts conforming to ASME B18.2.2. Bolts are to be 5/8 inch in diameter; minimum number of bolts for each coupling are to be [_____] [for [_____] inch pipe [,[_____] for [_____] inch pipe,] and [_____] for [_____] inch pipe]. Bolt holes in follower rings are to be of a shape to hold fast the necks of the bolts used. Sleeve-type mechanical couplings are not to be used as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint.

f. [Grooved] [and] [Shouldered] Type Joints: [Grooved pipe ends] [Shouldered pipe ends] and couplings are to conform to AWWA C606. Joint dimensions are to be as specified in AWWA C606 for rigid joints.

2.2.2.3 PVC Pressure Pipe and Associated Fittings

Pipe, couplings and fittings are to be manufactured of materials conforming to ASTM D1784, Class 12454B.

2.2.2.3.1 Pipe and Fittings Less Than 4 inch Diameter

2.2.2.3.1.1 Screw-Joint

Provide pipe conforming to dimensional requirements of ASTM D1785, Schedule 80, with joints meeting requirements of 150 psi working pressure, 200 psi hydrostatic test pressure, unless otherwise shown or specified. Provide fittings for threaded pipe conforming to requirements of ASTM D2464, threaded to conform to the requirements of ASME B1.20.1 for use with Schedule 80 pipe and fittings. Pipe couplings when used, are to be tested as required by ASTM D2464.

2.2.2.3.1.2 Push-On Joint

ASTM D3139, with ASTM F477 gaskets.[Fittings for push-on joints are to be iron conforming to AWWA C110/A21.10 or AWWA C153/A21.53 and AWWA C111/A21.11 with a cement-mortar lining conforming to AWWA C104/A21.4, standard thickness.]

2.2.2.3.1.3 Solvent Cement Joint

Provide pipe conforming to dimensional requirements of ASTM D1785 or ASTM D2241 with joints meeting the requirements of 150 psi working pressure and 200 psi hydrostatic test pressure. Fittings for solvent cement jointing are to conform to ASTM D2466 or ASTM D2467.

2.2.2.3.2 Pipe and Fittings 4 inch Diameter And Larger

Provide pipe conforming to AWWA C900 and be plain end or gasket bell end, Pressure Class [150 (DR 18)] [_____], with cast-iron-pipe-equivalent OD. Fittings are to be gray-iron or ductile-iron conforming to AWWA C110/A21.10 or AWWA C153/A21.53 and AWWA C111/A21.11 with a cement-mortar lining conforming to AWWA C104/A21.4, standard thickness. Fittings for pipe to pipe push-on joint ends are to conform with AWWA C900.

2.2.2.4 High Density Polyethylene Pipe (HDPE)

ASTM F894, Class 63, size 18 inch through 120 inch. ASTM F714, size 4 inch through 48 inch, will have pipe stiffness greater than or equal to 1170/D for cohesionless material pipe trench backfills. For all PE pipes, the polyethylene are to be certified by the resin producer as meeting the requirements of ASTM D3350, cell Class 334433C or higher. Fittings for High Density Polyethylene Pipe are to meet the same material specifications as the pipe class. Joints for HDPE meetingASTM F894 will be rubber gasket joints conforming to ASTM F477. HDPE meeting ASTM F714 will have fused joints in accordance with manufacturer's instruction.

2.2.2.5 Reinforced Plastic Mortar Pipe (RPMP)

Reinforced plastic mortar pipe are to be produced be in accordance with ASTM D3262 and have an outside diameter equal to ductile iron pipe dimensions from 18 inch to 48 inch. The inner surface of the pipe is to have a smooth uniform continuous resin-rich surface liner. The minimum pipe stiffness is to be 36 psi. RPMP is to be in accordance with ASTM D3262. Fittings for RPMP: ASTM D3840. Joints for RPMP: Bell and spigot gasket coupling utilizing an elastomeric gasket in accordance with ASTM D4161 and ASTM F477.

2.2.2.6 Reinforced Thermosetting Resin Pipe (RTRP)

RTRP pipe: ASTM D3262. Fittings for RTRP: ASTM D3262. Joints for RTRP: Bell and spigot type utilizing an elastomeric gasket in accordance with ASTM F477.

2.2.2.6.1 Filament Wound RTRP-I

RTRP-I is to conform to ASTM D2996, except pipe is to have an outside diameter equal to cast iron outside diameter or standard weight steel pipe. The pipe is to be suitable for a normal working pressure of 150 psi at 73 degrees F. The inner surface of the pipe is to have a smooth uniform continuous resin-rich surface liner conforming to ASTM D2996.

2.2.2.6.2 Centrifugally Cast RTRP-II

RTRP-II is to conform to ASTM D2997. Pipe is to have an outside diameter equal to standard weight steel pipe.

2.2.2.7 Dual Wall and Triple Wall Polypropylene

12 to 30 inch polypropylene pipe having a smooth interior and annular exterior corrugations, in compliance with ASTM F2736. Provide 30 to 60 inch polypropylene pipe having a smooth interior and exterior surfaces with annular inner corrugations, in compliance with ASTM F2764/F2764M. Pipe is suitable for gravity flow only and is to have a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D2412. Pipe sizes 12- through 60-inch diameters are to have a reinforced bell, manufacturer's pre-installed polymer composite band or a manufacturer's compatible pipe polymer composite band.

2.2.3 Piping Beneath Railroad Right-of-Way

Where pipeline passes under the right-of-way of a commercial railroad, piping is to conform to the specifications for pipelines conveying nonflammable substances in AREMA Eng Man, except as otherwise specified in this paragraph. For casing pipe provide ductile-iron pipe in lieu of cast-iron soil pipe. Ductile-iron pipe is to conform to and have strength computed in accordance with ASTM A746.

2.2.4 Cement Mortar

Provide cement mortar conforming to ASTM C270, Type M with Type II cement.

2.2.5 Portland Cement

Submit certificates of compliance stating the type of cement used in manufacture of concrete pipe, fittings, septic tanks, and precast manholes. Provide portland cement conforming to ASTM C150/C150M, Type [II] [V] for concrete used in concrete pipe, concrete pipe fittings, septic tanks, and manholes and type optional for cement used in concrete cradle, concrete encasement, and thrust blocking. [Use air-entraining admixture conforming to ASTM C260/C260M with Type V cement.] [,Use a cement containing less than 0.60 percent alkalies where aggregates are alkali reactive, as determined by Appendix XI of ASTM C33/C33M.]

2.2.6 Portland Cement Concrete

Provide portland cement concrete conforming to ASTM C94/C94M, compressive strength of 4000 psi at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement is to have a compressive strength of 2500 psi minimum at 28 days. Protect concrete in place from freezing and moisture loss for 7 days.

2.2.7 Precast Concrete Manholes

Provide precast concrete manholes, risers, base sections, and tops conforming to ASTM C478[and be manufactured in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION; base and first riser are to be monolithic].

2.2.8 Glass-Fiber-Reinforced Polyester Manholes

Glass-Fiber-Reinforced Polyester Manholes are to conform to ASTM D3753.

2.2.9 Gaskets and Connectors

Provide gaskets for joints between [manhole] [wastewater tanks]sections conforming to ASTM C443. Resilient connectors for making joints between [manhole] [wastewater tanks] and pipes entering manhole are to conform to[ASTM C1644] [ASTM C923 or ASTM C990].

2.2.10 External Preformed Rubber Joint Seals

An external preformed rubber joint seal is an accepted method of sealing cast iron covers to precast concrete sections to prevent ground water infiltration into sewer systems. All finished and sealed manholes constructed in accordance with paragraph entitled "Manhole Construction" are to be tested for leakage in the same manner as pipelines as described in paragraph entitled "Leakage Tests." The seal is to be multi-section with a neoprene rubber top section and all lower sections made of Ethylene Propylene Diene Monomer (EPDM) rubber with a minimum thickness of 60 mils. Each unit is to consist of a top and bottom section and have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic is to be a non-hardening butyl rubber sealant and seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. Extension sections are to cover up to two more adjusting rings. Properties and values are listed in the following table:

Properties, Test Methods and Minimum Values for Rubber used in Preformed Joint Seals				
Physical Properties	Test Methods	EPDM	Neoprene	Butyl Mastic
Tensile, psi	ASTM D412	1840	2195	--
Elongation, percent	ASTM D412	553	295	350
Tear Resistance, ppi	ASTM D624 (Die B)	280	160	--
Rebound, percent, 5 minutes	ASTM C972 (mod.)	--	--	11
Rebound, percent, 2 hours	ASTM C972	--	--	12

[2.2.11 Precast Concrete Septic Tanks

Provide precast concrete septic tanks risers, base sections, and tops conforming to ASTM C1227 and be manufactured in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION; base and first riser are to be monolithic.

][2.2.12 Glass-Fiber-Reinforced Polyester Septic Tanks

Glass-Fiber-Reinforced Polyester Septic Tanks are to conform to IAPMO Z1000.

]2.2.13 Septic Tank Piping

PVC pipe and fittings. [Provide NSF/ANSI 46 certified effluent filter on the outlet pipe.]

2.2.14 Siphon for Septic Tank

PVC or Polyethylene,of an approved standard design, and prompt and positive in action.

2.2.15 Sewage Absorption Field Materials

[Pipe is to be perforated corrugated polyethylene tubing conforming to ASTM F667/F667M.] [Pipe is to be perforated PVC pipe conforming to ASTM F758.] [Chambers are to be high density polyethylene conforming to IAPMO PS 63]

2.2.16 Frames, Covers, and Gratings for Manholes

[Submit certification on the ability of frame and cover to carry the imposed live load.] Frame and cover are to be cast gray iron, ASTM A48/A48M, Class 35B, cast ductile iron, ASTM A536, Grade 65-45-12, or reinforced concrete, ASTM C478 ASTM C478M. Frames and covers are to be circular [with] [without] vent holes. Size are to be [as indicated on the plans] [for 24 inch opening]. Stamp or cast the words "Sanitary Sewer" into covers so that it is plainly visible.

2.2.17 Manhole Steps

[Zinc-coated steel] [as indicated] conforming to 29 CFR 1910.27 [with a plastic or rubber coating pressure-molded to the steel is to be used. Provide plastic coating conforming to ASTM D4101, copolymer polypropylene. Rubber is to conform to ASTM C443, except shore A durometer hardness is to be 70 plus or minus 5.] Aluminum steps or rungs will not be permitted. Steps are not required in manholes less than 4 feet deep.

2.2.18 Manhole Ladders

Provide a steel ladder where the depth of a manhole exceeds 12 feet. The ladder is not to be less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. The two stringers are to be a minimum 3/8 inch thick and 2 inches wide. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Installation Drawings

Submit Installation Drawings showing complete detail, both plan and side view details with proper layout and elevations.

3.2 INSTALLATION

Backfill after inspection by the Contracting Officer. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer.

3.2.1 Connections to Existing Lines

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

3.2.2 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.2.2.1 Location

Terminate the work covered by this section at a point approximately 5 feet from the building[, unless otherwise indicated]. Install pressure sewer lines beneath water lines only, with the top of the sewer line being at least 2 feet below bottom of water line. When these separation distances can not be met, contact the Contracting Officer for direction.

3.2.2.1.1 Sanitary Piping Installation Parallel with Water Line

3.2.2.1.1.1 Normal Conditions

Install sanitary piping or manholes at least 10 feet horizontally from a water line whenever possible. Measure the distance from edge-to-edge.

3.2.2.1.1.2 Unusual Conditions

When local conditions prevent a horizontal separation of 10 feet, the sanitary piping or manhole may be laid closer to a water line provided that:

a. The top (crown) of the sanitary piping is to be at least 18 inches below the bottom (invert) of the water main.

b. Where this vertical separation cannot be obtained, construct the sanitary piping with AWWA-approved ductile iron water pipe pressure and conduct a hydrostatic sewer test without leakage prior to backfilling.

c. The sewer manhole is to be of watertight construction and tested in place.

3.2.2.1.2 Installation of Sanitary Piping Crossing a Water Line

3.2.2.1.2.1 Normal Conditions

Lay sanitary sewer piping by crossing under water lines to provide a separation of at least 18 inches between the top of the sanitary piping and the bottom of the water line whenever possible.

3.2.2.1.2.2 Unusual Conditions

When local conditions prevent a vertical separation described above, use the following construction:

a. Construct sanitary piping passing over or under water lines with AWWA-approved ductile iron water pressure piping and conduct a hydrostatic sewer test without leakage prior to backfilling.

b. Protect sanitary piping passing over water lines by providing:

   (1) A vertical separation of at least 18 inches between the bottom of the sanitary piping and the top of the water line.

(2) Adequate structural support for the sanitary piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.

(3) That the length, minimum 20 feet, of the sanitary piping be centered at the point of the crossing so that joints are equidistant and as far as possible from the water line.

3.2.2.1.3 Sanitary Sewer Manholes

No water piping must pass through or come in contact with any part of a sanitary sewer manhole.

3.2.2.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL.

3.2.2.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell [or groove] ends in the upgrade direction. Adjust spigots in bells [and tongues in grooves] to give a uniform space all around. Blocking or wedging between bells and spigots [or tongues and grooves] will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 25 feet apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Construct branch connections by use of regular fittings or solvent cemented saddles as approved. Provide saddles for PVC pipe conforming to Table 4 of ASTM D3034.

3.2.3 Special Requirements

3.2.3.1 Installation of Clay Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM C12 for pipe laying. Make joints with a compression joint material specified for clay pipe joints and assemble in accordance with the recommendations of the manufacturer of the pipe.

3.2.3.2 Installation of Concrete Gravity Sewer Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the provisions for rubber gasket jointing and jointing procedures of ACPA 01-103 or of ACPA 01-102, Chapter 9, "Installation, Inspection and Construction Testing." Make joints with the gaskets specified for concrete gravity sewer pipe joints. Clean and dry surfaces receiving lubricants, cements, or adhesives. Affix gaskets to pipe not more than 24 hours prior to the installation of the pipe. Protect gaskets from sun, blowing dust, and other deleterious agents at all times. Before installation of the pipe, inspect gaskets and remove and replace loose or improperly affixed gaskets. Align each pipe section with the previously installed pipe section, and pull the joint together. If, while pulling the joint, the gasket becomes loose and can be seen through the exterior joint recess when the pipe is pulled up to within 1 inch of closure, remove the pipe and remake the joint.

3.2.3.3 Installation of Concrete Pressure Lines

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the laying and joining requirements specified in the guide specifications for installation of pipe given in AWWA M9, Chapter 14, "Guide Specifications for Installation of Pipe."

3.2.3.3.1 Joints

Make joints with the gaskets specified for concrete pressure pipe joints, using an approved lubricant recommended by the pipe manufacturer. Assemble these joints in accordance with the joining requirements specified in the guide specifications for installation of pipe given in AWWA M9, Chapter 14, "Guide Specifications for Installation of Pipe," and with the recommendations given for laying the pipe in AWWA M9, Chapter 6, "Installation by Trenching or Tunneling -- Methods and Equipment."

3.2.3.3.2 Pipe Anchorage

Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.2.3.4 Installation of Ductile Iron Gravity Sewer Pipe

Unless otherwise specified, install pipe and associated fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of AWWA C600 for pipe installation and joint assembly.

a. [Make push-on joints with the gaskets and lubricant specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly.] Make mechanical-joints with the gaskets, glands, bolts, and nuts specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11.

b. Exterior protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet in accordance with AWWA C105/A21.5, using [Class A] [Class C] polyethylene film.

3.2.3.5 Installation of Ductile-Iron Pressure Lines

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of AWWA C600 for pipe installation, joint assembly, and valve-and-fitting installation.

a. [Make push-on joints with the gaskets and lubricant specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly.] Make mechanical-joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11. [Make flanged joints with gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight, taking care to avoid undue strain on flanges, fittings, and other accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; use of undersized bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange. When flanged pipe or fittings have dimensions that do not allow the making of a proper flanged joint as specified, replace it by one of proper dimensions.] [Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer, as approved.] [Make [grooved] [and] [shouldered] type joints with the couplings previously specified for this type joint connecting pipe with the [grooved] [or] [shouldered] ends specified for this type joint and assemble in accordance with the recommendations of the coupling manufacturer, as approved. [Groove pipe in the field only with approved groove cutting equipment designed especially for the purpose and produced by a manufacturer of grooved joint couplings; secure approval for field-cut grooves before assembling the joint.]]

b. Exterior protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet in accordance with AWWA C105/A21.5, using [Class A] [Class C] polyethylene film.

c. Pipe anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.2.3.6 Installation of PVC Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of ASTM D2321 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.2.3.7 Installation of PVC Pressure Pipe

Unless otherwise specified, install pipe and fittings in accordance with AWWA C605. AWWA C605 includes requirements such as excavation, installation, and placement of apputenances.

3.2.3.7.1 Pipe Less Than 4 Inch Diameter

3.2.3.7.1.1 Threaded Joints

Make by wrapping the male threads with joint tape or by applying an approved thread lubricant, then threading the joining members together.

Tighten the joints with strap wrenches which will not damage the pipe and fittings. Tighten the joint no more than 2 threads past hand-tight.

3.2.3.7.1.2 Push-On Joints

Bevel the ends of pipe for push-on joints to facilitate assembly. Mark pipe to indicate when the pipe is fully seated. Lubricate the gasket to prevent displacement. Exercise care to ensure that the gasket remains in proper position in the bell or coupling while making the joint.

3.2.3.7.1.3 Solvent-Weld Joints

Comply with the manufacturer's instructions.

3.2.3.7.2 Pipe 4 inch Diameter And Larger

Make push-on joints with AWWA C900 pipe with intrgral elastomeric gasket . For pipe-to-pipe push-on joint connections, use only pipe with push-on joint ends having factory-made bevel. For push-on joint connections to fittings, use cut spigot end of pipe off square, marked to match the manufacturer's insertion line and beveled to match factory supplied bevel. . Use an approved lubricant recommended by the pipe manufacturer for push-on joints. Assemble push-on joints for pipe-to-pipe joint connections in accordance with the requirements of AWWA C605. Assemble push-on joints for connection to fittings in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories and with the applicable requirements of AWWA C600 for joint assembly. Make mechanical-joints or flanged jointswith the gaskets, glands, bolts, nuts, and internal stiffeners specified for this type joint and assemble in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories or with the applicable requirements of AWWA C600 for ductile iron joint assembly, and with the recommendations of Appendix A to AWWA C111/A21.11. Cut off spigot end of pipe for mechanical-joint or flanged jointconnections and do not bevel.

3.2.3.7.3 Pipe Anchorage

Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.2.3.8 Installation of Dual Wall and Triple Wall Polypropylene

Install pipe in accordance with "General Requirements for installation of Pipelines" of this section, with the polypropylene pipe manufacturer's recommendations, and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Place a minimum of 6 inches of Class 1 or Class 2 backfill over the crown of the pipe with minimum 90 percent compaction.

3.2.3.9 Pipeline Installation Beneath Railroad Right-of-Way

Where pipeline passes under the right-of-way of a commercial railroad, install piping in accordance with the specifications for pipelines conveying nonflammable substances in AREMA Eng Man.

3.2.4 Concrete Work

Cast-in-place concrete is included in Section [03 30 00 CAST-IN-PLACE CONCRETE][03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE]. Support the pipe on a concrete cradle, or encased in concrete where indicated or directed.

3.2.5 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases with a smooth-surfaced semi-circular bottom conforming to the inside contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. For precast concrete construction, make joints between manhole sections with the gaskets specified for this purpose; install in the manner specified for installing joints in concrete piping. Parging will not be required for precast concrete manholes. Perform cast-in-place concrete work in accordance with the requirements specified under paragraph entitled "Concrete Work" of this section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously specified for pipe connectors to concrete manholes.

3.2.6 Miscellaneous Construction and Installation

3.2.6.1 Connecting to Existing Manholes

Connect pipe to existing manholes such that finish work will conform as nearly as practicable to the applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. Center the connection on the manhole. Holes for the new pipe are be of sufficient diameter to allow packing cement mortar around the entire periphery of the pipe but no larger than 1.5 times the diameter of the pipe. Cut the manhole in a manner that will cause the least damage to the walls.

3.2.6.2 Metal Work

3.2.6.2.1 Workmanship and Finish

Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

3.2.6.2.2 Field Painting

After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal, remove mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.2.7 Sewage Absorption Trench Construction

Grade trenches uniformly with no slope. [Lay perforated pipe with the perforations downward.] [Comply with the chamber manufacturer's instructions.]

3.2.8 Installations of Wye Branches

Install wye branches in an existing sewer using a method which does not damage the integrity of the existing sewer. Do not cutinto piping for connections except when approved by the Contracting Officer. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, support on a concrete cradle as directed by the Contracting Officer. Provide and install concrete required because of conditions resulting from faulty construction methods or negligence without any additional cost to the Government. Do not damage the existing sewer when installing wye branches in an existing sewer.

3.3 FIELD QUALITY CONTROL

The Contracting Officer will conduct field inspections and witness field tests specified in this section. Be able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

[3.3.1 Tests

Perform field tests and provide labor, equipment, and incidentals required for testing[, except that water and electric power needed for field tests will be furnished as set forth in Section [_____]].

3.3.1.1 Hydrostatic Sewer Test

When unusual conflicts are encountered between sanitary sewer and waterlines a hydrostatic pressure sewer test will be performed in accordance with the applicable AWWA standard for the piping material or AWWA C600[with a minimum test pressure of [_____]].

3.3.1.2 Leakage Tests for Nonpressure Lines

Test lines for leakage by either [infiltration tests and exfiltration tests,] [negative air pressure tests] [or by low-pressure air tests]. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

3.3.1.2.1 Infiltration Tests and Exfiltration Tests

[3.3.1.2.1.1 Precast Concrete Pipe Sewer Lines

Test leakage of precast concrete pipe in accordance with ASTM C969. The allowable leakage limit is located in ASTM C969. Make calculations in accordance with the Appendix to ASTM C969.

][3.3.1.2.2 Negative Air Pressure Test

[3.3.1.2.2.1 Concrete Pipe

Test concrete pipe test in accordance with ASTM C1214. The allowable vacuum loss is located in ASTM C1214 Make calculations in accordance with the Appendix to ASTM C1214.

][3.3.1.2.2.2 Precast Concrete Manholes

Test precast concrete sewer manhole test in accordance with ASTM C1244. The allowable vacuum drop is located in ASTM C1244 Make calculations in accordance with the Appendix to ASTM C1244.

]]3.3.1.2.3 Low-Pressure Air Tests

3.3.1.2.3.1 Clay Pipelines

Test clay pipe in accordance with ASTM C828. The allowable pressure drop is located in ASTM C828. Make calculations in accordance with the Appendix to ASTM C828.

3.3.1.2.3.2 PVC Pipelines

Test PVC pipe in accordance with UBPPA UNI-B-6. The allowable pressure drop is located in UBPPA UNI-B-6. Make calculations in accordance with the Appendix to UBPPA UNI-B-6.

3.3.1.2.3.3 Dual Wall and Triple Wall Polypropylene

Test polypropylene pipe in accordance with ASTM F1417 or UBPPA UNI-B-6. The allowable pressure drop is located in ASTM F1417 or UBPPA UNI-B-6 depending on the chosen test procedure. Make calculations in accordance with the Appendix to ASTM F1417 or UBPPA UNI-B-6 depending on the chosen test procedure.

[3.3.1.3 Tests for Pressure Lines

Test pressure lines in accordance with the applicable standard specified in this paragraph[, except for test pressures. For hydrostatic pressure test, use a hydrostatic pressure 50 psi in excess of the maximum working pressure of the system, but not less than 100 psi, holding the pressure for a period of not less than one hour. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system]. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

[3.3.1.3.1 Ductile-Iron Pressure Pipe

Test ductile-iron pressure pipe in accordance with the requirements of AWWA C600 for hydrostatic testing. Leakage on ductile-iron pipelines with mechanical-joints [or push-on joints] are not to exceed the amounts given in AWWA C600[; no leakage will be allowed at joints made by any other methods].

][3.3.1.3.2 Concrete Pressure Pipe

Test concrete pressure pipes in accordance with the recommendations in

AWWA M9. The leakage rate is dependent upon the type of concrete pressure used and the diameter of the pipe. The allowable leakage rate is indicated in AWWA M9, chapter titled, "Hydrostatic Testing and Disinfection of Mains".

][3.3.1.3.3 PVC Pressure Pipe

Test PVC pressure pipe in accordance with the requirements of AWWA C605 for hydrostatic and leakage tests. The quantity of water that must be supplied during testing is not to exceed the quantity of water calculated in accordance with AWWA C605 to maintain the specified test pressure within 5 psi.

]]3.3.1.4 Deflection Testing

Perform a deflection test on entire length of installed plastic pipeline on completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads determined in accordance with ASTM D2412. Deflection of pipe in the installed pipeline under external loads is not to exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.

3.3.1.4.1 Pull-Through Device

This device is to be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Space circular sections on the shaft so that the distance from external faces of front and back sections will equal or exceed the diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided the device meets the applicable requirements specified in this paragraph, including those for diameter of the device, and that the mandrel has a minimum of 9 arms. Ball, cylinder, or circular sections are to conform to the following:

a. A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.

b. Homogeneous material throughout, is to have a density greater than 1.0 as related to water at 39.2 degrees F, and a surface Brinell hardness of not less than 150.

c. Center bored and through-bolted with a 1/4 inch minimum diameter steel shaft having a yield strength of not less than 70,000 psi, with eyes or loops at each end for attaching pulling cables.

d. Suitably Back each eye or loop with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.

3.3.1.4.2 Deflection Measuring Device

Sensitive to 1.0 percent of the diameter of the pipe being tested and be accurate to 1.0 percent of the indicated dimension. Prior approval is required for the deflection measuring device.

3.3.1.4.3 Pull-Through Device Procedure

Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions.

3.3.1.4.4 Deflection measuring device procedure

Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of 4.5 percent of average inside diameter of pipe, replace pipe which has excessive deflection and completely retest in same manner and under same conditions.

[3.3.1.5 Dye Test

Perform a dye test from the projects sanitary sewer point of connection to the first downstream manhole on the next active sanitary sewer branch main. Use nontoxic non-staining sewer tracing dye. Test results are to be noted in the daily Construction Quality Control (CQC) Report as required in 01 45 00.00 10 Quality Control.

a. Continue testing until it can be visually confirmed by way of the dye that the sewer connection is appropriate or until deficiencies are discovered.

b. During the test, monitor the storm drainage system downstream from the project, either manholes or outfalls, for any sign of cross-connection.

][3.3.1.6 Smoke Test

Perform a smoke test on the relevant portion of the sewer system. Test results are to be noted in the daily Construction Quality Control (CQC) as required in 01 45 00.00 10 Quality Control.

a. Continue testing until it can be visually confirmed that the projects sanitary sewer point of connection has not been cross-connected to the storm drainage system.

b. During the test, monitor the storm drainage system, either manholes or outfalls, for any sign of cross-connection.

]][3.3.2 Field Tests for Cast-In-Place Concrete

Field testing requirements are covered in Section [03 30 00 CAST-IN-PLACE CONCRETE][03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE]

][3.3.3 Inspection

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; the light must show a practically full circle of light through the pipeline when viewed from the adjoining end of line.

3.3.3.1 Pre-Installation Inspection

Prior to connecting the new service, perform pre-installation inspection after trenching and layout is complete. Submit pre-installation inspection request for field support at least [14] [_____] days in advance. The Installation's Utilities Field Support personnel will perform the pre-installation inspection.

3.3.3.2 Post-Installation Inspection

Perform a post-installation inspection after connection has been made and before the connection is buried. Submit post-installation inspection request for field support at least [14] [_____] days in advance. The Installation's Utilities Field Support personnel will perform the post-connection inspection.[During the post-installation inspection the Contractor will be responsible for performing a [dye test] [smoke test].]

] -- End of Section --

SECTION 33 31 23.00 10

SANITARY SEWER FORCE MAIN PIPING
08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C105/A21.5	(2018) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast
AWWA C200	(2012) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

AWWA C207	(2018) Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in. (100 mm through 3600 mm)
AWWA C208	(2017) Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C210	(2015) Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C300	(2016) Reinforced Concrete Pressure Pipe, Steel-Cylinder Type
AWWA C301	(2014; R 2019) Prestressed Concrete Pressure Pipe, Steel-Cylinder Type
AWWA C303	(2017) Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type
AWWA C500	(2019) Metal-Seated Gate Valves for Water Supply Service
AWWA C508	(2017) Swing-Check Valves for Waterworks Service, 2 In. Through 48-In. (50-mm Through 1,200-mm) NPS
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C900	(2016) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
AWWA C909	(2016) Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In. (100 mm) and Larger

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2122	(2016) Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated

	Pipe (SDR Series)
ASTM D2464	(2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007; R 2015) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D2774	(2021) Underground Installation of Thermoplastic Pressure Piping
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3035	(2015) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3754	(2019) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer and Industrial Pressure Pipe
ASTM D4101	(2017) Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials
ASTM D4161	(2014) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F1483	(2017) Standard Specification for Oriented Poly(Vinyl Chloride), PVCO, Pressure Pipe

DUCTILE IRON PIPE RESEARCH ASSOCIATION (DIPRA)

DIPRA TRD	(2016) Thrust Restraint Design for Ductile Iron Pipe

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-78 (2011) Cast Iron Plug Valves, Flanged and Threaded Ends

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Disposal of Waste Water

Final Test Report

1.3 DELIVERY, STORAGE, AND HANDLING

Do not damage pipe, fittings and accessories, and pipe coatings during delivery, handling, and storage.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

Provide piping in locations and sizes as specified in the following table. Also conform to the respective specifications and other requirements specified below

Location	Piping Size Range	Piping Material
Force Mains	Less than 4 inches in diameter	Galvanized Steel, Polyvinyl Chloride (PVC) Plastic, Polyethylene (PE) Plastic or Polypropylene Plastic
Inside Pump Stations	Less than 4 inches	Galvanized Steel
[Force Mains][and][Inverted Siphons]	4 inches in diameter and larger	Ductile Iron, Steel, Concrete Pressure Pipe, PVC Plastic, Oriented PVC PE Plastic, or Reinforced Thermosetting Resin Pipe (RTRP)
[Force Mains][and][Inverted Siphons]	8 inches in diameter and larger	May be Reinforced Plastic Mortar Pressure (RPMP)

Location	Piping Size Range	Piping Material
Inside Pump Stations	4 inches in diameter and larger	Ductile Iron Pipe with Bolted Flange Joints

2.1.1 Concrete Pressure Pipe

Provide concrete pressure pipe and fittings that conform to [AWWA C300,][AWWA C301,][or][AWWA C303,]as applicable for the service requirements, with rubber gasket joints of the type using steel bell and spigot joint rings.

2.1.2 Plastic Pipe

2.1.2.1 PE Pipe

ASTM D3350 and ASTM D3035, minimum pressure rating of 100 psi at 73.4 degrees F.

2.1.2.2 Polypropylene Pipe

ASTM D2122 and ASTM D4101.

2.1.2.3 PVC Pressure Pipe

a. PVC Pressure Pipe and Fittings Less Than 4 inches Diameter: ASTM D1785, Schedule [40][80][120], or ASTM D2241, SDR [21][26][32.5], with screw joints, push-on joints, or solvent weld joints.

b. PVC Pressure Pipe and Fittings 4 inches Diameter and Larger: ASTM D2241, SDR [21][26][32.5], or AWWA C900, Class [100][150][200], with push-on joints.

2.1.2.4 Oriented Polyvinyl Chloride (PVCO) Plastic Pipe

Provide pipe, couplings, and fittings manufactured of material conforming to ASTM D1784, Class 12454-B. Provide pipe conforming to AWWA C909, Class 150, and to ASTM F1483 with an outside diameter equal to cast iron outside diameter.

2.1.3 RPMP Pipe

Provide RPMP in accordance with ASTM D3754 produced by centrifugal casting and with an outside diameter equal to ductile iron pipe dimensions from 18 inch to 48 inch. Provide a smooth uniform continuous resin-rich surface liner coating the entire inner surface of the pipe. Ensure the minimum pipe stiffness provided is 36 psi.

2.1.4 RTRP Lines

ASTM D2996, 350 psi rated, cast iron pipe dimensions only, with elastomeric gasket joints. Fittings: AWWA C110/A21.10, rated 150 psi. Use inside sleeves provided by the manufacturer when mechanical joint fittings are used.

2.1.5 Ductile Iron Pipe

2.1.5.1 Ductile Iron Pipe

AWWA C151/A21.51, working pressure not less than 150 psi, unless otherwise shown or specified.

2.1.5.2 River Crossing Pipe

AWWA C151/A21.51, minimum thickness Class 54 with joints in compliance with applicable requirements of AWWA C110/A21.10.

2.1.5.3 Fittings, Mechanical

AWWA C110/A21.10, rated for 150 psi.

2.1.5.4 Fittings, Push-On

AWWA C110/A21.10 and AWWA C111/A21.11, rated for 150 psi.

2.1.6 Steel Pipe

2.1.6.1 Steel Pipe, 6 inches Diameter and Larger

AWWA C200.

2.1.6.2 Steel Pipe Less Than 6 inches Diameter

ASTM A53/A53M, standard weight, threaded end, galvanized.

2.1.6.3 Fittings, 6 inches Diameter and Larger

AWWA C200, fabricated in compliance with AWWA C208.

2.1.6.4 Fittings Less Than 6 inches Diameter

ASME B16.3, galvanized.

2.2 JOINTS

2.2.1 PE Piping

2.2.1.1 Heat Fusion Joints

ASTM D2657.

2.2.1.2 Flanged Joints

ASME B16.1 or AWWA C207.

2.2.1.3 Mechanical Joints

ASME B16.1.

2.2.2 Polypropylene Piping

Heat Fusion Joints: ASTM D2657.

2.2.3 PVC Piping

Provide centering rings or stops to ensure couplings used with plain end pipe are centered on the joint.

2.2.3.1 Screw Joint Fittings

ASTM D2464, Schedule 80

2.2.3.2 Push-On Joint Fittings

ASTM D3139, with ASTM F477gaskets

2.2.3.3 Solvent Cement

ASTM D2564

2.2.4 PVCO Pipe

Provide joints conforming to ASTM D3139 and elastomeric gaskets conforming to ASTM F477.

2.2.5 Ductile Iron Piping

2.2.5.1 Push-on Joints

AWWA C111/A21.11.

2.2.5.2 Mechanical Joints

AWWA C111/A21.11 as modified by AWWA C151/A21.51.

2.2.5.3 Flanged Joints

AWWA C115/A21.15.

2.2.6 Steel Piping

2.2.6.1 Push-on Joints

AWWA C200.

2.2.6.2 Mechanical Joints

AWWA C200.

2.2.6.3 Flanged Joints

AWWA C207.

2.2.7 RPMP Piping

Provide bell and spigot gasket coupling joints utilizing an elastomeric gasket in accordance with ASTM D4161 and ASTM F477.

2.3 VALVES

2.3.1 Gate Valves

Provide gate valves 3 inches and larger in compliance with AWWA C500. Provide non-rising stem (NRS) valves for buried service, 2 inch square nut operated with joints applicable to the pipe or installation. Furnish buried valves with extension stems comprising socket, extension stem and operating nut, and of an appropriate length to bring operating nut to within 6 inches of grade. Provide one 4 foot "T" handle valve wrench for each quantity of 6 buried valves. Provide outside screw and yoke (OS&Y), handwheel operated with flange ends for gate valves that are exposed or installed inside unless otherwise indicated. Cast an arrow and the word "OPEN" on all gate valve operating nuts and handwheels in raised letters to indicate the direction of opening. Equip gate valves 14 inches and larger with gearing to reduce operating effort. Equip gate valves 14 inches and larger, installed in horizontal lines in horizontal position with stems horizontal, with bronze track, roller and scrapers to support the weight of the gate for its full length of travel. Fit gate valves 14 inches and larger installed in vertical pipe lines with stems horizontal with slides to assist the travel of the gate assembly.

2.3.2 Check Valves

Provide iron-bodied check valves that permit free flow of sewage forward and provide a positive check against backflow. Design check valves for a minimum working pressure of 150 psi or as indicated. Directly cast the manufacturer's name, initials, or trademark and also the size of the valve, working pressure, and direction of flow on the body.

2.3.2.1 Ball Check Valves

Provide iron-bodied ball check valves, with flanged ends, that are of the non-slam type. Provide 125 pound type flanges complying with ASME B16.1 with stainless steel ball unless otherwise specified.

2.3.2.2 Swing Check Valves

Comply with AWWA C508. Provide with iron body, bronze mounted, and flanged ends. Provide 125 pound type flanges, complying with ASME B16.1.

2.3.3 Plug Valves

Provide cast iron valves complying with MSS SP-78 or steel plug valves in compliance with API Spec 6D.

2.3.4 Pinch Valves

Provide double acting, jam-proof type pinch valves with unobstructed streamlined flows and built-in operator. Provide iron bodied valves with a non-rising handwheel. Provide a sleeve of pure gum rubber, neoprene, Buna N or hypalon as required for service. Provide a valve with flanged ends of 125 pound type in compliances with ASME B16.1.

2.3.5 Air Release Valves

Provide air release valves designed to permit release of air from an empty pipe during filling and capable of discharging accumulated air in the line while the line is in operation and under pressure. Attach valves by means of threaded pipe connections. Vent valves to the atmosphere.

2.3.5.1 Manual Air Release Valves

Consisting of an 3 inch gate valve and 3 inch ductile iron pipe and fittings. Install the valve with its line of flow in the horizontal position.

2.3.5.2 Automatic Air Release Valve

Compound lever type capable of withstanding operating pressures of 150 psi, with a 1/2 inch outlet. Provide with iron body and cover of the valve and a stainless steel float. Provide internal parts made entirely of stainless steel or bronze. Provide valve specifically adapted for use with sewage and complete with hose and blow-off valves to permit backflushing without dismantling the valve.

2.4 VALVE VAULTS

Cast iron or concrete, except design concrete vaults installed in locations subject to vehicular traffic to withstand the following [_____] AASHTO load designation as outlined in AASHTO HB-17. Provide extension type cast iron vaults with slide type adjustment and flared base. Provide 3/16 inch minimum metal. Ensure that the vault length is adaptable, without full extension, to the depth of cover over the pipe at the valve locations. Manufacture concrete vaults accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION. Cast the word "SEWER" in the cover. [Provide secure latch/lock mechanism to prevent unauthorized entry or tampering with the components within.]

2.5 MISCELLANEOUS MATERIALS

Provide miscellaneous materials in compliance with the following requirements:

2.5.1 Pipe Coatings and Linings

a. Steel, interior: AWWA C203 or AWWA C210.

b. Steel, exterior, buried: AWWA C203.

c. Steel, exterior, exposed: AWWA C210.

2.5.2 Joint Lubricants

Provide joint lubricants as recommended by the pipe manufacturer.

2.5.3 Bolts, Nuts and Glands

AWWA C111/A21.11.

2.5.4 Joint Compound

A stiff mixture of graphite and oil or inert filler and oil.

2.5.5 Joint Tape

ASTM D3308.

2.5.6 Bond Wire

Bond wire type RHW or USE, Size 1/0 AWG, neoprene jacketed copper conductor shaped to stand clear of the joint.

PART 3 EXECUTION

3.1 INSTALLATION

Install pipe, pipe fittings, and appurtenances at the locations indicated. Perform excavation, trenching, and backfilling as specified in Section [31 00 00 EARTHWORK][31 23 00.00 20 EXCAVATION AND FILL].

3.1.1 Cutting

Cut pipe in a neat manner with mechanical cutters. Use wheel cutters where practicable. Grind sharp and rough edges smooth and remove loose material from the pipe before laying.

3.1.2 Laying

Except where otherwise authorized, lay pipe with bells facing the direction of laying. Before lowering and while suspended, inspect the pipe for defects. Reject defective material. Lay pipe in compliance with the following:

Ductile Iron	AWWA C600
Steel	AWWA C600
Concrete	Manufacturer's instructions
Polyvinyl Chloride	Manufacturer's instructions
Polyethylene	ASTM D2774
Polypropylene	ASTM D2774
Reinforced Thermosetting Resin	Manufacturer's instructions
Reinforced Plastic Mortar	Manufacturer's instructions

3.1.3 Jointing

3.1.3.1 Concrete Pressure Pipe

Follow the manufacturer's instructions when lubricating and installing rubber gaskets. Provide joints that comply with the manufacturer's instructions. Fill the external annular space with cement mortar or with a portland cement-filled polyurethane loop. For pipe 24 inch diameter and larger, fill the internal annular space with cement mortar and struck off to ensure a smooth and continuous surface between pipe sections. Pipe less than 24 inch diameter must have a rope or trowelable mastic affixed to the concrete face of the bell socket before joining the sections of pipe. Ensure the mastic provided causes no problems with the rubber gasket and ensure the gasket fills the interior annular space when the pipe sections are pushed together.

3.1.3.2 Joints for PE Pipe

Provide heat fusion joints that comply with the manufacturer's instructions concerning equipment, temperature, melt time, heat coat, and joining time. Make flanged and mechanical joints in compliance with the manufacturer's

instructions.

3.1.3.3 Joints for Polypropylene Pipe

Ensure heat fusion joints comply with the manufacturer's instructions concerning equipment, temperature, melt time, heat coat, and joining time.

3.1.3.4 Joints for PVC Pipe

a. Make threaded joints by wrapping the male threads with joint tape or by applying an approved thread lubricant, then threading the joining members together. Tighten the joint with strap wrenches taking care not to damage the pipe and fittings. Tighten the joint no more than 2 threads past hand-tight.

b. Bevel the ends of pipe for push-on joints to facilitate assembly. Mark pipe to indicate when the pipe is fully seated. Lubricate the gasket to prevent displacement. Ensure the gasket remains in proper position in the bell or coupling while the joint is made.

c. Ensure solvent-weld joints comply with the manufacturer's instructions.

3.1.3.5 Joints for RPMP Pipe

Use an elastomeric gasket in accordance with ASTM D4161.

3.1.3.6 Joints for RTRP Lines

Provide elastomeric gasket joints in compliance with the manufacturer's instructions.

3.1.3.7 Joints for Ductile Iron Pipe

Install mechanical and push-on type joints in compliance with AWWA C600 and the manufacturer's instructions. Install flanged joints in compliance with manufacturer's instructions.

3.1.3.8 Joints for Steel Pipe

Make screw joints tight with joint tape or joint compound applied with a brush to the male threads only. Install mechanical joints, push-on joints, and flanged joints in compliance with the manufacturer's instructions.

3.1.4 Coating and Lining

Field coat non-galvanized steel pipe in compliance with AWWA C203. Test the applied materials by means of a spark-type electrical device in compliance with AWWA C203. Repair flaws and holidays in the coating or lining of the pipe and the pipe joints; with the repaired areas at least equal in thickness to the minimum required for the pipe.

3.1.5 PE Pipe Encasement

[When installed underground, encase pipe with [_____] mil thick polyethylene in accordance with AWWA C105/A21.5.] [Encase in accordance with AWWA C105/A21.5.]

3.1.6 Installation of Valves

Prior to installation, clean valves of all foreign matter and inspect for damage and then fully open and close valves to ensure that all parts are properly operating. Install valves with the stem in the vertical position. [Install valves in valve vaults as indicated] [_____].

3.1.7 Installation of Valve Boxes

Install valve boxes over each outside gate valve, unless otherwise indicated. Center valve boxes over the valve. Carefully tamp fill around each valve box to a distance of 4 feet on all sides or to undisturbed trench face, if less than 4 feet.

3.1.8 Installation of Valve Vaults

Install valve vaults as indicated.

3.1.9 Drain Lines

Install drain lines where indicated. The drain line consists of a tee in the main line with a 4 inch diameter branch, a 4 inch diameter elbow, and a 4 inch gate valve.

3.1.10 Thrust Restraint

[Provide thrust restraint as specified in Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.] [Provide plugs, caps, tees and bends deflecting 11-1/4 degrees or more, either vertically or horizontally, with thrust restraint.] Securely anchor valves or provide with thrust restraints to prevent movement. Install thrust restraints made from either thrust blocks or, for ductile-iron pipes, restrained joints.

3.1.10.1 Thrust Blocks

Provide concrete thrust blocking of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 2000 psi after 28 days. Place blocking between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, place the base and thrust bearing sides of thrust blocks directly against undisturbed earth. Place the side of thrust blocks not subject to thrust against forms, if applicable. Provide the area of bearing as shown or as directed. Place blocking so that the fitting joints are accessible for repair. Use steel rods and clamps, protected by galvanizing or by coating with bituminous paint, to anchor vertical down bends into gravity thrust blocks.

3.1.10.2 Restrained Joints

For ductile iron pipe, design restrained joints in accordance with DIPRA TRD.

3.1.11 Grout

Provide grout mix for exterior joint protection on concrete pipes of 1 part portland cement, 2 parts sand, and of sufficient liquid consistency to flow into the joint recess beneath the diaper. Provide grout mix for interior joint protection of 1 part portland cement and 1 part sand. Substitute a polyurethane foam loop, impregnated with portland cement, in lieu of grout for exterior joints, if directed.

3.1.12 Bonded Joints

Where indicated, provide a thermally welded metallic bond at each joint, including joints made with flexible couplings or rubber gaskets, of ferrous-metallic piping to effect continuous conductivity.

3.2 FIELD QUALITY CONTROL

Perform both a pressure test and a leakage test on all pipelines. [Obtain the Contracting Officer's approval of the method proposed for disposal of waste water from hydrostatic tests.] [The Contractor is responsible for all testing.] [Perform testing using an independent testing laboratory, subject to approval by the Contracting Officer.] [Contractor will coordinate all tests to ensure they are witnessed by the Contracting Officer.] Notify the Contracting Officer at least 7 days in advance of equipment tests. Submit the final test report to the Contracting Officer within 30 days after the test.

3.2.1 Pressure Test

After installing the pipe, joints, and thrust blocks, wait at least five days before pressure testing. For the pressure test, partially backfill the trench but leave the joints exposed for examination, then fill the pipe with water to expel all air. Subject the pipeline to a test pressure of 100 psi or 150 percent of the working pressure, whichever is greater, for a period of at least one hour. Open and close each valve several times during the test. Examine the exposed pipe, joints, fitting, and valves for leaks. Stop visible leaks or replace defective pipe, fittings, joints, or valves.

3.2.2 Leakage Test

Conduct the leakage test subsequent to or concurrently with the pressure test. Place the amount of water permitted as leakage for the line in a sealed container attached to the supply side of the test pump. Apply no other source of supply to the pump or line under test. Pump the water into the line by the test pump as required to maintain the specified test pressure as described for a 2 hour period. The test will be considered a failure upon exhaustion of the supply or the inability to maintain the required pressure. PE pipe experiences diametric expansion and pressure elongation during initial testing. Consult the manufacturer prior to testing for special testing considerations. Determine allowable leakage by the following I-P formula:

L = NDP/K Where:

L = Allowable leakage in gallons per hour.

N = Number of joints in length of pipeline tested.

D = Nominal diameter of the pipe in inches.

P = Square root of the test pressure in psig.

K = 7400 for pipe materials.

At the conclusion of the test, measure the amount of water remaining in the container and record the results in the test report.

[Test ductile iron pressure lines in accordance with the requirements of AWWA C600.]

[Test concrete pressure lines in accordance with the recommendations of AWWA M9.]

[Test plastic pressure lines in accordance with the recommendations of AWWA C605.]

3.2.3 Retesting

If any deficiencies are revealed during any test, correct such deficiencies and repeat the tests until the results of the tests are within specified allowances, without additional cost to the Government.

-- End of Section --

SECTION 33 32 16

PACKAGED UTILITY WASTEWATER PUMPING STATIONS
11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast
AWWA C500	(2019) Metal-Seated Gate Valves for Water Supply Service
AWWA C509	(2015) Resilient-Seated Gate Valves for Water Supply Service
AWWA C515	(2020) Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
AWWA C517	(2009) Resilent-Seated Cast-Iron Eccentric Plug Valves
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances

AWWA C605	(2021) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings
AWWA M23	(2020) Manual: PVC Pipe - Design and Installation - Third Edition

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A615/A615M	(2020) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C443	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2018a) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D883	(2020a) Standard Terminology Relating to Plastics
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

ASTM D2464	(2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3753	(2019) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003; R 2008) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 820	(2016) Standard for Fire Protection in Wastewater Treatment and Collection Facilities

UNDERWRITERS LABORATORIES (UL)

UL 67 (2018; Reprint Jul 2020) UL Standard for Safety Panelboards

UL 489 (2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings

Erection/Installation Drawings

SD-03 Product Data

Submersible Sewage Grindernonclog Pumps; G [, [_____]]

Pump Performance Curve; G [, [_____]]

Pump Motor; G [, [_____]]

Pump Control System; G [, [_____]]

Wet Well and Valve Vault; G [, [_____]]

Flexible Flanged Coupling; G [, [_____]]

Station Piping and fittings; G [, [_____]]

Valves; G [, [_____]]

Spare Parts Data; G [, [_____]]

Access Hatch Covers

SD-05 Design Data

Buoyancy Calculations; G [, [_____]]

SD-06 Test Reports

Pump Test[; G[, [____]]]

[Pressure Sensor Test[; G[, [____]]]

][Float Test[; G[, [____]]]

] SD-07 Certificates

Submersible Sewage Grindernonclog Pumps; G [, [_____]]

Recycled Material Content[; G[, [____]]]

Manhole Chamber[; G[, [____]]]

Access Hatch Covers

Gate Valves[; G[, [____]]]

Check Valves[; G[, [____]]]

Blowers[; G[, [____]]]

Dehumidifier[; G[, [____]]]

Pump Motor[; G[, [____]]]

SD-08 Manufacturer's Instructions

Manhole Chamber[; G[, [____]]]

Access Hatch Covers

Pump Control System[; G[, [____]]]

Gate Valves[; G[, [____]]]

Check Valves[; G[, [____]]]

Blowers[; G[, [____]]]

Dehumidifier[; G[, [____]]]

Pump Motor[; G[, [____]]]

Special Tools[; G[, [____]]]

Posted Instructions[; G[, [____]]]

SD-10 Operation and Maintenance Data

Operation And Maintenance Manuals

SD-11 Closeout Submittals

Warranty[; G[, [____]]]

1.3 QUALITY CONTROL

1.3.1 Installer Qualifications

Provide manufacturer's authorized pump representative who is trained and approved for installation of pumps and packaged pump station required for this project.

1.4 DELIVERY, STORAGE, AND HANDLING OF MATERIALS

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials in enclosures or under protective covering. Rubber gaskets which are not to be installed immediately must be stored under cover, out of direct sunlight. Do not store materials directly on the ground. Keep interior of pipes, valves and fittings free of dirt and debris.

1.4.2 Handling

Handle pipe, fittings, valves, and other accessories in such manner as to ensure delivery to the trench in sound, undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Carry pipe to the trench; do not drag it. Do not use any device or fitting inserted into (such as loader forks) or attached to (such as chain hooks) the bell or spigot ends of the pipe to transport pipe. Handle ductile iron pipe, fittings, and accessories in accordance with AWWA C600. Handle PVC pipe, fittings, and accessories in accordance with AWWA C605.

1.5 WARRANTY

Provide manufacturer's standard warranty for a minimum of one year for package pump station including pumps, valves, controls, wet well basin and accessories.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a complete packaged sewage pump station with submersible grinder nonclog pumps including equipment and materials, installed and ready for operation. The pump supplier furnishes the controls, pumps and rail system to ensure unit integrity.

Submit fabrication drawings before installation. Submit drawings covering necessary or recommended changes to accommodate the equipment offered. Show on the drawings the design of the chamber, with dimensions, types, and thicknesses of materials, and elevation levels with reference to those elevations indicated.

Submit erection/installation drawings for the manhole chamber with the required equipment and accessories. Provide precast reinforced concrete manhole sections conforming to ASTM C478. Show the design of the chamber, with dimensions, types, and thicknesses of materials, and elevation levels with reference to those elevations indicated.

2.2 SUBMERSIBLE SEWAGE GRINDER NONCLOG PUMPS

Provide submersible sewage nonclog pumps with grinder units as indicated. Provide UL listed pumps for explosion proof Class 1, Division 1, Groups C and D hazardous locations. Provide submersible, centrifugal sewage pumps and grinder units capable of grinding the materials found in normal domestic sewage, including plastics, rubber, sanitary napkins, disposable diapers, animal hair and wooden articles into a finely ground slurry with particle dimensions no greater than [1/4][_____] inch of the nonclogging type with passageways designed to pass 3 inch diameter spheres without clogging. Provide pump capacity, number of pumps and motor characteristics as indicated on the drawings. Select pumps to continuously operate in a submerged or partially submerged condition.

2.2.1 Pump Construction

2.2.1.1 Casing

Provide hard, close-grained cast iron casing or steel that is free from blow holes, porosity, hard spots, shrinkage defects, cracks, and other injurious defects. Provide casings permitting replacement of wearing parts. Ensure all joints are gasketed to prevent leakage. Ensure passageways permit smooth flow of sewage and are free of sharp turns and projections. Use free standing pump support legs of cast-iron providing enough clearance for the solids to get into the grinder.

2.2.1.2 Impeller

Provide a [stainless steel] [bronze] [_____] impeller for the grinder pump with stainless steel cutter, grinder, or slicer assembly. Provide nonclogging type cast-iron impeller, conforming to ASTM A48/A48M, Class 30, for a submersible nonclog pump. Ensure the impeller has a smooth surface and allows free flowing with the clearance to permit objects in the sewage to pass. Fit and key, spline, or thread impeller on shaft, and lock in such manner that lateral movement is prevented and reverse rotation will not cause loosening.

2.2.1.3 Bearings

Provide heavy duty ball thrust bearing or roller type bearing sized to withstand imposed loads. Oil lubricate bearings.

2.2.1.4 Lubrication

Provide [grease type lubrication with fittings for a grease gun and, if not easily accessible, with grease tubing extending to convenient locations.][the pump manufacturer's standard type grease fittings.] [self lubricating, permanently sealed bearings.]

2.2.1.5 Balance

Balance rotating parts of the equipment mechanically and hydraulically to operate throughout the required range without excessive end thrust, vibration, and noise. Conform allowable vibration limits with ISO 1940-1, Table 1. Existence of defects that cannot be eliminated by adjustment will be sufficient cause for rejection of the equipment.

2.3 PUMP MOTOR

Provide hermetically sealed electric motors with moisture and temperature-sensing probes in the wet well NEMA MG 1, [_____] RPM, [_____] volt, [_____] phase, and [_____] Hz cycle for submersible pumps. Motor horsepower must not be less than pump horsepower at any point on the pump performance curve. Fit motors with lifting "eyes" capable of supporting entire weight of pump and motor. Seal the power cable inside the motor end bell. Provide a waterproof power cable for its full length. Motors shall be UL listed for explosion proof Class 1, Division 1, Groups C and D. Air filled motors are not acceptable. Oil used must be able to be disposed as non-hazardous waste.

2.4 PUMP CONTROL SYSTEM

2.4.1 General

Provide an automatic type pump operating control including all necessary components to function reliably. Mount controls in a NEMA [3R][_____] rated [stainless steel][_____] control panel. Ensure equipment subject to contact with sewage or sewage gases is corrosion-resistant metal. Provide an electronic controller that automatically activates and alternates the pump operation. If the liquid level continues to rise to the plans-specified level, the controller engages both pumps to operate simultaneously until both shut off at the specified low level. Provide hand-off-auto switches to choose the mode of operation for each pump. Provide controls with a 12 VDC powered float switch connected to the alarm contact of the battery charger to activate high-level alarms.

Protect pumping stations from lightning and transient voltage surges and equip with phase protection.

Provide the station with a three-wire, 4-pole (grounding) receptacle for a portable generator in case there is an external power outage.

Design the control system to operate pumps at the power characteristics as shown on the plans. Ensure all controls and wiring meet or exceed the requirements of NFPA 70.

For pumps specified as explosion proof, have pump power and control installation meets NEC requirements for Class 1, Division 1, Group D Hazardous Location, including intrinsically safe controls. Provide components that are UL listed or FM approved.

Require the control function to provide for the operation of the pumps under normal conditions and alternates the pumps on each pump down cycle.

In the event the incoming flow exceeds the pumping capacity of the lead pump, the offline pumps automatically start to handle the increased flow. As the flow decreases, the pumps cut off at the elevations set on the controller.

2.4.2 Enclosure

Provide a NEMA 3R rated enclosure manufactured from stainless steel. [The enclosure is a wall mount type suitable for mounting on strut or channel with a minimum depth sized to adequately house all the components.]Provide a rubber composition door gasket and assures a positive weatherproof seal. Provide a door that opens a minimum of 180 degrees and is equipped with a 3-point latch and padlockable handle.

Provide a dead front mounted in the panel to provide protection of personnel from live internal wiring. Install cutouts for breaker handles to allow operation of breakers without entering the compartment.

Mount all control switches, indicator pilot lights, elapsed time meters, duplex receptacle and other operational devices on the external surface of the dead front.

Ensure the dead front opens a minimum of 150 degrees to allow access to equipment for maintenance.

[Manufacture the back plate from 12-gauge (minimum) steel and finished with a primer coat and two (2) coats of baked on white enamel.]Mount all hardware to the subpanel with machine thread tapped holes. Sheet metal screws are not acceptable. Permanently identify all devices to match the schematic diagram.

Provide an enclosure ventilator located near the top of the enclosure on the opposite side of the generator receptacle. Provide a rain and vermin proof ventilator and made of fire retardant thermoplastic material.

2.4.3 Level Control System

[Provide a sealed, mercury-free float switch control system to sense variations of sewage level in the wet well.

Use a direct acting float switch consisting of a normally-open mercury switch enclosed in a float. Use float molded of rigid high-density polyurethane foam, color-coded and coated with a durable, water and corrosion-resistant jacket of clear urethane.

Provide stainless steel float brackets in accordance with manufacturer's recommendations.

Mount floats at fixed elevations as shown on the drawings.

Use floats designed to tilt and operate their switches causing sequential turn-on turn-off of the pump, when the liquid level being sensed rises or falls past the float.

Float switches must be intrinsically safe relays. Provide an intrinsically safe barrier relay between the wet well and the control panel.

][Provide the pump station with a submersible pressure type level sensor and an electronic pump controller. Sense levels by a 24 DVC, 1 percent submersible pressure transmitter provided by controller manufacturer. Construct the system as follows:

a. The pressure type level sensor is a submersible type, suspended on its cable.

b. Install the sensor per manufacturer's instructions for wet well installations, including any recommended mounting accessories.

c. The level sensor is as follows:

   (1) Select the sensor range based on the wet well depth.

   (2) The sensor output is 4-20mA proportional to water level, 2-wire type.

   (3) Construct all exposed parts of [316 Stainless Steel][_____].

   (4) Fill the sensor with Silicon Oil.

   (5) Power the Sensor by 24 VDC output from electronic pump controller.

d. Mount the electronic pump controller in the starter panel enclosure, and be visible from the front of the swing-out panel, with the enclosure door opened. The electronic pump controller is as follows:

(1) Accept a 4-20 mA, 2 wire level signal, and indicate the wet well level digitally in direct engineering units (feet).

(2) Provide pump control outputs, with independent adjustment for each pump starting and stopping setpoint. Indicate each level setpoint digitally in direct engineering units.

(3) Power to the unit is 120 VAC.

(4) Equip controller with hand/off/auto (H.O.A.) switches and pump on indicating lights (one each per pump).

] Provide an intrinsically safe barrier relay between the wet well and the control panel.

2.4.4 Alternator

Provide an alternator control switch to operate in connection with each float. Use an alternator control switch to alternate the operation of the pumps and operate both pumps if the water level rises above the second high water level. Incorporate time delay function and devices in the alternator controls such that both sewage pumps cannot be started simultaneously for an adjustable period of 10 to 120 seconds after shutdown. Use the delay function designed to operate in any condition of start-up in either normal or emergency operational mode.

2.4.5 Sewage Pump Alarm and Control Panel

Enclose alarm panel in NEMA [4X] [3R] enclosure and with a flashing red light that is visible from 50 feet away, with long life bulb in guarded enclosure and 6 inch diameter horn. Use horns capable of emitting 120 DB at 10 feet. Power alarm horn and light from 12V DC power supply with battery backup. Provide a rechargeable battery rated to power both the horn and light for a minimum of two hours upon loss of main power. Provide circuitry to automatically recharge the battery after main power is restored. Use batteries capable of being fully recharged in no more than 20 hours. Use panel with power on light, push to test button for horn and light and push to silence button for horn and light with automatic reset for next alarm.

2.4.5.1 Alarms

Provide a test function ability for the alarm system. Provide alarms to activate under the following conditions:

a. High liquid level as sensed by the level control system.

b. Loss of main power.

c. No flow light as sensed by limit switch on the check valve or as sensed by current sensors.

d. Pump failure via temperature overload or motor heat sensor trip; provide motor high temperature light.

e. Seal failure with indication light.

2.4.5.2 Circuit Breakers

a. Provide an individual circuit breaker for each pump.

b. Include a control circuit breaker and an alarm circuit breaker in the control panel.

c. Allow for two additional spare 115V single phase 20A circuit breakers for local pole lighting and future spare.

d. Provide circuit breakers in accordance with UL 489

e. Conform to UL 67 for circuit breaker mounting.

2.4.5.3 Motor Starter and Overload Protection

Provide an International Electrotechnical Commission (IEC) rated motor starter and thermal overload protection located in the control panel for each pump. Include undervoltage release, manual reset buttons and hand-automatic selector switches.

2.4.5.4 Power Lugs

a. Size the incoming power lugs for the proper voltage, amperage, and horsepower for each pump station.

b. Include grounding lugs for the incoming power. Provide a dedicated grounding lug in the control panel for each pump.

c. Size ground lug and rod according to local and base electrical codes and install by a licensed electrician.

d. Use UL listed power lugs.

e. Conform to UL 67 for required power lug mounting.

2.4.5.5 Anti-Condensation Heater

a. Provide an anti-condensation heater in the control panel that is sized based upon the size of the particular pump station's control panel size.

b. Power the heater from the control voltage transformer for three phase pump motor units and from the incoming power for single phase pump motor units.

c. Control the heater by a thermostat, coming on at 50 degree F and going off at 65 degree F.

d. Clearly label panel directory for breakers.

2.4.5.6 Trouble Light

Provide a fluorescent trouble shooting light in the panel that is hard-wired into an appropriately sized circuit breaker. It is acceptable for the light and one of the convenience outlets to share the same circuit breaker.

2.4.5.7 Convenience Outlets

a. Place two duplex convenience outlets in the control panel; utilize one for the battery charger. The battery receives power from the control voltage transformer via the alarm fuse.

b. Upsize the alarm fuse to 1 to 1.5 amps for the battery charger.

c. Provide each outlet with its own 20 amp 115/1/60 circuit breaker.

[2.4.5.8 Connection for Portable Generator

Provide receptacle for connection for portable generator. Provide manual transfer switch for receptacle matching generator electrical power requirements.

]2.4.5.9 Additional Requirements

a. Provide elapsed time meter for each pump that measures run time in hours to 9999.9.

b. Do not place junction boxes between pumps, control systems and control panels; provide conduit seals at all wet well penetrations. If this is unavoidable, use NEMA 7 construction.

2.4.6 Electrical Requirements

Install labels to identify switches and controls. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field installed equipment.

2.5 WET WELL AND VALVE VAULT

2.5.1 Wet Well and Valve Vault

Provide a fiberglass reinforced polyester resin basin with integral valve vault precast concrete wet well; include a separate precast concrete valve vault. Provide a wet well and valve vault with inside diameters [as indicated][of [_____] inch] and to the depths indicated on the drawings.[

Precast structures may be provided in lieu of cast-in-place structures.]

2.5.1.1 Fiberglass Basins

a. Buoyancy Calculations: Submit buoyancy calculations sealed by a licensed professional engineer assuming seasonal high groundwater elevation at proposed finished grade. Prevent flotation in accordance with manufacturer's written instructions. Include manufacturer's written instructions with submitted calculations.

b. Select Fiberglass Reinforced Polyester (FRP) wet well in accordance with ASTM D883 relating to plastics and ASTM D3753.

(1) Use commercial grade polyester resins evaluated as a laminate by test or determined by previous service to be acceptable for use in the wastewater environment.

(2) Use a commercial grade continuous strand fiberglass reinforcement material.

(3) Design FRP based on the following assumed conditions. Provide independent third party testing.

(a) Hydrostatic pressure of 62.4 pounds/square foot with water at ground surface.

(b) Saturated soil weight of 120 pounds/cubic foot.

(c) Soil modulus of 700 pounds/square foot.

(d) Pipe stiffness values as specified in ASTM D3753.

(e) Provide FRP laminate with a surface hardness of 90 percent Barcol.

2.5.1.2 Precast Concrete Structures

Submit manufacturer's data indicating percentage of recycled material content in packaged sewage lift stations to verify affirmative procurement compliance.

Fly ash is required as an admixture and is to conform to ASTM C618, Class [F][C]. Fly ash replacement of cement is not to exceed 20 percent (maximum one part fly ash to four parts cement) by weight.

Ground granulated blast furnace slag [is required] [used] as an admixture [and] is to conform to ASTM C989/C989M, Grade [120] with between 25 to 50 percent maximum cement replacement by weight. Submit certificate to verify EPA-CPG compliance.

a. Buoyancy Calculations: Submit buoyancy calculations sealed by a licensed professional engineer assuming seasonal high groundwater elevation at proposed finished grade.

b. Construct precast concrete structures in accordance with ASTM C478, except as specified herein. Provide precast concrete structures with a compressive strength of 4000 psi at 28 days and an air entrainment of 6 percent, plus or minus 2 percent, and a minimum wall thickness of 5 inches. ASTM A615/A615M reinforcing bars. ASTM C443, Type B gaskets for joint connections. Use monolithic base and first riser.

2.5.2 Access Hatch Covers

Provide [aluminum][_____] access hatch covers as indicated. Include lifting mechanism, automatic hold open arm, slam lock with handle, and flush lift handle with vinyl grip. Use automatic hold open arm that locks in the 90 degree position. Use cover that is 1/4 inch diamond plate with 1/4 inch channel frame and continuous anchor flange. Use access hatch cover capable of withstanding a live load of 300 lb/sq. ft. Provide stainless steel cylinder lock with two keys per lock. Key all the locks the same.

2.5.3 Wet Well Base Material

Provide crushed stone as indicated and specified in Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL.[Provide a polyethylene vapor barrier as indicated and specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.]

2.5.3.1 Ventilating Blower

Ensure blowers maintain air changes in accordance with[NFPA 820][every

[5] [_____] minutes]. Mount a manual and automatic switch on the side of the entrance tube for operation of the blower. Provide vent to atmosphere with covers and screens to prevent the entrance of rain, insects, and rodents. Automatically actuate blower upon opening the entrance tube cover, unless overridden by the manual control.

2.5.3.2 Dehumidifier

Furnish and install a packaged dehumidifier in accordance with lift station manufacturer's recommendations. Include in controls a humidistat and low-temperature cutout/discharge condensate to the wet well.

2.6 STATION PIPING

Provide pressure piping, emergency pump connection, air release valves, and related accessories for force main piping outside the sewage wet well and valve vault in accordance with Section 33 30 00 SANITARY SEWERAGE.

2.6.1 Ductile-Iron Pressure Pipe and Associated Fittings

Conform to AWWA C151/A21.51, Pressure Class 350.

2.6.1.1 Flanged Pipe

Conform to AWWA C115/A21.15, ductile iron.

2.6.1.2 Fittings

AWWA C110/A21.10, flanged. Provide flanged joint fittings within wet well and valve vault as indicated. Provide mechanical joint fittings outside valve vault enclosure as indicated. Use fittings with pressure rating at least equivalent to that of the pipe.

2.6.1.3 Joints

AWWA C115/A21.15 for flanged joints. Use bolts, nuts, and gaskets for flanged connections recommended in the Appendix to AWWA C115/A21.15. Provide ductile iron flange for setscrewed flanges in accordance with ASTM A536, Grade 70-50-05 or 60-42-10, and meeting the applicable requirements of ASME B16.1, Class 125. Use 190,000 psi tensile strength, heat treated, and zinc-coated steel setscrews for setscrewed flanges. Conform to the applicable requirements for mechanical-joint gaskets specified in AWWA C111/A21.11 for setscrewed flange gaskets. Use setscrewed gasket designed to provide for confinement and compression of gasket when joint to adjoining flange is made.

2.6.2 PVC Plastic Pressure Pipe and Associated Fittings

2.6.2.1 Pipe and Fittings Less Than 4 inch Diameter

Use pipe, couplings and fittings manufactured of materials conforming to ASTM D1784, Class 12454-B.

a. Screw-Joint: Follow dimensional requirements of ASTM D1785 Schedule 80 pipe, with joints meeting requirements of 150 psi working pressure, 200 psi hydrostatic test pressure, unless otherwise shown or specified. Follow ASTM D2464 and ASME B1.20.1 for use with Schedule 80 threaded pipe and fittings. Test pipe couplings when used, as required by ASTM D2464.

b. Push-On Joint: ASTM D3139, with ASTM F477 gaskets. Fittings for push-on joints: AWWA C110/A21.10 or AWWA C111/A21.11. Iron fittings and specials: cement-mortar lined (standard thickness) in accordance with AWWA C104/A21.4.

c. Solvent Cement Joint: Use pipe that matches the dimensional requirements of ASTM D1785 or ASTM D2241 with joints meeting the requirements of 150 psi working pressure and 200 psi hydrostatic test pressure. Use fittings for solvent cement jointing that match the requirements of ASTM D2466 or ASTM D2467.

2.6.3 Insulating Joints

Provide between pipes of dissimilar metals a rubber gasket or other approved type of insulating joint or dielectric coupling to effectively prevent metal-to-metal contact between adjacent sections of piping.

2.6.4 Accessories

Provide flanges, connecting pieces, transition glands, transition sleeves, and other adapters as required.

2.6.5 Flexible Flanged Coupling

Provide flexible flanged couplings applicable for sewage as indicated. Use flexible flanged coupling designed for a working pressure of 350 psi.

2.7 VALVES AND OTHER PIPING ACCESSORIES

2.7.1 Isolation Gate Valves in Valve Vault

Conform to AWWA C500 for gate valves with outside-screw-and-yoke rising-stem type with double disc gates and flanged ends. Conform to AWWA C509 for valves with outside-screw-and-yoke rising-stem type with flanged ends. Provide valves that open by counterclockwise rotation of the valve stem. [Bolt and construct stuffing boxes to permit easy removal of parts for repair of gate valves.] Use valves from one manufacturer.

2.7.1.1 Valves Larger Than 2 Inches

[Resilient seat gate valves conforming to AWWA C509 with non-rising stems and flanged ends.

][Resilient seat eccentric plug valves conforming to AWWA C517 with operating handle and flanged ends.

]2.7.1.2 Valves 2 Inches and Smaller

[Gate valves conforming to MSS SP-80 with non-rising stems and threaded ends.

][Ball valves with PTFE seats and seals, brass body and end cups, chrome plated brass ball and screwed ends.

]2.7.2 Check Valves Less Than 4 inch Diameter

Neoprene ball check valve with integral hydraulic sealing flange, designed for a hydraulic working pressure of 175 psi.

2.7.3 Check Valves 4 inch and Larger Diameter

Provide nonclogging swing check valve rated for not less than 175 psig working pressure capable of passing 3-inch diameter solids. Match cast iron to ASTM A126 and flanged ends to AWWA C110/A21.10 Buna-N disc and integral seat.

Provide a positive horizontal, swing check type check valves. Provide valves that permit a free flow of sewage forward and a positive check against backflow. Provide iron body valves with a removable cover for inspection and removal of the gate assembly. Provide [bronze][_____] gate, gate seats, shaft, studs, and nuts.

2.7.4 Identification Tags and Plates

Provide the manufacturer's name or trademark on a corrosion-resistant identification plate or cast integrally, stamped, or otherwise permanently marked in a conspicuous place on each item of equipment. Include on the pump identification plate the pump capacity in gpm, pump head in feet and speed of rotation. Cast on the body of the pump the direction of rotation.

2.7.5 Pipe Support

Use pipe support schedule 40 galvanized steel piping matching ASTM A53/A53M. Provide either ASME B16.3 or ASME B16.11 galvanized threaded fittings.

2.7.6 Miscellaneous Metals

Use stainless steel bolts, nuts, washers, anchors, and supports for installation of equipment.

2.7.7 Quick Disconnect System with Hydraulic Sealing Flange and Rail System

Use quick disconnect system consisting of a steel base plate for supporting the pumps, a hydraulic sealing flange, pump guide rails and the discharge pipe supports. Provide stainless steel guide rails, brackets and lifting chain for raising and lowering the pump in the basin. Build guides onto pump housing to fit the guide post to assure perfect alignment between pump and guide rails.

2.7.8 Wet Well Vent

Provide a [flanged ductile iron pipe and bend, conforming to AWWA C115/A21.15] [galvanized steel pipe and bend, conforming to ASTM A53/A53M] with insect screening.

2.8 EXCAVATION, TRENCHING, AND BACKFILLING

Provide in accordance with Section [31 00 00 EARTHWORK][31 23 00.00 20 EXCAVATION AND FILL], except as specified herein.

PART 3 EXECUTION

3.1 INSTALLATION

Provide pump station in accordance with drawings and requirements of the respective equipment manufacturers. Dampen and isolate equipment vibration.

3.1.1 Equipment Installation

Install equipment in accordance with these specifications and the manufacturer's installation instructions. Grout equipment mounted on concrete foundations before installing piping. Install piping to avoid imposing stress on equipment. Match flanges before securing bolts.

3.1.2 Installation of Ductile-Iron Pressure Pipe and Fittings

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS FOR INSTALLATION OF PIPELINES of Section 33 30 00 SANITARY SEWERAGE, and with the requirements of AWWA C600 for pipe installation, joint assembly, and valve-and-fitting installation.

Make flanged joint with gaskets, bolts, and nuts specified for this type joint. Make flanged joints tight, avoid strain on flanges, fittings, and other accessories. Align bolt holes for each flanged joint. Use bolts sized for the bolt holes; use of undersized bolts is not permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange.

3.1.3 Installation of PVC Plastic Pressure Pipe and Fittings

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS FOR INSTALLATION OF PIPELINES of Section 33 30 00 SANITARY SEWERAGE, with the recommendations for pipe joint assembly and appurtenance installation in AWWA M23, "Installation."

3.1.3.1 Pipe Less than 4 Inch Diameter:

a. Make threaded joints by wrapping the male threads with joint tape or by applying an approved thread lubricant, then threading the joining members together. Tighten joints with strap wrenches that will not damage the pipe and fittings. Do not tighten joint more than 2 threads past hand-tight.

b. Push-On Joints: Bevel ends of pipe for push-on joints to facilitate assembly. Mark pipe to indicate when the pipe is fully seated. Lubricate gasket to prevent displacement. Ensure that the gasket remains in position in the bell or coupling while making the joint.

c. Solvent-weld joints: Comply with the manufacturer's instructions.

3.1.4 Valves

Make and assemble joints to gate valves and check valves as specified for making and assembling the same type joints between pipe and fittings.

Install valves in accordance with manufacturer's installation instructions. Install gate valves as described in AWWA C500, AWWA C509, and AWWA C515 and with AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500.

3.1.5 Miscellaneous

Attach a plactic laminated final as-built controls drawing to the inside of the front door. Include a list of all legends. Identify the pump nameplate data on the drawing and on the as-built plans.

Permanently mark all component parts in the control panel and identified as they are indicated on the drawing. Mark on the back plate adjacent to the component. Identify all control conductors with wire markers at each end as close as practical to the end of conductor.

3.2 FIELD QUALITY CONTROL

Provide appliances, materials, water, and equipment for testing, [except that water and electric power needed for field tests will be provided as set forth in Division 01] [and bear full expenses in connection with the testing]. Conduct testing after equipment, electrical services, and piping are installed, and the pump station is ready for operation. Correct defects discovered to the satisfaction of the Contracting Officer, and tests repeated, at no expense to the Government, until the equipment functions as intended and designed.

3.2.1 Testing Procedure

Perform a pump test, [pressure sensor test][float test]. Submit the test results to the Contracting Officer.

Test all panels to the power requirements as shown on the plans to assure proper component operation. Activate each control function to check for proper operation and indication.

3.2.2 Field Representative

A representative of the pump manufacturer is to direct the startup of the station and instruct representatives of the Government in startup and operation procedures.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Operation and Maintenance

Submit operation and maintenance manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA for package lift stations, including Equipment Description, Assembly and Installation Procedures, Adjustment and Alignment, Checkout Procedures, Procedures of Operation and Troubleshooting. Include preventative maintenance and inspection procedures for package lift stations. Include in procedures the frequency of preventative maintenance, inspection, adjustment, lubrication, and cleaning necessary to minimize corrective maintenance and repair.

Supply special tools that are required for maintenance and testing of the package lift stations.

Submit spare parts data, including a complete list of parts and supplies with current unit prices and source of supply. List parts and supplies that are either normally furnished at no extra cost with the purchase of equipment, or specified to be furnished as a part of the contract, and list additional items recommended by the manufacturer to ensure an efficient operation for a period of one year.

Install on or near the package lift stations, a complete package of posted instructions, consisting of labels, signs, and templates of operating instructions.

Provide a list or reference all specific operation and maintenance procedures that are required to keep the warranty valid.

-- End of Section --

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SECTION 33 34 56.00 10

DRAINAGE FIELD DOSING CHAMBERS
08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.3 (2021) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.39 (2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4 (2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water

AWWA C110/A21.10 (2012) Ductile-Iron and Gray-Iron Fittings for Water

AWWA C111/A21.11 (2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

AWWA C151/A21.51 (2017) Ductile-Iron Pipe, Centrifugally Cast

AWWA C153/A21.53 (2019) Ductile-Iron Compact Fittings for Water Service

AWWA C600 (2017) Installation of Ductile-Iron Mains and Their Appurtenances

AWWA C605 (2021) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings

AWWA M55 (2020; 2nd Ed) PE Pipe - Design and Installation

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M (2020) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM C443 (2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using

	Rubber Gaskets
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM D883	(2020a) Standard Terminology Relating to Plastics
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3753	(2019) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F714	(2022) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
ASTM F794	(2021) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F894	(2019) Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G[, [_____]]

Dosing Tank

SD-05 Design Data

Buoyancy Calculations for Fiberglass Basins

Buoyancy Calculations For Precast Concrete Structures

SD-06 Test Reports

Rapid Inflow Test

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling and in accordance with manufacturer's instructions. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets and any other ultraviolet sensitive material under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, and other accessories free of dirt and debris.

1.3.2 Handling

Handle pipe, fittings, and other accessories in accordance with manufacturer's instructions and in a manner to ensure delivery to the final installed location in sound undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Clean the materials of foreign matter before being installed. Replace material found to be defective with sound material at no additional expense to the Government. Store rubber gaskets and other ultraviolet sensitive materials under cover out of direct sunlight until they are ready for installation.

Handle ductile iron pipe, fittings, and accessories in accordance with AWWA C600.

Handle PVC and PVCO pipe, fittings, and accessories in accordance with AWWA C605.

Handle PE pipe, fittings, and accessories in accordance with AWWA M55.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a [deep seal][trapless] type dosing siphon suitable for the service required, completely automatic in operation, starting promptly when the sewage has reached the predetermined high water level, and shutting off positively at the low water level. Accomplish the starting, stopping, and alternating operations without the use of electrical or mechanical devices having moving parts. Capacities of equipment and materials must be not less than those specified or indicated. Secure the manufacturer's name, address, and catalog or model number on a plate in a conspicuous place on each siphon bell. In lieu of nameplate, cast integrally the manufacturer's name or trademark with the equipment, or standard, or otherwise permanently marked.

2.2 MATERIAL

Provide materials and equipment conforming to the publications and other requirements specified below. Provide other material and equipment as specified and as shown on the approved detail drawings. Provide products from manufacturers regularly engaged in the manufacture of such products. Material and equipment must essentially duplicate items that have been in satisfactory use at least 2 years prior to [bid opening][installation][source selection]. Submit complete drawings and other descriptive data as the Contracting Officer may require said data to demonstrate compliance with the contract documents, not less than [_____] days before starting installation of any material or equipment. Submit all detail drawings, catalog cutsheets, part numbers, and other material to document compliance with the specifications at one time. If departure from the contract drawings is deemed necessary, submit details of such departure, including changes in related portions of the project and the reasons therefore, with the drawings. Make approved departures at no additional cost to the Government. Submit a complete list in triplicate of parts and supplies for each different item of equipment listed, with current unit prices and sources of supply. Submit a list of parts and supplies that are either normally furnished at no extra cost with the purchase of the equipment or are specified to be furnished as a part of the contract. Submit a list of additional items recommended by the manufacturer to assure efficient operation for a period of 120 days, not later than four months prior to the date of beneficial use.

2.2.1 Pipe and Fittings

2.2.1.1 Ductile Iron Pressure Pipe and Fittings

Provide ductile-iron pipe that conforms to AWWA C151/A21.51, Thickness Class [_____]. Provide fittings that conform to AWWA C110/A21.10 or AWWA C153/A21.53. [Provide fittings with push-on joint ends that conform to the same material and operational requirements as fittings with mechanical-joint ends, except for modifying the bell design, as approved, to function as a push-on joint.] Provide fittings with a pressure rating at least equivalent to that of the pipe. Ensure the ends of the pipe and fittings provided are suitable for the joints specified hereinafter. Provide pipe and fittings with cement-mortar lining conforming to AWWA C104/A21.4, standard thickness.

2.2.1.1.1 Ductile Iron Joints and Jointing Materials

a. Joints, general: Provide [push-on joints] [or] [mechanical joints] for pipe and fittings except as otherwise specificed in this paragraph. [Supply mechanical-joints where indicated.] [Provide Flanged Joints where indicated.] [Use of sleeve-type mechnical coupling joints in lieu of push-on joint is allowable.] [Use of [grooved] [or] [shouldered] type joints in lieu of push-on joint [or flanged joint], is allowable, except where joint is buried.]

b. Push-on joints: Supply pipe ends and fitting ends, gaskets, and lubricant for joint assembly which conform to AWWA C111/A21.11.

c. Mechanical joints: Supply dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets which conform to AWWA C111/A21.11.

2.2.1.2 PVC Plastic Gravity Sewer Piping

2.2.1.2.1 PVC Plastic Gravity Pipe and Fittings

[ASTM D3034, SDR 35, or ASTM F949 with ends suitable for elastomeric gasket joints.] [ASTM F794, Series 46, for ribbed sewer pipe with smooth interior, size 8 inch through 48 inch diameters.]

2.2.1.2.2 PVC Plastic Gravity Joints and Jointing Material

Provide joints conforming to ASTM D3212. Provide gaskets conforming to ASTM F477.

2.2.1.3 High Density Polyethylene Pipe (HDPE)

ASTM F894, Class 63, size 18 inch through 120 inch. ASTM F714, size 4 inch through 48 inch, with pipe stiffness greater than or equal to 1170/D for cohesionless material pipe trench backfills. For all PE pipes, certify that the polyethylene meets the requirements of ASTM D3350, cell Class 334433C or higher. Provide fittings for High Density Polyethylene Pipe of the same material specifications as the pipe class. Provide rubber gasket joints conforming to ASTM F477 for all HDPE meeting ASTM F894. Use fused joints on all HDPE meeting ASTM F714 per manufacturer's instructions.

2.2.1.4 Pipe Fittings

2.2.1.4.1 Ductile Iron Fittings

AWWA C110/A21.10 and AWWA C111/A21.11 [_____] psi working pressure.

2.2.1.4.2 Polyvinyl Chloride (PVC) Fittings

ASTM D3034.

2.2.1.4.3 Polyethylene Fittings

ASTM D3350.

2.2.1.4.4 Malleable-Iron Fittings

ASME B16.3.

2.2.1.4.5 Malleable-Iron Unions

ASME B16.39.

2.2.2 Siphon Bells, Inlet Castings, and Similar Equipment

Supply polyvinyl chloride (PVC) or polyethylene siphon bells, air bells, inlet castings, and similar equipment. Molded or fitted siphons are acceptable. Provide siphon bells with suitable connections for the air-control piping and mount the sniff pipe over the [_____] inch diameter feed pipe. Supply siphons that discharge at a maximum rate of flow of [_____] gpm while operating under a drawing depth of [_____] inches, and under the head conditions as indicated. Provide for an average rate of inflow of [_____] gpm and the minimum 4-hour average rate [_____] gpm.

2.2.2.1 Polyvinyl Chloride (PVC)

ASTM D3034.

2.2.2.2 Polyethylene

ASTM D3350.

2.2.3 Valves

Bronze, MSS SP-80, Type [_____].

2.2.4 Dosing Tank

2.2.4.1 Dosing Tank

Provide fiberglass reinforced polyester resin basin [or] precast concrete tank. Provide with inside diameters [as indicated][of [_____] inch] and to the depths indicated on the drawings.

2.2.4.1.1 Fiberglass Basins

a. Buoyancy Calculations for Fiberglass Basins: Submit buoyancy calculations sealed by a licensed professional engineer. Prevent flotation in accordance with manufacturer's written instructions. Include manufacturer's written instructions with submitted calculations.

b. Provide Fiberglass Reinforced Polyester (FRP) dosing tanks in accordance with ASTM D883 relating to plastics.

   (1) Use commercial grade polyester resins evaluated as a laminate by test or determined by previous service to be acceptable for use in the wastewater environment.

   (2) Use a commercial grade continuous strand fiberglass reinforcement material.

   (3) Design FRP based on the following assumed conditions. Provide independent third party testing.

      (a) Hydrostatic pressure of 62.4 pounds/square foot with water at ground surface.

      (b) Saturated soil weight of 120 pounds/cubic foot.

      (c) Soil modulus of 700 pounds/square foot.

      (d) Pipe stiffness values as specified in ASTM D3753.

      (e) Provide FRP laminate with a surface hardness of 90 percent Barcol.

2.2.4.2 Precast Concrete Structures

a. Buoyancy Calculations for Precast Concrete Structures: Submit buoyancy calculations sealed by a licensed professional engineer.

b. Construct precast concrete structures in accordance with ASTM C478, except as specified herein. Provide precast concrete structures with a compressive strength of 4000 psi at 28 days and an air entrainment of 6 percent, plus or minus 2 percent, and a minimum wall thickness of 5 inches. ASTM A615/A615M reinforcing bars. ASTM C443, Type B gaskets for joint connections.

2.2.4.3 Access Hatch Covers

Provide [aluminum][_____] access hatch covers as indicated. Include lifting mechanism, automatic hold open arm, slam lock with handle, and flush lift handle with vinyl grip. Use automatic hold open arm that locks in the 90 degree position. Use 1/4 inch diamond plate cover with 1/4 inch channel frame and continuous anchor flange. Use access hatch cover capable of withstanding a live load of 300 lb/sq. ft. Provide stainless steel cylinder lock with two keys per lock. Identically key the locks.

2.2.5 Cycle Counters

Provide a non-electric, mechanical cycle counter integrally mounted with the siphon that is adjustable to accurately count the fill/empty cycles for each siphon. Provide counter that operates by means of a gravity float switch.

2.2.6 Painting

[Factory powder coat][Factory paint][Field paint] all ferrous material installed under this specification. Thoroughly clean, prime, and finish painted any painted components in accordance with the recommendations of the manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

Install the Dosing Siphon System in accordance with the recommendations of the manufacturer as approved. Utilize workers experienced in the installation of this type of equipment.

3.1.1 Siphons

Install siphons in accordacne with the approved detail drawings. [Install each siphon with a seal trap in the discharge pipe of such depth to maintain an effective seal against blowing at all times.] [Discharge each siphon into an airtight piping system having a discharge point above the lowest point in the connecting pipe to form an effective seal.] [Install siphons for alternating operation from a common chamber with auxiliary equipment necessary for alteration in a predetermined sequence. Arrange and valve the air piping to permit removal of any number of the siphons from service without disturbing the alternating operation of the remaining siphons.] [Install equipment for twin dosing tanks including air bells, air-locking inflow connection, and all similar equipment that may be necessary to alternate the inflow from one tank to the other and to prevent flow into the tank when the siphon in the tank is discharging.]

3.1.2 Piping

Install piping with fittings and valves of similar material, with sufficient to facilitate maintenance or removal. [Assemble cast iron piping using a stiff mixture of graphite and oil, or an inert filler and oil, or an approved graphite compound, applied with a brush to the male threads only.]

3.2 SYSTEM STARTUP

Perform field tests, and provide labor, equipment, and incidentals required for testing, including water as needed for field tests. Produce evidence, when required, that items of work have been constructed in accordance with Contract requirements.

3.2.1 Testing Procedure

Test piping in accordance with Section 33 30 00 SANITARY SEWERS. Test in operation all equipment to demonstrate compliance with the Contract requirements.

3.2.2 Dosing Siphon System

3.2.2.1 Normal Operation

Test system in operation and in accordance with the authority having jurisdiction over sewage system, under design conditions to ensure operation of equipment. Provide appliances, materials, water, and equipment for testing, and bear full expenses in connection with the testing. Conduct testing after equipment is installed, piping is installed, liquid is flowing, and the system is ready for operation. Correct defects discovered to the satisfaction of the Contracting Officer, and tests repeated, at the expense of the Contractor, until the equipment functions as intended and designed.

3.2.2.2 Rapid Inflow Test

Test System as outlined above, but with an inflow equal to [2][3][____] times the average daily flow for [10][30][__] minutes. Record results and submit to the Contracting Officer.

3.3 PROTECTION

Field painting is specified in Section 09 90 00 PAINTS AND COATINGS.

-- End of Section --

SECTION 33 40 00

STORMWATER UTILITIES
11/21

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Pipe Culverts and Storm Drains

The length of pipe installed will be measured along the centerlines of the pipe from end to end of pipe without deductions for diameter of manholes. Pipe will be paid for at the contract unit price for the number of linear feet of culverts or storm drains placed in the accepted work.

1.1.2 Box Culverts

The length of box culvert installed will be measured along the centerline of the box from end to end of the box culvert. Box Culvert will be paid for at the contract unit price for the number of linear feet of box culverts placed in the accepted work.

1.1.3 Storm Drainage Structures

The quantity of manholes and inlets will be measured as the total number of manholes and inlets of the various types of construction, complete with frames and gratings or covers and, where indicated, with fixed side-rail ladders, constructed to the depth of [_____] feet in the accepted work. The depth of manholes and inlets will be measured from the top of grating or cover to invert of outlet pipe. Manholes and inlets constructed to depths greater than the depth specified above will be paid for as units at the contract unit price for manholes and inlets, plus an additional amount per linear foot for the measured depth beyond a depth of [_____] feet.

1.1.4 Walls and Headwalls

Walls and headwalls will be measured by the number of cubic yards of reinforced concrete, plain concrete, or masonry used in the construction of the walls and headwalls. Wall and headwalls will be paid for at the contract unit price for the number of walls and headwalls constructed in the completed work.

1.1.5 Flared End Sections

Flared end sections will be measured by the unit. Flared end sections will be paid for at the contract unit price for the various sizes in the accepted work.

1.1.6 Sheeting and Bracing

Payment will be made for that sheeting and bracing ordered to be left in place, based on the number of square feet of sheeting and bracing remaining below the surface of the ground.

1.1.7 Rock Excavation

Payment will be made for the number of cubic yards of material acceptably excavated, as specified and defined as rock excavation in Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL, measured in the original position, and computed by allowing actual width of rock excavation with the following limitations: maximum rock excavation width, 30 inches for pipe of 12 inch or less nominal diameter; maximum rock excavation width, 16 inches greater than outside diameter of pipe of more than 12 inch nominal diameter. Measurement will include authorized overdepth excavation. Payment will also include all necessary drilling and blasting, and all incidentals necessary for satisfactory excavation and disposal of authorized rock excavation. No separate payment will be made for backfill material required to replace rock excavation; include this cost in the unit price bid per cubic yard for rock excavation. In rock excavation for manholes and other appurtenances, 1 foot will be allowed outside the wall lines of the structures.

1.1.8 Backfill Replacing Unstable Material

Payment will be made for the number of cubic yards of select granular material required to replace unstable material for foundations under pipes or drainage structures, which will constitute full compensation for this backfill material, including removal and disposal of unstable material and all excavating, hauling, placing, compacting, and all incidentals necessary to complete the construction of the foundation satisfactorily.

1.1.9 Concrete Ditch Lining

Payment will be made for the number of linear feet of concrete ditch lining including any steel reinforcing accepted in the completed work measured along the centerline of the ditch.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges
AASHTO M 43	(2005; R 2018) Standard Specification for Sizes of Aggregate for Road and Bridge Construction
AASHTO M 167M/M 167	(2017; R 2021) Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches
AASHTO M 190	(2004; R 2019) Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M 219	(1992; R 2021) Standard Specification for Corrugated Aluminum Alloy Structural Plate for Field-Bolted Pipe, Pipe-Arches, and

Arches

AASHTO M 243	(1996; R 2021) Standard Specification for Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches
AASHTO M 288	(2021) Standard Specification for Geosynthetic Specification for Highway Applications
AASHTO M 294	(2021) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A716	(2018) Standard Specification for Ductile Iron Culvert Pipe
ASTM A760/A760M	(2015, R 2020) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM A798/A798M	(2022) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications
ASTM A807/A807M	(2019) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications
ASTM A929/A929M	(2018) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe
ASTM A1011/A1011M	(2018a) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B26/B26M	(2018; E 2018) Standard Specification for Aluminum-Alloy Sand Castings
ASTM B745/B745M	(2015; R 2021) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains

ASTM C12	(2022) Standard Practice for Installing Vitrified Clay Pipe Lines
ASTM C14	(2020) Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C14M	(2020) Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)
ASTM C32	(2013; R 2017) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C55	(2017) Standard Specification for Concrete Building Brick
ASTM C62	(2017) Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C76	(2020) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C76M	(2020) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C139	(2017) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C270	(2019a; E 2019) Standard Specification for Mortar for Unit Masonry
ASTM C425	(2021) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C478/C478M	(2020) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C506	(2020) Standard Specification for Reinforced Concrete Arch Culvert, Storm

	Drain, and Sewer Pipe
ASTM C506M	(2020) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C507	(2020) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C507M	(2020) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C655	(2019a) Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
ASTM C655M	(2019a) Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C700	(2018) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C828	(2011; R 2021) Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C923/C923M	(2020) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C990	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM C1103	(2019) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C1103M	(2019) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C1433	(2020) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM C1433M	(2018) Standard Specification for Precast

	Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers (Metric)
ASTM D1056	(2020) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1171	(2018) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking Outdoors (Triangular Specimens)
ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F679	(2016) Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F714	(2022) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
ASTM F794	(2021) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on

	Controlled Inside Diameter
ASTM F894	(2019) Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings
ASTM F1417	(2011a; E 2020) Standard Practice for Installation Acceptance of Plastic Non-pressure Sewer Lines Using Low-Pressure Air
ASTM F2418	(2019) Standard Specification for Polypropylene (PP) Corrugated Wall Stormwater Collection Chambers
ASTM F2562/F2562M	(2015; R 2019) Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage
ASTM F2620	(2020a; E 2021) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
ASTM F2764/F2764M	(2019) Standard Specification for 6 to 60 in. [150 to 1500 mm] Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications
ASTM F2881/F2881M	(2021; E 2021) Standard Specification for 12 to 60 in. (300 to 1500 mm) Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications
ASTM F2922	(2013; R 2018) Standard Specification for Polyethylene (PE) Corrugated Wall Stormwater Collection Chambers
ASTM F3219	(2019) Standard Specification for 3 to 30 in. (75 to 750 mm) Polypropylene (PP) Corrugated Single Wall Pipe and Fittings

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Leakage Test; G[, [_____]]

SD-07 Certificates

Hydrostatic Test on Watertight Joints; G[, [_____]]

Frame and Cover or Gratings; G[, [_____]]

SD-08 Manufacturer's Instructions

Placing Pipe and Box Culvert; G[, [_____]]

SD-11 Closeout Submittals

Post-Installation Inspection Report; G[, [_____]]

LID Verification Report; G[, [_____]]

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage and unload and store materials with minimumal handling. Do not store materials directly on the ground. Keep the inside of pipes and fittings free of dirt and debris. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe in accordance with the manufacturer's recommendations and discard if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

1.4.2 Handling

Handle materials in a manner that ensures delivery to the trench in sound, undamaged condition. Carry pipe to the trench.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe sizes for culverts and storm drains are indicated on the drawings.

2.1.1 Concrete Pipe

2.1.1.1 Reinforced Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C76M ASTM C76, Class [I] [II] [III] [IV] [V] [as indicated], or ASTM C655M ASTM C655, [_____] D-Load [as indicated].

2.1.1.2 Reinforced Arch Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C506M ASTM C506, Class [A-II] [A-III] [A-IV] [as indicated].

2.1.1.3 Reinforced Elliptical Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C507M ASTM C507, Class [HE-A] [HE-I] [HE-II] [HE-III] [HE-IV] [as indicated] for horizontal elliptical pipe and Class [VE-II] [VE-III] [VE-IV] [VE-V] [VE-VI] [as indicated] for vertical elliptical pipe.

2.1.1.4 Nonreinforced Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C14M ASTM C14, Class [1] [2] [3] [as indicated].

2.1.2 Clay Pipe

ASTM C700, [standard] [extra] strength, [bell-and-spigot piping only].

2.1.3 Corrugated Steel Pipe

Provide Type [I] [and] [II] [or] [IR] [and] [IIR] corrugated steel pipe conforming to ASTM A760/A760M with [zinc] [or] [aluminum (Type 2)] coating. [Provide Type [I] [II] pipe with helical 2-2/3 by 1/2 inch corrugations.] [Provide Type [IR] [IIR] pipe with helical 3/4 by 3/4 by 7-1/2 inch corrugations.]

[Provide pipe that is fully asphalt coated [and [part] [fully] asphalt paved] conforming to AASHTO M 190 Type [A] [C] [D].] [Provide pipe that is polymer precoated in accordance with ASTM A 762/A 762M with pipe fabricated from ASTM A 742/A 742M Grade 10/10 polymer precoated sheet.]

2.1.4 Corrugated Aluminum Pipe

Provide Type [I] [and] [II] [or] [IR] [and] [IIR] corrugated aluminum pipe conforming to ASTM B745/B745M. [Provide Type [I] [II] pipe with helical 2-2/3 by 1/2 inch corrugations.] [Provide Type [IR] [IIR] pipe with helical 3/4 by 3/4 by 7-1/2 inch corrugations.]

[Provide pipe that is fully asphalt coated [and [part] [fully] asphalt paved] conforming to AASHTO M 190 Type [A] [C] [D].]

2.1.5 Structural Plate, Steel Pipe, Pipe Arches and Arches

Assembled with galvanized steel nuts and bolts, from galvanized corrugated steel plates conforming to AASHTO M 167M/M 167. [Provide pipe coating conforming to the requirements of [AASHTO M 190 Type A] [AASHTO M 243].]

2.1.6 Structural Plate, Aluminum Pipe, Pipe Arches and Arches

Assembled with either aluminum alloy, aluminum coated steel, stainless steel or zinc coated steel nuts and bolts. Provide nuts and bolts, and aluminum alloy plates conforming to AASHTO M 219. [Provide pipe coating conforming to the requirements of [AASHTO M 190, Type A] [AASHTO M 243].]

2.1.7 Ductile Iron Culvert Pipe

Provide ductile iron culvert pipe conforming to ASTM A716.

2.1.8 Poly Vinyl Chloride (PVC) Pipe

2.1.8.1 Type PSM PVC Pipe

ASTM D3034, maximum SDR 35.

2.1.8.2 Profile PVC Pipe

ASTM F794, Series 46.

2.1.8.3 Smooth Wall PVC Pipe

ASTM F679.

2.1.8.4 Corrugated PVC Pipe

ASTM F949.

2.1.9 Polyethylene (PE) Pipe

2.1.9.1 Smooth Wall PE Pipe

ASTM F714, maximum DR of 21 for pipes 3 to 24 inches in diameter and maximum DR of 26 for pipes 26 to 48 inches in diameter. Polyethylene compound material designation PE3608.

2.1.9.2 Corrugated PE Pipe

AASHTO M 294, Type S. Provide pipe walls having the following properties:

Nominal Size (inch)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in. to the 4th/in.)
12	1.5	0.024
15	1.91	0.053

Nominal Size (inch)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in. to the 4th/in.)
18	2.34	0.062
24	3.14	0.116
30	3.92	0.163
36	4.50	0.222
42	4.69	0.543
48	5.15	0.543
54	5.67	0.800
60	6.45	0.800

2.1.9.3 Profile Wall PE Pipe

ASTM F894, RSC 160. Provide pipe walls having the following properties:

Nominal Size (inch)	Minimum Wall Area (square in/ft)	Minimum Moment (in to the 4th/in)	
		Cell Class 334433C	Cell Class 335434C
18	2.96	0.052	0.038
21	4.15	0.070	0.051
24	4.66	0.081	0.059
27	5.91	0.125	0.091
30	5.91	0.125	0.091
33	6.99	0.161	0.132
36	7.81	0.202	0.165
42	8.08	0.277	0.227
48	8.82	0.338	0.277

2.1.10 Steel Reinforced Polyethylene (SRPE) Pipe

Provide SRPE pipe conforming to the requirements of ASTM F2562/F2562M, Class [___] [as indicated].

2.1.11 Polypropylene(PP) Pipe

Provide double wall and triple wall pipe meeting the requirements of ASTM F2764/F2764M or ASTM F2881/F2881M, Class [I] [II].

2.2 PIPE JOINTS

[Provide joints that have been tested for and meet the requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.]

2.2.1 Concrete Pipe

2.2.1.1 Rubber Gasket Joints

Provide rubber gasket joints of a design and physical requirements conforming to ASTM C443. [Provide rubber gaskets that meet the oil resistant gasket requirements of ASTM C443M ASTM C443.]

2.2.1.2 Preformed Flexible Sealant Joints

Provide joints made with preformed flexible joint sealant conforming to ASTM C990.

2.2.2 Clay Pipe

Provide joints made with factory-fabricated resilient materials conforming to ASTM C425.

2.2.3 Corrugated Steel and Aluminum Pipe

Factory reform each end of pipe with helical corrugations to create annular corrugations of the same dimensions as those in the pipe. Provide reformed ends with a width equal to at least half the width of the band being used. Join pipe using annular corrugated [or] [partially corrugated] coupling bands. Except as otherwise specified or indicated, provide annular corrugated [or] [partially corrugated] coupling bands including connectors and hardware conforming to [ASTM A760/A760M] [ASTM B745/B745M]. Provide coupling bands with either rod and lug or angle-bolt type connectors.

2.2.3.1 Annular Corrugated Bands

Provide sleeve type gaskets made of approximately 3/8 inch thick by 7 inch minimum width closed cell, expanded synthetic rubber, fabricated in the form of a cylinder with a diameter approximately 10 percent less than the nominal pipe size with annular corrugated type bands. Provide sleeve type gaskets that meet the requirements of ASTM D1056, Type 2 [A1] [B3] [_____], and have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D1171

2.2.3.2 Partially Corrugated Bands

Provide partially corrugated type bands with two O-ring gaskets and a sealant strip where the band ends overlap. Provide rubber O-ring gaskets that are 13/16 inch in diameter for pipe diameters of 36 inches or smaller and 7/8 inch in diameter for larger pipe having 1/2 inch deep end corrugation.

2.2.4 Ductile Iron Pipe

Provide push-on type joints with rubber gaskets.

2.2.5 PVC Plastic Pipe

Provide solvent cement or elastomeric gasket type joints in accordance with the specification for the pipe and as recommended by the pipe manufacturer. Use solvent cement conforming to ASTM D2564. Provide gaskets for elastomeric joints conforming to ASTM F477.

2.2.6 Smooth Wall PE Plastic Pipe

Join pipe using butt fusion method conforming to ASTM F2620. No offset in alignment between adjacent pipe ends is permitted.

2.2.7 Corrugated PE Plastic Pipe

Provide [soil] [silt] [water] tight joints conforming to the requirements in AASHTO M 294. [Make water tight joints using a PE coupling and rubber gaskets as recommended by the pipe manufacturer. Provide rubber gaskets conforming to ASTM F477.]

2.2.8 Profile Wall PE Pipe

Provide gasketed or thermal weld type with integral bell joints in accordance with ASTM F894.

2.2.9 Steel Reinforced Polyethylene (SRPE) Pipe

Provide joints meeting the requirements of ASTM D3212.

2.2.10 Dual Wall and Triple Wall PP Pipe

Provide two gaskets conforming to ASTM F477 on the spigot. Gaskets must be installed by the pipe manufacturer and be covered with a removable, protective wrap to ensure the gaskets are free from debris. Use a joint lubricant available from the manufacturer on the gasket and bell during assembly. [ASTM F2881/F2881M for 12 to 60 inches pipe][ASTM F3219 for 12 to 30 inches pipe][ASTM F2764/F2764M for 30 to 60 inches pipe] diameters must have a reinforced bell with a polymer composite band installed by the manufacturer. Provide fittings conforming to [ASTM F2881/F2881M] [ASTM F3219] [ASTM F2764/F2764M]. Utilize a spun-on, welded or integral bell and spigot with gaskets meeting ASTM F477 for bell and spigot connections.

2.3 PRECAST REINFORCED CONCRETE BOX CULVERT

Manufacture precast reinforced concrete box culverts in accordance with and conforming to ASTM C1433M ASTM C1433.

2.4 THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS

Provide [perforated] [non-perforated] themoplastic corrugated wall stormwater collection chambers. Provide [polyethylene chambers conforming to ASTM F2922] [or] [polypropylene chambers conforming to ASTM F2418]. Provide chamber classification as indicated on the drawings.

2.5 UNDERGROUND STORMWATER RETENTION/DETENTION SYSTEM

Provide an underground stormwater retention/detention system that includes [thermoplastic corrugated wall stormwater collection chambers and corrugated PE pipe manifolds] [corrugated PE pipe] [corrugated steel pipe] as indicated. Provide foundation and embedment stone that is washed, crushed and angular conforming to AASHTO M 43 size 3, 357, 4, 467, 5, 56, or 57. Provide initial fill material conforming to AASHTO M 43 size 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9 or 10. Provide geotextile conforming to AASHTO M 288.

2.6 MISCELLANEOUS MATERIALS

2.6.1 Concrete

Unless otherwise specified, provide concrete and reinforced concrete conforming to the requirements for [_____] psi concrete under Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide air content by volume of concrete mixture, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Determine air content in accordance with ASTM C231/C231M. Provide a minimum concrete covering over steel reinforcing of not less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. For concrete deposited directly against the ground, provide a covering thickness of at least 3 inches between steel and ground. Provide expansion-joint filler material conforming to ASTM D1751, or ASTM D1752, or provide be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.6.2 Mortar

Mortar is not allowed for pipe joints. Provide mortar for pipe connections to drainage structures [and brick or block construction] conforming to ASTM C270, Type M, except that the maximum placement time will be 1 hour. Provide a sufficient quantity of water in the mixture to produce a stiff workable mortar but in no case may the quantity exceed [_____] [5] gallons of water per sack of cement. Use water that is clean and free of harmful acids, alkalis, and organic impurities. Use the mortar within 30 minutes after the ingredients are mixed with water.

2.6.3 Precast Concrete Segmental Blocks

Provide precast concrete segmental block conforming to ASTM C139, not more than 8 inches thick, not less than 8 inches long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.6.4 Brick

Provide brick conforming to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Provide mortar for jointing and plastering consisting of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. Provide joints that arecompletely filled and that are smooth and free from surplus mortar on the inside of the structure. Plaster brick structures with 1/2 inch of mortar over the entire outside surface of the walls. Lay brick in stretcher courses with a header course every sixth course for square or rectangular structures. Lay brick radially with every sixth course a stretcher course for round structures.

2.6.5 Precast Reinforced Concrete Manholes

Provide precast reinforced concrete manholes conforming to ASTM C478/C478M . Provide joints between precast concrete risers and tops that are [full-bedded in cement mortar and smoothed to a uniform surface on both interior and exterior of the structure] [or] [made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph PIPE JOINTS].

2.6.6 Frame and Cover or Gratings

[Submit certification on the ability of frame and cover or gratings to carry the imposed live load indicated on the drawings.] Provide frame and cover or gratings made of cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.0-T6. [Provide curb inlet grates conforming to the weight, shape, size, and waterway openings indicated on the plans.]Stamp or cast the word "Storm Sewer" into covers so that it is plainly visible.

2.6.7 Steel Ladder

Provide a steel ladder where the depth of the storm drainage structure exceeds 12 feet. Provide ladders not less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. Provide two stringers that are a minimum 3/8 inch thick and 2-1/2 inches wide. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

2.6.8 Resilient Connectors

Provide flexible, watertight connectors conforming to ASTM C923/C923M for connecting pipe to manholes and inlets.

2.6.9 Flared End Sections

2.6.9.1 Metal Flared End Sections

Provide sections of a standard design fabricated from zinc or aluminum (Type 2) coated steel sheets meeting requirements of ASTM A929/A929M.

2.6.9.2 Concrete Flared End Sections

Provide sections of a standard design fabricated with reinforced concrete.

2.6.10 Modular Trench Drains

Provide modular trench drains consisting of [plastic] [or] [precast concrete] sections. Provide trench with width and invert slope as indicated on the drawings. Provide trench drain sections and grates rated for DIN Class [____].

2.6.10.1 Plastic Sections

Provide polyethylene, polypropylene, polyester, PVC or HDPE sections with UV inhibitors and interlocking tongue and groove joints. Provide channels with [ductile iron] [cast iron] frames.

2.6.10.2 Precast Concrete Sections

Provide concrete sections made of fiber reinforced concrete or polyester polymer concrete with male/female connections between channel sections. Provide channels with [ductile iron] [or] [galvanized steel] [or] [stainless steel] edge rails.

2.6.10.3 Grates

Utilize [ductile iron] [cast iron] [galvanized steel] [stainless steel] trench grates. Attach trench grates to sections as recommended by the manufacturer.

2.6.11 Corrugated Steel Pipe Slotted Drain

Provide slotted drain consisting of galvanized steel grate welded in a continuous slot cut in the top of a corrugated steel pipe. Use Type I corrugated steel pipe conforming to ASTM A760/A760M with zinc coated [____] gage steel sheet and helical 2-2/3 by 1/2 inch corrugations. Provide grates with a 1-3/4 inch wide top opening and a [uniform height of [2-1/2 inches] [6 inches] [_____] inches] [variable height as indicated]. Fabricate grating using two [straight] [trapezoidal] sided 3/16 inch thick steel bearing bars with 3/16 inch thick steel solid web spacers spaced at 6 inch centers. Fabricate grating using steel conforming to ASTM A1011/A1011M, grade 36. Galvanize steel grating in accordance with ASTM A123/A123M. Fillet weld grate to the corrugated steel pipe on each side of the grate at every other corrugation. Join pipe sections with coupling bands.

2.6.12 Downspout Boots

Use boots conforming to ASTM A48/A48M, Class 30B or 35B of the size and shape indicated for connecting exterior downspouts to the storm-drainage system.

2.6.13 Flap Gates

Provide [medium] [or] [heavy]-duty flap gates with [circular] [rectangular] openings that are double-hinged. [Provide top pivot points that are adjustable.] Provide one-piece cast iron seats with a raised section around the perimeter of the waterway opening to provide the seating face. Provide [cast iron] [bronze] [stainless steel] [neoprene] seating face. Provide one-piece cast iron covers with necessary reinforcing rib, lifting eye for manual operation, and bosses to provide a pivot point connection with the links. Provide [cast iron] [bronze] [stainless steel] [neoprene] seating face on the cover. Provide cast or ductile iron links and hinge arms. Provide bronze bushings in the holes of pivot points. Provide fasteners that are either galvanized steel, bronze or stainless steel.

2.7 TESTS, INSPECTIONS, AND VERIFICATIONS

2.7.1 Hydrostatic Test on Watertight Joints

Perform a hydrostatic test on the watertight joint types as proposed. This test will be conducted at the plant or by an independent laboratory. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested.

2.7.1.1 Concrete, Clay, PVC, PE, SRPE and PP Pipe

Provide joints in reinforced and nonreinforced concrete pipe meeting the performance requirements in ASTM C990M ASTM C990 or ASTM C443M ASTM C443. Provide joints in clay pipe meeting the test requirements in ASTM C425. Provide joints in PVC, PE, SRPE, and PP plastic pipe meeting the test requirements in ASTM D3212.

2.7.1.2 Corrugated Steel and Aluminum Pipe

Perform a hydrostatic pressure test on the proposed joining system in accordance with ASTM A760/A760M. The joining system must not leak when subjected to an internal hydrostatic pressure of 10 psi for a 10 minute period

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, BOX CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavate trenches, excavate for appurtenances and backfill for culverts and storm drains, in accordance with the applicable portions of Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL and the requirements specified below.

3.1.1 Trenching

Excavate trenches to the width indicated on the drawings or as specified herein. Trench width should permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Place sheeting and bracing, where required, within the trench width as specified, without any overexcavation.

3.1.2 Removal of Rock

Replace rock in either ledge or boulder formation with suitable materials to provide a compacted earth cushion. Provide a compacted earth cushion between unremoved rock and the pipe with a thickness of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Maintain the cushion under the bell as well as under the straight portion of the pipe where bell-and-spigot pipe is used. Provide a compacted earth cushion between unremoved rock and the box culvert of at least 8 inches in thickness for concrete box culverts. Excavate rock as specified and defined in Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe or box culvert, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, remove such material to the depth required and replace with select granular material to the proper grade. Compact select granular material as specified in paragraph FINAL BACKFILL. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, perform such removal and replacement at no additional cost to the Government.

3.2 BEDDING AND INITIAL BACKFILL

Provide a firm bedding foundation of uniform density throughout the entire length of the pipe or box culvert.

3.2.1 Concrete Pipe

Use select granular material conforming to Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL for haunch and bedding material.

Compact haunch and outer bedding to at least [____] [90] percent laboratory maximum density and place in layers not exceeding 6 inch loose thickness for compaction by hand-operated compactors and 200 mm 8 inches for other than hand-operated machines. Loosely place middle bedding and do not compact. After the pipe has been properly bedded, place haunch material, at a moisture content that will facilitate compaction, evenly along both sides of the pipe and thoroughly compact each layer with mechanical tampers or rammers to the springline of the pipe. Thoroughly compact the haunch material under the haunches of the pipe. For bell and spigot pipe, form a depression in bedding material for bells so entire barrel of pipe is uniformly supported. Minimize the length, depth, and width of bell depressions to that required for properly making the particular type of joint.

3.2.1.1 Trenches

After the pipe has been properly bedded and haunch material placed to the midpoint (springline) of the pipe, backfill and compact the remainder of the trench by spreading and rolling or compacting by mechanical rammers or tampers in layers not exceeding 6 inches. Test for density as necessary to ensure conformance to the compaction requirements specified below. [Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly.] Leave untreated sheeting in place beneath structures or pavements.

3.2.1.2 Fill Sections

For pipe placed in fill sections, uniformly spread fill material longitudinally on both sides of the pipe in layers not exceeding 6 inches in compacted depth, and compact by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches above the top of the pipe must extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, place and thoroughly compact the remainder of the fill in layers not exceeding 8 inches.

3.2.2 Clay Pipe

Provide bedding for clay pipe as specified by ASTM C12.

3.2.3 Corrugated Steel and Aluminum Pipe

Provide bedding and structural backfill for corrugated steel and aluminum pipe and pipe arch in accordance with ASTM A798/A798M. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow v-shape. Structural backfill material consists of materials classified by ASTM D2487 as either GW, GM, GP-GM, GW-GM, GC, GP-GC or SW. Provide bedding for corrugated structural plate pipe meeting the requirements of ASTM A807/A807M.

3.2.4 Ductile Iron Pipe

Provide bedding for ductile iron pipe as shown on the drawings.

3.2.5 Plastic Pipe

Provide bedding for PVC, PE, SRPE and PP pipe meeting the requirements of ASTM D2321. Use Class IB or II material for PVC, PE, SRPE pipe bedding, haunching, and initial backfill. Use Class I, II, or III material for PP pipe bedding, haunching and initial backfill.

3.2.6 Precast Reinforced Box Culvert

Use granular material a minimum of 6 inches in depth for bedding precast concrete box culverts in trenches with soil foundation. Provide granular bedding in trenches with rock foundation that is 1/2 inch in depth per foot of depth of fill. The minimum depth of bedding will be 8 inch up to a maximum depth of 24 inches. Loosely place the granular bedding. Provide uniform support along the entire length of box culvert.

3.2.6.1 Trenches

After the box culvert has been properly bedded, place selected material from excavation or borrow, at a moisture content that will facilitate compaction, along both sides of box culvert in layers not exceeding 6 inches in compacted depth. Bring the backfill up evenly on both sides of box culvert for the full length box culvert. Thoroughly compact each layer with mechanical tampers or rammers. Continue this method of filling and compacting until the fill has reached an elevation equal to the top of the box culvert. Backfill and compact the remainder of the trench by spreading and rolling or by compacting with mechanical rammers or tampers in layers not exceeding [_____] inches. Test density as necessary to ensure conformance to the compaction requirements specified below. [Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly.] Leave untreated sheeting in place beneath structures or pavements.

3.2.6.2 Fill Sections

Use backfill material and placement and compaction procedures for box culvert placed in fill sections as specified below. Uniformly spread the fill material longitudinally on both sides of the box in layers not exceeding 6 inches in compacted depth. Compacted by rolling parallel with pipe or by using mechanical tamping or ramming. Prior to commencing normal filling operations, the width of the fill at a height of 12 inches above the top of the box must extend a distance of not less than twice the outside width of the box culvert on each side of the box or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the box, place and thoroughly compacte the remainder of the fill in layers not exceeding [_____] inches.

3.3 PLACING PIPE AND BOX CULVERT

Submit printed copies of the pipe or box culvert manufacturer's recommended pipe or box culvert installation procedures prior to installation. Thoroughly examine each section of pipe or box culvert before being laid; do not use defective or damaged pipe. Protect plastic pipe, excluding SRPE pipe, from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Lay pipelines to the grades and alignment indicated. Provide proper facilities for lowering sections of pipe into trenches. [Place lifting lugs in vertically elongated corrugated steel or aluminum pipe in the same vertical plane as the major axis of the pipe.] Do not lay pipe in water or when trench conditions or weather are unsuitable for such work. Divert drainage or dewater trenches during construction as necessary. Deflection of installed flexible pipe must not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Corrugated Steel and Aluminum	5
Ductile Iron Culvert	3
Plastic (PVC, HDPE, SRPE, and PP)	5

3.3.1 Concrete, Clay, PVC, Ribbed PVC, Ductile Iron Pipe

Lay pipe proceeding upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Elliptical and Elliptical Reinforced Concrete Pipe

Place pipe so that the manufacturer's reference lines, designating the top of the pipe, are within 5 degrees of a vertical plane through the longitudinal axis of the pipe. Prevent damage to or misalignment of the pipe during backfilling operations.

3.3.3 PE, SRPE, and Dual Wall and Triple Wall PP Pipe

Lay on a bed shaped to line and grade and joint sections together in accordance with manufacturer's guidelines.

3.3.4 Corrugated Steel and Aluminum Pipe and Pipe Arch

Lay pipe with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Install part paved pipe so that the centerline of bituminous pavement in the pipe, indicated by suitable markings on the top at each end of the pipe sections, coincides with the specified alignment of pipe. Provide fully paved steel pipe or pipe arch with the sheet thickness of the pipe or pipe arch painted or otherwise indicated on a label applied on the inside of the pipe or pipe arch. Coat any unprotected metal in the joints with bituminous material as specified in AASHTO M 190 or AASHTO M 243. Protect interior coating against damage from insertion or removal of struts or tie wires. Use lifting lugs to facilitate moving pipe without damage to exterior or interior coatings. Handle pipe or pipe arch and coupling bands during transportation and installation with care to preclude damage to the coating, paving or lining. Repair damaged coatings, pavings and linings in accordance with the manufacturer's recommendations prior to placing backfill. Remove and replace pipe on with coating, paving or lining that has been damaged to such an extent that satisfactory field repairs cannot be made. Accomplish vertical elongation, where indicated, in the factory. Provide suitable markings or properly placed lifting lugs to ensure placement of factory elongated pipe in a vertical plane.

3.3.5 Structural-Plate Steel

Install structural plate in accordance with ASTM A807/A807M. Assemble structural plate in accordance with instructions furnished by the manufacturer. Instructions must show the position of each plate and the order of assembly. Tighten bolts progressively and uniformly, starting at one end of the structure after all plates are in place. Repeat the operation to ensure that all bolts are tightened to meet the torque requirements of 200 foot-pounds plus or minus 50 foot-pounds. Check power wrenches used by the use of hand torque wrenches or long-handled socket or structural wrenches for amount of torque produced. Check and adjust power wrenches frequently as needed, according to type or condition, to ensure proper adjustment to supply the required torque.

3.3.6 Structural-Plate Aluminum

Assemble structural plate in accordance with instructions furnished by the manufacturer. Instructions must show the position of each plate and the order of assembly. Tighten bolts progressively and uniformly, starting at one end of the structure after all plates are in place. Repeat the operation to ensure that all bolts are torqued to a minimum of 100 foot-pounds on aluminum alloy bolts and a minimum of 150 foot-pounds on galvanized steel bolts. Check power wrenches used by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced. Check and adjust power wrenches as frequently as needed, according to type or condition, to ensure that they are in proper adjustment to supply the required torque.

3.3.7 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe must be at least half the nominal pipe diameter or 3 feet apart, whichever is less.

3.3.8 Jacking Reinforced Concrete Pipe

Install jacking pipe and operate jacking equipment in accordance with Section 33 05 23 TRENCHLESS UTILITY INSTALLATION.

3.3.9 Precast Reinforced Concrete Box Culvert

Proceed upgrade with laying of sections and point tongue ends of tongue-and-groove box culvert section in the direction of flow.

3.4 JOINTING

3.4.1 Concrete and Clay Pipe

3.4.1.1 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe and Box Culverts

Follow the recommendation of the particular manufacturer in regard to sealing compound special installation requirements. When lubricants, primers, or adhesives are used, only apply on surfaces that are dry and clean. Affix sealing compounds to the pipe or box culvert not more than 3 hours prior to installation of the pipe or box culvert. Protect sealing compounds from the sun, blowing dust, and other deleterious agents at all times. Inspect sealing compounds before installation of the pipe or box culvert, and remove and replace any loose or improperly affixed sealing compound. Align the pipe or box culvert with the previously installed pipe or box culvert, and pull the joint together.

3.4.1.2 Flexible Watertight Joints

Use lubricants, cements, adhesives, and other special installation requirements for gaskets and jointing materials as recommended by the manufacturer. When lubricants, cements, or adhesives are used, only apply on surfaces that are clean and dry. Affix gaskets and jointing materials to the pipe not more than 24 hours prior to the installation of the pipe, and protect from the sun, blowing dust, and other deleterious agents at all times. Inspect gaskets and jointing materials before installing the pipe; remove and replace any loose or improperly affixed gaskets and jointing materials. Align the pipe with the previously installed pipe, and push the joint home. If the gasket becomes visibly dislocated when joining sections of pipe, remove the pipe and remake the joint.

3.4.2 Corrugated Steel and Aluminum Pipe

3.4.2.1 Field Joints

Provide transverse field joints designed so that the successive connection of pipe sections will form a continuous line free of appreciable irregularities in the flow line. Provide joints meeting the general performance requirements described in ASTM A798/A798M. Suitable transverse field joints which satisfy the requirements for one or more of the joint performance categories can be obtained with the following types of connecting bands furnished with suitable band-end fastening devices: corrugated bands, bands with projections, flat bands, and bands of special design that engage factory reformed ends of corrugated pipe. Keep the space between the pipe and connecting bands free from dirt and grit so that corrugations fit snugly. While being tightened, tap the connecting band with a soft-head mallet of wood, rubber or plastic, to take up slack and ensure a tight joint. [Fill the annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 30 inches or larger, with a bituminous material after jointing.] Provide field joints for each type of corrugated metal pipe that maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations. [Provide bands of the type, size, and sheet thickness indicated. Provide angles or lugs and bolts of the size indicated.] [Provide bands and angles or lugs and bolts as specified in the applicable standards or specifications for the pipe.]

3.4.2.2 Flexible Watertight, Gasketed Joints

Use lubricants or cements and other special installation requirements as recommended by the gasket manufacturer. Where sleeve type gaskets are used, place the gasket over one end of a section of pipe for half the width of the gasket. Then double over the other half over the end of the same pipe. When the adjoining section of pipe is in place, roll the doubled-over half of the gasket over the adjoining section. Correct any unevenness in overlap so that the gasket covers the end of pipe sections equally. Center connecting bands over adjoining sections of pipe, and place rods or bolts in position and tighten nuts. Band Tightening: Tighten the band evenly, keep even tension on the rods or bolts, and the gasket; properly seat the gasket in the corrugations. Keep watertight joints uncovered for a period of time designated by the Contracting Officer. Before covering joints, measure the tightness of the nuts with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, retighten the nut with a torque wrench and keep uncovered until a tight, permanent joint is assured.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construct manholes of precast reinforced concrete. Construct inlets of [precast] [or] [cast in place] reinforced concrete. Provide manholes and inlets complete with frames and covers or gratings[; and with fixed galvanized steel ladders] as indicated. [The wall along the line where steel ladders are installed must be vertical for its entire length. Adequately anchor ladders to the wall by means of steel inserts spaced not more than 6 feet vertically, and install to provide at least 6 inches of space between the wall and the rungs.] [Make pipe connections to concrete manholes and inlets with flexible, watertight connectors.]

3.5.2 Walls and Headwalls

Construct [walls] [headwalls] as indicated.

3.6 INSTALLATION OF TRACER WIRE AND WARNING TAPE

[Install a continous length of tracer wire for the full length of each run of nonmetallic pipe in accordance with Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL. Attach wire to top of pipe in such a manner that it will not be displaced during construction operations.] [Install warning tape above all storm drain pipe in accordance with Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL.]

3.7 UNDERGROUND STORMWATER RETENTION/DETENTION SYSTEM

Install [pipe] [and] [collection chambers] as recommended by the manufacturer. Place foundation and embedment stone as recommended by the manufacturer of the [pipe] [collection chambers]. Begin compaction of initial fill after 12 inches of material have been placed over the [pipe] [chambers]. Compact initial fill in 6 inch thick layers to 90 percent maximum density. Use roller with a gross vehicle weight not exceeding 12,000 lbs and a dynamic force not exceeding 20,000 lbs.

3.8 FINAL BACKFILL

Backfill trenches with satisfactory material deposited in layers of a maximum of 8 inches loose thickness and compacted to 90 percent of maximum density for cohesive soils and 95 percent of maximum density for cohesionless soils in accordance with Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL. Testing is the responsibility of the Contractor and will be performed at no additional cost to the Government. Unless otherwise specified, determine field in-place density of final backfill at a frequency of one test per 50 linear feet, or fraction thereof, of each lift of backfill. Submit test results in accordance with Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL. Do not displace or damage pipe or box when compacting final backfill by rolling or operating heavy equipment parallel with the pipe or box. Movement of construction machinery over a culvert or storm drain at any stage of construction will be at the Contractor's risk. Repair or replace any damaged pipe. Protect concrete pipes with a minimum of 3 feet of cover prior to permitting heavy construction equipment to pass over them during construction. Provide the minimum cover for construction loads over corrugated steel pipes as specified in Section 26, Division II of AASHTO HB-17. Provide minimum cover for construction loads over plastic pipes as specified in ASTM D2321.

3.9 FIELD QUALITY CONTROL

3.9.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.

[3.9.1.1 Leakage Test

Test pipe lines for leakage prior to completing backfill by performing either an exfiltration test, low pressure air pipeline test or by individual pipe joint testing. Submit leakage test results to the Contracting Officer.

3.9.1.1.1 Exfiltration Test

Prior to exfiltration tests, backfill the trench up to at least the lower half of the pipe. If required, place sufficient additional backfill to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. When the water table is 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, measure infiltration using a suitable weir or other device acceptable to the Contracting Officer. Perform exfiltration test by filling the line to be tested with water so that a head of at least 2 feet is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. Allow the filled line to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, reestablish the head. Measure the amount of water required to maintain this water level during a 2-hour test period. Leakage as measured by the exfiltration test must not exceed [250 gallons per inch in diameter per mile of pipeline per day] [0.2 gallons per inch in diameter per 100 feet of pipeline per hour]. Correct visible leaks encountered regardless of leakage test results.

3.9.1.1.2 Low Pressure Air Pipeline Tests

Perform low pressure air testing for vitrified clay pipes in accordance with ASTM C828. Perform low pressure air testing for plastic pipe in accordance with ASTM F1417. Perform low pressure air testing procedures for other pipe materials using the pressures and testing times prescribed in ASTM C828, after consultation with the pipe manufacturer.

3.9.1.1.3 Individual Pipe Joint Testing

Testing of individual joints for leakage by low pressure air or water must conform to ASTM C1103M ASTM C1103.

][3.9.1.2 Deflection Testing

Conduct deflection test no sooner than 30 days after completion of final backfill and compaction testing. Clean or flush all lines prior to testing. Perform a deflection test on entire length of installed flexible pipeline upon completion of work adjacent to and over the pipeline, including backfilling, placement of fill, grading, paving, placement of concrete, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads must not exceed the limits in paragraph PLACING PIPE AND BOX CULVERT above as percent of the average inside diameter of pipe. Use a [laser profiler or] mandrel to determine if allowable deflection has been exceeded.

[3.9.1.2.1 Laser Profiler

Inspect pipe interior with laser profiling equipment. Utilize low barrel distortion video equipment in accordance with UFGS 33 01 30.16 TV INSPECTION OF SEWER LINES for pipe diameters 48 inches or less. [For initial post installation inspections for pipe diameters larger than 48 inches, perform a visual inspection of the pipe interior.]

][3.9.1.2.2 Mandrel

Pass the mandrel through each run of pipe by pulling it by hand. If deflection readings in excess of the allowable deflection of average inside diameter of pipe are obtained, stop and begin test from the opposite direction. The mandrel must meet the pipe manufacturer's recommendations and the following requirements. Provide a mandrel that is rigid, nonadjustable, has a minimum of 9 fins, pulling rings at each end, and is engraved with the nominal pipe size and mandrel outside diameter. The mandrel must be 5 percent less that the ceritified-actual pipe diameter for plastic pipe, 5 percent less than the certified-actual pipe diameter for corrugated steel and aluminum, 3 percent less than the certified-actual pipe diameter for ductile iron culvert pipe. The Government will verify the outside diameter (OD) of the Contractor provided mandrell through the use of Contractor provided proving rings.

]]3.9.1.3 Tracer Wire Continuity

Test tracer wire for continuity after initial and final backfilling of pipes. Verify that tracer wire is locatable with electronic utility location equipement. Repair breaks or separations and re-test for continuity.

3.9.2 Inspection

[3.9.2.1 Post-Installation Inspection

[Perform a CCTV inspection and video recording of pipes with diameters 48 inches or less in accordance with UFGS 33 01 30.16 TV INSPECTION OF SEWER LINES. Visually inspect pipes with diameters larger than 48 inches.] Inspect each segment of pipe for alignment, settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection. An engineer must evaluate all defects to determine if any remediation or repair is required.

[3.9.2.1.1 Concrete Pipe

An engineer must evaluate all pipes with cracks with a width greater than 0.25 mm 0.01 inches, but less than 0.10 inches to determine if any remediation or repair is required.

][3.9.2.1.2 Flexible Pipe

Check each flexible pipe (PE, PVC, PP, corrugated steel and aluminum) for rips, tears, joint separations, soil migration throught the joint, cracks, localized buckling, bulges, settlement and alignment.

][3.9.2.1.3 Post-Installation Inspection Report

The deflection results and final post installation inspection report must include: [a copy of all video taken,] pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

]]3.9.2.2 Low Impact Development Inspection

Inspect Low Impact Development (LID) features indicated on the design portion of the LID Verification Report. Certify LID features were constructed according to plans and specifications or by submitting as-built drawings in accordance with UFGS 01 78 00 Closeout Submittals. When as-built drawings show deviations to the LID features, document the deviations on the LID Verification Report.

3.9.3 Repair of Defects

3.9.3.1 Leakage Test

When leakage exceeds the maximum amount specified, correct source of excess leakage by replacing damaged pipe and gaskets and retest.

3.9.3.2 Deflection Testing

When deflection readings are in excess of the allowable deflection of average inside diamater of pipe are obtained, remove pipe which has excessive deflection and replace with new pipe. Retest 30 days after completing backfill, leakage testing and compaction testing.

3.9.3.3 Inspection

Replace pipe or repair defects indicated in the Post-Installation Inspection Report.

3.9.3.3.1 Concrete Pipe

Replace pipes having cracks with a width greater than 0.1 inches.

3.9.3.3.2 Flexible Pipe

Replace pipes having cracks or splits.

3.10 PROTECTION

Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.

3.11 WARRANTY PERIOD

Pipe segments found to have defects during the warranty period must be replaced with new pipe and retested.

-- End of Section --

SECTION 33 46 13

FOUNDATION DRAINAGE
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 252	(2009; R 2017) Standard Specification for Corrugated Polyethylene Drainage Pipe
AASHTO M 294	(2021) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter

ASTM INTERNATIONAL (ASTM)

ASTM A74	(2021) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A760/A760M	(2015, R 2020) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM B745/B745M	(2015; R 2021) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
ASTM C4	(2004; R 2014) Standard Specification for Clay Drain Tile and Perforated Clay Drain Tile
ASTM C14	(2020) Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C412	(2011) Concrete Drain Tile
ASTM C425	(2021) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C444	(2017) Standard Specification for Perforated Concrete Pipe
ASTM C508/C508M	(2000; R 2015) Asbestos-Cement Underdrain Pipe

ASTM C654	(2011) Porous Concrete Pipe
ASTM C700	(2018) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM D2751	(2005) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM F667/F667M	(2016; R 2021) Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings
ASTM F758	(2014) Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

1.2 SYSTEM DESCRIPTION

1.2.1 Extent

Furnish and install foundation drainage as a complete system [to 5 feet beyond the building] [as shown].

1.2.2 Outlet Connections

[Connect foundation pipe to the storm drainage system as shown and specified in Section 33 40 00 STORMWATER UTILITIES.] [Terminate foundation pipe as shown.]

1.2.3 Drainage Lines

Construct drainage lines of drain tile, perforated pipe, or porous pipe.

1.2.4 Outlet Lines

Construct outlet lines of closed-joint nonperforated, nonporous pipe.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will

review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Materials.

SD-07 Certificates

Materials.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect materials placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Do not expose plastic pipe to direct sunlight for more than 6 months from time of manufacturer to installation.

PART 2 PRODUCTS

2.1 MATERIALS

Provide pipe for foundation drainage system of the type and size indicated. Use appropriate transitions, adapters, or joint details where pipes of different types or materials are connected. Submit two randomly selected samples of each type of pipe and fitting, prior to delivery of materials to the site, and certifications from the manufacturers attesting that materials meet specification requirements.

2.1.1 Clay Pipe

ASTM C700, standard or extra strength.

2.1.2 Perforated Clay Pipe

ASTM C700, standard or extra strength.

2.1.3 Concrete Pipe

Conform to ASTM C14, Class [1][2][3].

2.1.4 Perforated Concrete Pipe

Conform to ASTM C14, Class [1][2][3] with perforations conforming to ASTM C444, Type [I][II].

2.1.5 Porous Concrete Pipe

Conform to ASTM C654, standard or extra strength class.

2.1.6 Clay Drain Tile

ASTM C4, [standard][extra-quality][heavy-duty] class.

2.1.7 Perforated Clay Drain Tile

ASTM C4, [standard][extra-quality][heavy-duty] class.

2.1.8 Concrete Drain Tile

Conform to ASTM C412,
[standard-][special-][extra-][heavy-duty-extra-]quality.

2.1.9 Cast-Iron Soil Pipe

ASTM A74, [extra-heavy][service].

2.1.10 Perforated Corrugated Steel Pipe

ASTM A760/A760M, Type III.

2.1.11 Perforated Corrugated Aluminum Alloy Pipe

ASTM B745/B745M Type III, Class [I] [II].

2.1.12 Perforated Asbestos-Cement Underdrain Pipe

ASTM C508/C508M.

2.1.13 Plastic Pipe

Provide plastic pipe containing ultraviolet inhibitor to provide protection from exposure to direct sunlight.

2.1.13.1 Corrugated Polyethylene (PE) Drainage Pipe

Furnish ASTM F667/F667M heavy duty for pipe 3 to 6 inches in diameter inclusive, ASTM F667/F667M for pipe 8 to 24 inches in diameter; or AASHTO M 252 for pipe 3 to 10 inches in diameter or AASHTO M 294 for pipe 12 to 24 inches in diameter. Furnish pipe manufacturer's standard fittings and conforming to the indicated specification.

2.1.13.2 Acrylonitrile-Butadiene-Styrene (ABS) Pipe

ASTM D2751, with a maximum SDR of 35.

2.1.13.3 Polyvinyl Chloride (PVC) Pipe

ASTM F758, Type PS 46, ASTM D3034, or ASTM F949 with a minimum pipe stiffness of46 psi.

2.1.13.4 Circular Perforations in Plastic Pipe

Cleanly cut circular holes no more than 5/16 inch or less than 3/16 inch in diameter, and arrange in rows parallel to the longitudinal axis of the pipe. Place perforations approximately 3 inches apart, center-to-center, along rows. Place rows approximately 1-1/2 inches apart and arrange in a staggered pattern so that all perforations lie at the midpoint between perforations in adjacent rows. Space rows no more than 155 degrees of circumference. Do not perforate the spigot or tongue end of the pipe for a length equal to the depth of the socket and continue perforations at uniform spacing over the entire length of the pipe. Manufacturer's standard perforated pipe which essentially meets these requirements may be used with prior approval of the Contracting Officer.

2.1.13.5 Slotted Perforations in Plastic Pipe

Cleanly cut circumferential slots so as not to restrict the inflow of water and uniformly spaced along the length and circumference of the tubing. Width of slots exceeding 1/8 inch or less than 1/32 inch is not permitted. Length of individual slots exceeding 1-1/4 inches on 3 inch diameter tubing is not permitted; 10 percent of the tubing inside nominal circumference on 4 to 8 inch diameter tubing; and 2-1/2 inches on 10 inch diameter tubing. Symmetrically space rows of slots so that they are fully contained in quadrants of the pipe. Center slots in the valleys of the corrugations of profile wall pipe. Provide water inlet area consisting of a minimum of 0.5 square inch/linear foot of tubing. Manufacturer's standard perforated pipe which essentially meets these requirements may be used with prior approval of the Contracting Officer.

2.1.14 Fittings

Provide fittings consisting of compatible materials for pipe, of corresponding weight and quality, and as specified herein.

2.1.15 Cleanouts and Piping Through Walls

Provide cleanout pipe and fittings and piping through walls and footings consisting of cast-iron soil pipe. Each cleanout must have a brass ferrule and a cast-brass screw-jointed plug with socket or raised head for wrench.

2.1.16 Cover and Wrapping Materials for Open Joints in Drain Tile

Cover material may be tar paper, roofing paper, reinforced building paper, glass fiber fabric, or other similar type material. Wrapping material must be 18-14 mesh, 0.01 inch diameter nonferrous wire cloth.

2.1.17 Bedding and Pervious Backfill for Foundation Drains

Provide bedding and pervious backfill [in accordance with Section 31 00 00 EARTHWORK] [coarse aggregate conforming to ASTM C33/C33M, size number [8] [4] inch] [_____].

2.1.18 Protective Covering for Pervious Backfill

Provide protective covering that is [building paper] [fiberglass mat of lime borosilicate glass fibers. Provide fibers that are 8 to 12 microns in average diameter, 2 to 4 inches in length, and bond with phenol formaldehyde resin. Provide roll type, nonperforated, water permeable mat with thickness between 1/4 and 1/2 inch and density of 3/4 pcf] [filter fabric conforming to Section 33 46 16 SUBDRAINAGE SYSTEM].

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Trenching and Excavation

Perform required trenching and excavation in accordance with Section 31 00 00 EARTHWORK. Keep trenches dry during installation of drainage system. Make changes in direction of drain lines with 1/8 bends. Use wye fittings at intersections.

3.1.2 Bedding

Place graded bedding, minimum 6 inches in depth, in the bottom of trench for its full width and length compacted as specified prior to laying of foundation drain pipe. Rest each section firmly upon the bedding, through the entire length, with recesses formed for bell joints. Except for recesses for bell joints, fully support the lower quadrant of the pipe.

3.1.3 Pipe Laying

Lay drain lines to true grades and alignment with a continuous fall in the direction of flow. Face bells of pipe sections upgrade. Clean interior of pipe thoroughly before being laid. When drain lines are left open for connection to discharge lines, temporarily close the open ends and mark the location with wooden stakes. Lay perforated pipe with perforations facing down. Remove and relay any length that has had its grade or joints disturbed at no additional cost to the Government. Install perforated corrugated polyethylene drainage tubing and plastic piping in accordance with manufacturer's specifications and as specified herein. Do not install tubing and piping with physical imperfections.

3.1.4 Jointing

3.1.4.1 Perforated and Porous Pipes

Lay perforated and porous types of drain pipes with closed joints.

3.1.4.2 Nonperforated Drain Tile

Lay nonperforated and plain-end drain tile with 1/8 to 1/4 inch open joints. Cover or wrap open joints. Place one thickness of the cover material over the joint of covered joints. Overlap the joint no less than 4 inches on each side and cover the tile for no less than the upper half or more than the upper two-thirds of the circumference of the tile. Use strips of wire cloth wrapping material3 inches wide for wrapped joints, with ends fastened together.

3.1.4.3 Perforated Corrugated Metal Pipe

Join perforated corrugated metal pipe sections with standard connecting bands and bolts furnished by the pipe manufacturer.

3.1.4.4 Joints of Concrete or Clay Sewer Pipe

Caulk joints of concrete or clay sewer pipe with oakum and fill solid with cement mortar except where compression joints conforming to ASTM C425 are used on vitrified clay pipe.

3.1.4.5 Joints of Cast-Iron Pipe

Caulk joints of cast-iron pipe or connections between cast-iron and porous concrete pipes with oakum gasket and fill with lead.

3.1.4.6 Perforated Asbestos-Cement Pipe Joints

Make perforated asbestos-cement pipe joints with tapered couplings or with sleeve-type couplings suitable for holding the pipe firmly in alignment without use of sealing compound or gaskets.

3.1.4.7 Plain-End Perforated Clay

Make plain-end perforated clay drain tile joints with spring-wire clips, coated with a rust preventive, that will maintain a taut but elastic joint between sections when laid.

3.1.4.8 ABS Pipe

Join ABS pipe using solvent cement or elastomeric joints and in accordance with ASTM D2751, with dimensions and tolerances in accordance with TABLE II therein.

3.1.4.9 PVC Pipe

Furnish PVC pipe joints in accordance with ASTM D3034, ASTM D3212, or ASTM F949.

3.1.4.10 Corrugated Polyethylene

Furnish corrugated polyethylene (PE) pipe joints in accordance with ASTM F667/F667M or ASTM F667/F667M.

3.1.5 Outlet Lines

The outlet end of drain lines connecting with an open gutter or outfall must be [covered with a removable wire basket of 16-mesh copper or bronze wire cloth fastened with brass or wire straps] [finished as shown].

3.1.6 Cleanouts

Provide cleanouts in locations indicated. Set cleanouts in unpaved areas in 12 by 12 by 4 inch concrete blocks.

3.2 Backfilling

After joints and connections have been inspected and approved, place the specified pervious backfill material [a minimum width of 6 inches on each side of the pipe or tile] [for the full width of the trench and full width between pipe and adjacent walls] and 12 inches above the top of the pipe. Place the backfill preventing displacement of or injury to the pipe or tile. Place a protective covering, as specified, over the pervious backfill for the full width of the trench before regular backfill is placed. Compact backfill as specified in Section 31 00 00 EARTHWORK.

-- End of Section --

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SECTION 33 46 16

SUBDRAINAGE PIPING
05/18

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Pipe Subdrains

Measure the length of pipe installed from end to end along the centerlines without any deduction for the diameter of the manholes. Pipe will be paid for according to the number of linear feet of subdrains placed in the accepted work. Payment for bedding and [drainage layer] [filter] materials, except geotextiles, will be included in the payment for the pipe subdrain system.

1.1.2 Blind or French Drains

Blind or french drains will be paid for by the linear foot and measured from end to end along the centerlines of the completed drains.

1.1.3 Manholes

Manholes to be paid for will be the number of manholes completed with base, rungs or ladders, frames, and covers or gratings (where specified) constructed in the accepted work.

1.1.4 Flushing and Observation Risers

Flushing and observation risers to be paid for will be the number of flushing and observation risers completed with frames and covers (where specified) constructed in the accepted work.

1.1.5 Geotextile

Measure geotextile for payment by the square [yard][foot] in place. Measure overlapped joints and seams as a single layer of cloth.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 190	(2004; R 2019) Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M 252	(2009; R 2017) Standard Specification for Corrugated Polyethylene Drainage Pipe
AASHTO M 288	(2021) Standard Specification for Geosynthetic Specification for Highway

Applications

ASTM INTERNATIONAL (ASTM)

ASTM A27/A27M	(2020) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A760/A760M	(2015, R 2020) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM A762/A762M	(2019) Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM A798/A798M	(2022) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications
ASTM B745/B745M	(2015; R 2021) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3753	(2019) Glass-Fiber-Reinforced Polyester Manholes and Wetwells

ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM F758	(2014) Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Geotextile

Pipe and Pipe Fittings

SD-06 Test Reports

Geotextile JP-8 Fuel Resistance Test

SD-07 Certificates

Geotextile

Pipe and Pipe Fittings

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage; unload, and store with minimum handling. Do not store materials directly on the ground. Keep the inside of pipes and fittings sfree of dirt and debris. Keep, during shipment and storage, geotextile wrapped in burlap or similar heavy duty protective covering. Protect the geotextile from mud, soil, dust, and debris. Do not store geotextile materials in direct sunlight. Install plastic pipe within 6 months from the date of manufacture unless otherwise approved.

1.4.2 Handling

Handle materials in such a manner as to ensure delivery to the trench in sound undamaged condition. Carry pipe to the trench.

PART 2 PRODUCTS

2.1 PIPE FOR SUBDRAINS

Submit samples of pipe and pipe fittings, before starting the work. Provide type and sizes of subdrain pipe indicated. Submit certifications from the manufacturers attesting that materials meet specification requirements. Certificates are required for drain pipe and fittings.

2.1.1 Plastic

Provide plastic pipe containing ultraviolet inhibitor to provide protection from exposure to direct sunlight. Provide pipe with with bell and spigot or solvent cement joints. Provide manufacturer's standard type fittings conforming to the indicated specification.

2.1.1.1 Polyvinyl Chloride (PVC) and Fittings

ASTM D3034, ASTM F949 or ASTM F758, Type PS 46.

2.1.1.2 Corrugated Polyethylene (PE) and Fittings

AASHTO M 252, Type S or SP as indicated.

2.1.1.3 Pipe Perforations

Provide pipe perforations with a minimum water inlet area of 0.5 square inch per linear foot and as specified below.

2.1.1.3.1 Circular Perforations in Plastic Pipe

Cleanly cut circular holes not more than 3/8 inch or less than 3/16 inch in diameter and arrange in rows parallel to the longitudinal axis of the pipe. Provide pipe with perforations spaced uniformly along rows. Unless otherwise recommended by the pipe manufacturer, provide pipe with rows approximately 1-1/2 inches apart and arranged in a staggered pattern so that all perforations lie at the midpoint between perforations in adjacent rows. Space the rows over not more than 155 degrees of circumference. Provide pipe that is not perforated for a length equal to the depth of the socket at the spigot or tongue end and provide perforations that continue at uniform spacing over the entire length of the pipe.

2.1.1.3.2 Slotted Perforations in Plastic Pipe

Cleanly cut circumferential slots so as not to restrict the inflow of water and uniformly spaced along the length and circumference of the pipe. Provide pipe with slots not exceeding 1/8 inch nor less than 1/32 inch in width. Provide pipe with individual slot lengths not exceeding 10 percent of the pipe inside nominal circumference on 6 to 8 inch diameter pipe, and 2-1/2 inches on 10 inch diameter pipe. Symmetrically space rows of slots so that they are fully contained in 2 quadrants of the pipe. Center slots in the valleys of the corrugations of profile wall pipe.

2.1.2 Corrugated Steel

ASTM A760/A760M, Type I or III, as indicated [with a coating conforming to AASHTO M 190, Type A]. Provide Class 1 perforations in Type III pipe. Pipe sheet thickness 0.064 inch.

2.1.3 Corrugated Aluminum Alloy

ASTM B745/B745M, Type I or III, as indicated [with a bituminous coating conforming to AASHTO M 190, Type A]. Provide Class 1 perforations in Type III pipe. Pipe sheet thickness 0.064 inch.

2.1.4 Precoated Corrugated Steel

ASTM A762/A762M, Type I or III, as indicated. Provide Class 1 perforations in Type III pipe.

2.2 GEOTEXTILE

[Provide geotextile conforming to AASHTO M 288 and meeting the subsurface drainage requirements.] [Provide geotextile meeting the requirements in Section 31 05 19.13 GEOTEXTILES FOR EARTHWORK.][Provide geotextile that is a [woven] [nonwoven] pervious sheet of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polypropylene (PP) or polyester (PET). The use of woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Add stabilizers and/or inhibitors to the base polymer, as needed, to make the filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure. The equivalent opening size (AOS) will be no finer than US Standard Sieve No. [_____] and no coarser than US Standard Sieve No. [_____]. AOS is defined as the number of the US Standard sieve having openings closest in size to the filter fabric openings. [The percent open area will not be less than [_____] percent and not more than [_____] percent. Percent open area is defined as the summation of open areas divided by the total area of the filter fabric and expressed as a percent.] The minimum grab strength will be 160 pounds in accordance with ASTM D4632/D4632M. Provide geotextile with filaments constructed so as to retain their relative position with respect to each other. [Selvage or otherwise finish the edges of the geotextile to prevent the outer material from pulling away from the fabric.] [Provide geotextile that is woven into a width that may be installed as shown without longitudinal seams.]]

Submit samples of geotextile and certifications from the manufacturers attesting that geotextile meets specification requirements.

2.3 [DRAINAGE LAYER] [SUBDRAIN FILTER AND BEDDING] MATERIAL

[Provide drainage layer material meeting the requirements in Section 32 11 23.23 BASE COURSE DRAINAGE LAYERS][Provide subdrain filter and bedding material composed of washed sand, sand and gravel, crushed stone, crushed stone screenings, or slag composed of hard, tough, durable particles free from adherent coatings. Filter material may not contain corrosive agents, organic matter, or soft, friable, thin, or elongated particles. Provide filter material that is evenly graded between the limits specified in TABLE I. Gradation curves will exhibit no abrupt changes in slope denoting skip or gap grading. Provide filter materials that are clean and free from soil and foreign materials. Remove and replace filter blankets found to be dirty or otherwise contaminated with material meeting the specific requirements, at no additional cost to the Government.

TABLE I			
	Type I Gradation E 11 ASTM C33/C33M	Type II Gradation 57 ASTM C33/C33M	Type III Gradation [_____] [_____]
ASTM C136/C136M Sieve Size	Percent Passing	Percent Passing	Percent Passing
1-1/2 inch	--	100	[_____]
1 inch	--	90 - 100	[_____]
3/8 inch	100	25 - 60	[_____]
No. 4	95 - 100	5 - 40	[_____]
No. 8	--	0 - 20	[_____]
No. 16	45 - 80	--	[_____]
No. 50	10 - 30	--	[_____]
No. 100	0 - 10	--	[_____]

]

2.4 DRAINAGE STRUCTURES

2.4.1 Concrete

Provide concrete and reinforced concrete conforming to the requirements for [3,000] [_____] psi concrete in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.4.2 Mortar

Provide mortar for connections to drainage structures that is composed of one part by volume of portland cement and two parts of sand. Provide sufficient quantity of water in the mixture to produce a stiff workable mortar. Use water that is clean and free of injurious acids, alkalies, and organic impurities. Use the mortar within 30 minutes from the time the ingredients are mixed with water.

2.4.3 Manholes and Appurtenances

2.4.3.1 Precast Reinforced Concrete Manhole Risers and Tops

ASTM C478.

2.4.3.2 Precast Concrete Manhole Bases

ASTM C478. Provide bases that allow suitable connection with influent and effluent lines and to provide a suitable base structure for riser sections.

2.4.3.3 Glass Fiber-Reinforced Polyester (FRP)

ASTM D3753.

2.4.3.4 Frames and Covers or Gratings

Except as otherwise permitted, provide frames and gratings, or frames and covers of either cast iron with tensile strength test not less than ASTM A48/A48M Class 25 or steel conforming to ASTM A27/A27M, Class 65-35. Required weight, shape, and size are indicated on the drawings. Frames and covers not subjected to vehicular traffic or storage may be of malleable iron where indicated. Provide malleable-iron frames and covers conforming to ASTM A47/A47M and of the weight, shape, and size indicated.

2.4.3.5 Steel Ladder

Provide a steel ladder where the depth of a manhole exceeds 12 feet. The ladder will be not less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. Provide two stringers that are a minimum 3/8 inch thick and 2 inches wide. Adequately anchor ladder to the wall by means of steel inserts spaced not more than 6 feet apart vertically, and install so as to provide at least 6 inches of space between the wall and the rungs. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

2.5 TESTS, INSPECTIONS, AND VERIFICATIONS

2.5.1 Geotextile JP-8 Fuel Resistance Test

Immerse five unaged geotextile samples, 4 (plus or minus 0.2) by 6 (plus or minus 0.2) inches in JP-8 fuel at room temperature for a period of 7 days. Test each sample for tensile strength and elongation in accordance with ASTM D4632/D4632M. Provide geotextile with a strength in any direction of not less than 85 percent of the strength specified in paragraph GEOTEXTILE.

PART 3 EXECUTION

3.1 EXCAVATION AND BEDDING FOR SUBDRAIN SYSTEMS

Excavate trenches, including the removal of rock and unstable material, in accordance with Section [31 00 00 EARTHWORK] [31 23 00.00 20 EXCAVATION AND FILL]. Place bedding material in the trench as indicated or as required as replacement materials used in those areas where unstable materials were removed. Compact bedding material as specified for cohesionless material in Section 31 00 00 EARTHWORK.

3.2 MANHOLES AND FLUSHING AND OBSERVATION RISERS

3.2.1 Manholes

Install manholes complete with frames and covers or gratings at the locations and within the limits and sizes indicated. Construct manholes of one of the materials specified for manholes in paragraph DRAINAGE STRUCTURES. [Completely fill precast concrete manhole joints so that they are smooth and free of surplus mortar or mastic on the inside of the structure.] Use either precast or cast-in-place concrete manhole bases.

3.2.2 Flushing and Observation Risers

Install flushing and observation riser pipes with frames and covers at the locations indicated. Construct risers of non-perforated [plastic] [or] [galvanized] [bituminous coated] [corrugated metal] pipe. Join riser pipes to the subdrain system as indicated.

3.3 INSTALLATION OF GEOTEXTILE AND PIPE FOR SUBDRAINS

3.3.1 Installation of Geotextile

3.3.1.1 Trench Lining and Overlaps

Grade trenches to be lined with geotextile to obtain smooth side and bottom surfaces so that the geotextile will not bridge cavities in the soil or be damaged by projecting rock. Lay the geotextile flat but not stretched on the soil, and secure it with anchor pins in accordance with manufacturer's instructions. Overlap at least 6 to 12 inches, and secure with anchor pins along the overlaps.

3.3.2 Installation of Pipe for Subdrains

3.3.2.1 Pipelaying

Install pipe in accordance with the manufacturer's recommendations. Thoroughly examine each section of pipe before being laid; do not use defective or damaged pipe. Do not lay pipe when the trench conditions or weather is unsuitable for such work. Remove water from trenches by sump pumping or other approved methods. Lay the pipe to the grades and alignment as indicated. Bed the pipe to the established gradeline. Center perforations on the bottom of the pipe. Lay bell-and-spigot type with the bell ends upstream. Approval of all in-place pipes by the Contracting Officer is required prior to backfilling.

3.3.2.2 Jointings

3.3.2.2.1 Perforated Corrugated Metal Pipe or Bituminous Coated, Perforated Corrugated Metal Pipe

Securely fasten together the sections of perforated corrugated metal pipe or bituminous coated, perforated corrugated metal pipe standard connecting bands furnished by the manufacturer of the pipe.

3.3.2.2.2 Bituminous Coated or Uncoated Corrugated Aluminum Pipe

If aluminum pipe is to be connected to dissimilar metal, insulate the connection by bituminous coating or other nonconductive material. Securely fasten standard joints between corrugated aluminum pipe with standard connecting bands furnished by the manufacturer of the pipe.

3.4 INSTALLATION OF [DRAINAGE LAYER][FILTER] MATERIAL AND BACKFILLING FOR PERFORATED SUBDRAINS

After perforated pipe for subdrains has been laid, inspected, and approved, place [drainage layer] [filter] material around and over the pipe to the depth indicated. Place the [drainage layer] [filter] material in layers not to exceed 8 inches thick. [Saturate by flooding.] [Thoroughly compact each layer using mechanical tampers or rammers.]

3.5 INSTALLATION OF BEDDING AND BACKFILL FOR NON-PERFORATED SUBRAIN OUTFALL PIPE

3.5.1 Plastic Pipe

Place and compact pipe embedment for plastic pipe in accordance with

ASTM D2321. Use Class IB or II embedment materials.

3.5.2 Corrugated Metal Pipe

Place and compact bedding ans structural backfill for corrugated metal pipe in accordance with ASTM A798/A798M. Use structural backfill materials classified by ASTM D2487 as either GW, GM, GP-GM, GW-GM, GC, GP-GC or SW.

3.6 INSTALLATION OF AND BACKFILLING FOR BLIND OR FRENCH DRAINS

Place filter material as indicated and compact as specified for cohesionless materials in Section [31 00 00 EARTHWORK] [31 23 00.00 20 EXCAVATION AND FILL]. Extend filter material to a suitable outlet or to an outlet through a pipeline as indicated. Place and compact overlying backfill material as specified in Section [31 00 00 EARTHWORK] [31 23 00.00 20 EXCAVATION AND FILL].

-- End of Section --

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SECTION 33 47 13

POND AND RESERVOIR LINERS
11/14, CHG 2: 11/15

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D413	(1998; R 2017) Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D751	(2006; R 2011) Coated Fabrics
ASTM D4437/D4437M	(2016; R 2018) Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes
ASTM D6214/D6214M	(2013) Determining the Integrity of Field Seams Used in Joining Geomembranes by Chemical Fusion Methods
ASTM D6392	(2012; R 2018) Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
ASTM D7002	(2016) Standard Practice for Leak Location on Exposed Geomembranes Using the Water Puddle System
ASTM D7006	(2013) Standard Practice for Ultrasonic Testing of Geomembranes
ASTM D7007	(2016) Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials
ASTM D7176	(2006; R 2011) Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes Used in Buried Applications
ASTM D7272	(2006; R 2018) Standard Test Method for Determining the Integrity of Seams Used in

	Joining Geomembranes by Pre-manufactured Taped Methods
ASTM D7408	(2012; R 2020) Non Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams
ASTM D7700	(2015) Standard Guide for Selecting Test Methods for Geomembrane Seams

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GM13	(2016) Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
GSI GRI GM17	(2015) Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
GSI GRI GM18	(2015) Test Methods, Test Properties and Testing Frequencies for Flexible Polypropylene (fPP and fPP-R) Nonreinforced and Reinforced Geomembranes
GSI GRI GM19	(2002; R 2013) Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
GSI GRI GM21	(2016) Test Methods, Properties and Frequencies for Ethylene Propylene Diene Terpolymer (EPDM) Nonreinforced and Scrim Reinforced Geomembranes
GSI GRI GM25	(2009; R 2012) Test Methods, Test Properties and Testing Frequency for Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Liner System; G[, [_____]]

SD-03 Product Data

Liner; G[, [_____]]

Seaming Adhesive

Penetration Assemblies; G[, [_____]]

Filter Fabric; G[, [_____]]

Sealants

SD-07 Certificates

Liner; G[, [_____]]

Filter Fabric

SD-08 Manufacturer's Instructions

Liner; G[, [_____]]

Seaming Adhesive

Sealants

SD-11 Closeout Submittals

Manufacturer's Warranty; G[, [_____]]

Installation Warranty; G[, [_____]]

1.3 DELIVERY AND STORAGE

Deliver liner [and filter fabric] to site in largest sizes possible to minimize field seaming. Protect from sunlight and other ultraviolet light sources during storage. Keep cements and adhesives from extreme cold or heat. Keep materials clean and dry.

1.4 QUALITY ASSURANCE

1.4.1 Required Drawing

Submit drawing of liner system indicating sheet and seam layout, anchorage details, and penetration details.

1.5 WARRANTY

1.5.1 Manufacturer's Warranty

Provide the Manufacturer's Warranty to the Contracting Officer. Ensure Warranty is valid for a minimum of [2] [5] [_____] years from the date of project closeout, showing the Government as warranty recipient.

1.5.2 Installation Warranty

Provide the Installation Warranty to the Contracting Officer, along with final test reports. Ensure Warranty is valid for a minimum of [2] [5] [_____] years from the date of project closeout, showing the Government as warranty recipient.

PART 2 PRODUCTS

2.1 LINER

2.1.1 High Density Polyethylene (HDPE)

[Smooth] [Textured] HDPE manufactured in accordance with and conforming to GSI GRI GM13, [_____] mils thick.

2.1.2 Linear Low Density Polyethylene (LLDPE)

[Smooth] [Textured] LLDPE manufactured in accordance with and conforming to GSI GRI GM17, [_____] mils thick.

2.1.3 Flexible Polypropylene (fPP and fPP-R)

[Unreinforced] [Reinforced] fPP manufactured in accordance with and conforming to GSI GRI GM18, [_____] mils thick.

2.1.4 Ethylene Propylene Diene Terpolymer(EPDM)

[Unreinforced] [Reinforced] EPDM manufactured in accordance with and conforming to GSI GRI GM21,[45 mils][60 mils] thick.

2.1.5 Reinforced Linear Low Density Polyethylene (LLDPE-R)

Reinforced LLDPE-R manufactured in accordance with and conforming to GSI GRI GM25, [_____] mils thick.

2.1.6 Polyvinyl Chloride (PVC)

PVC manufactured in accordance with and conforming to ASTM D7176, [_____] mils thick.

2.2 ACCESSORIES

2.2.1 ADHESIVE

Provide seaming adhesive compatible with type of liner used as recommended by manufacturer.

2.2.2 SEALANT

Provide sealants compatible with the type of liner used as recommended by manufacture. The use of silicone sealant is not allowed with PVC liner materials.

2.2.3 PENETRATIONS

Provide manufacturer's standard factory fabricated penetration assemblies. Make penetration assemblies of the same base material as liner and at least 45 mils thick.

2.3 FILTER FABRIC

Provide a permeable, synthetic barrier sheet resistant to mildew, chemicals in soil, stable under freeze-thaw cycles, which will not shrink or expand under wet conditions, and will not unravel or become clogged during use. Filter cloth must have a minimum tensile strength of 120 pounds. Allowable open area must not exceed [36] [_____] percent and must not be less than [4] [_____] percent. Percent open area is defined as the summation of open areas divided by total area of filter cloth. Equivalent Opening Size (EOS) must not be finer than the U.S. Standard sieve No. [70] [_____].

PART 3 EXECUTION

3.1 SURFACE PREPARATION

3.1.1 Soil or Granular Subgrade

Prepare subgrade in accordance with Section 31 00 00 EARTHWORK. Remove vegetation, boulders and rocks larger than 3/4 inch in size and other sharp objects. Fill in holes, including stake holes. Inspect subgrade surface and correct defects prior to continuing construction.

3.1.2 Concrete

Provide concrete surfaces and pipe anchorages in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide smooth surfaces with no sharp projections or abrupt surface changes. Compact earth within 12 inches of any concrete surfaces to 100 percent maximum density, in accordance with ASTM D698.

3.2 CLEANING OF LINER SHEET

Clean liner sheets of dust, dirt, and other foreign matter. Carefully clean area (both mating surfaces) of seams. [Remove surface [bloom] or [cure] with solvent recommended by manufacturer.]

3.3 FILTER FABRIC INSTALLATION

Place synthetic fiber filter fabric on prepared subgrade. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. [Obtain approval of filter fabric installation before placing fill. Place fill on fabric in the direction of overlaps and compact as specified in Section [31 00 00 EARTHWORK][31 23 00.00 20 EXCAVATION AND FILL]]. Follow manufacturer's recommended installation procedures.

3.4 LINER INSTALLATION

3.4.1 Placement

Position liner on previously prepared surface [or filter fabric] as indicated. Unroll or unfold carefully. Avoid stretching. Allow liner to lie in a relaxed state [for a minimum of 1/2 hour] prior to seaming.

3.4.2 Seams and Laps

Provide personnel handling or applying seaming adhesive with protective clothing and other appropriate safety equipment. Apply seaming adhesive and make field seam. Make lap or seam [_____] [6 inches] wide. Seal lap or seam using rollers or hand pressure removing any wrinkles at that time. A plank or board may be used for back-up during sealing but remove prior to completion of installation. [For supported liners apply splicing cement to cut edges of liner and seal with a strip of unsupported liner of same material as liner.] [For supported liners apply splicing cement to cut edges (exposed scrim) of liner.]

3.4.3 Repairs

Make repairs to liner with same material as liner. Extend patch 6 inches in all directions from puncture. Use same method as for seams.

3.5 ANCHORAGE

3.5.1 Earth Anchorage

Make perimeter trench [a minimum of 12 inches wide by 12 inches deep] [as indicated]. After installation of liner in reservoir is complete, place liner in perimeter trench and backfill trench.

3.5.2 Anchorage to Structures

Remove curing compounds and coatings from structures in joint areas. Use bonding adhesive recommended by manufacturer to make joints. Make joint to structures [at least 12 inches wide.] [the width indicated. Use batten strips of stainless steel bars to reinforce joint.]

3.6 BACKFILL OVER LINER

Cover installed liner with earth to depth [indicated.] [of 18 inches.] [Cover liner within time limits specified by liner manufacturer.] Place earth on liner using rubber tired or tracked vehicles. Drive only on earth cover. Correct any damage to liner caused by covering operations.

3.7 FIELD QUALITY CONTROL

3.7.1 Tests

Use ASTM D7700 to determine appropriate test methods necessary to evaluate geomembrane seams for materials listed in this specification. [Take one destructive field seam sample per [1640 feet] [_____] feet of seam.] [Perform an electrical leak detection survey.]

3.7.1.1 Nondestructive testing (NDT)

3.7.1.1.1 Nonreinforced testing

Perform NDT in accordance with ASTM D4437/D4437M. For HDPE, LLDPE, fPP and PVC use ASTM D7006 for ultrasonic testing of materials and seams. For PVC, ASTM D7006 is only applicable to factory seam testing.

3.7.1.1.2 Reinforced testing

Perform NDT in accordance with ASTM D4437/D4437M.

3.7.1.2 Destructive testing

Perform destructive testing in accordance with GSI GRI GM19.

3.7.1.2.1 Nonreinforced testing

For HDPE, LLDPE, and fPP perform destructive testing in accordance with ASTM D6392.

[For EPDM perform destructive testing in accordance with ASTM D7272.

][For PVC perform destructive testing in accordance with ASTM D7408.

]3.7.1.2.2 Reinforced testing

For reinforced geomembranes materials listed in this specification perform destructive testing in accordance with ASTM D751, ASTM D6214/D6214M, and ASTM D6392.

[3.7.1.3 Adhesion to Flexible Substrate

For EPDM perform adhesion test in accordance with ASTM D413.

]3.7.1.4 Electrical Leak Location

For HDPE, LLDPE, fPP and PVC provide electrical leak location in accordance with ASTM D7002 and ASTM D7007.

3.7.1.5 Leakage Testing

Test pond or reservoir for leakage. Determine leakage rate. Leakage rate (Q) must not exceed the lesser of 1 gallon per minute or the amount given by the following formula. Q (Leakage rate in gallons per minute) equals A (Area of liner in thousands of square feet) multiplied by the square root of H (Depth of liquid in feet), the product then divided by 80.

3.7.2 Inspection

Inspect completed liner for pinholes, punctures, and tears. Inspect seams and joints for unbonded areas. Repair defects as specified herein.

-- End of Section --

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SECTION 33 51 13.00 30

NATURAL-GAS METERING
05/10

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.1	(2000) Diaphragm Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
AGA ANSI B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA ANSI B109.3	(2019) Rotary-Type Gas Displacement Meters

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25-16	(2016) Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.33	(2012; R 2017) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psi, (Sizes NPS 1/2 - NPS 2)

ASME B16.38	(2012; R 2017) Large Metallic Valves for Gas Distribution Manually Operated, NPS 2 1/2 (DN 65) to NPS 12 (DN 300), 125 psig 8.6 bar) Maximum
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.8	(2018; Supplement 2018) Gas Transmission and Distribution Piping Systems
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

MASTER PAINTERS INSTITUTE (MPI)

MPI 9	(2016) Alkyd, Exterior Gloss (MPI Gloss Level 6)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION

(SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4	(2007) Brush-Off Blast Cleaning
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II
SSPC SP 1	(2015) Solvent Cleaning
SSPC SP 3	(2018) Power Tool Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
49 CFR 195	Transportation of Hazardous Liquids by Pipeline

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Pressure Regulator; G[, [_____]]

Valves

Risers

Transition Fittings

Gas Meter; G[, [_____]]

SD-07 Certificates

Welder's Qualifications

Welder's Identification Symbols

1.4 QUALITY ASSURANCE

1.4.1 Welder's Qualifications

Comply with ASME B31.8. The steel welder will provide a copy of a certified ASME B31.8 qualification test report. Submit each welder's identification symbols, assigned number, or letter, used to identify work of the welder. Affix symbols immediately upon completion of welds. Welders making defective welds after passing a qualification test will be given a requalification test and, upon failing to pass this test, will not be permitted to work this contract.

1.4.2 Safety Standards

Conform to 49 CFR 192 [and 49 CFR 195].

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store pipe and fittings carefully. Plug or cap pipe ends during transportation or storage to minimize dirt and moisture entry. Do not subject to abrasion or concentrated external loads.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Conform to NFPA 54 and with requirements specified herein.

2.2 PIPE AND FITTINGS

2.2.1 Aboveground and Within Buildings and Vaults

2.2.1.1 Pipe

Black steel in accordance with ASTM A53/A53M, Schedule [40] [80], threaded ends for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.

2.2.1.2 Threaded Fittings

ASME B16.3, black malleable iron

2.2.1.3 Socket-Welding Fittings

ASME B16.11, forged steel

2.2.1.4 Butt-Welding Fittings

ASME B16.9, with backing rings of compatible material

2.2.1.5 Unions

ASME B16.39, black malleable iron. Provide dielectric unions where cathodic protection is provided on steel gas mains and/or service lines.

2.2.1.6 Flanges and Flanged Fittings

ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1. Flange faces will have integral grooves of rectangular cross-sections which afford containment for self-energizing gasket material.

2.2.2 Risers

Manufacturer's standard riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide [remote bolt-on or bracket] [or] [wall-mounted] riser supports [as indicated].

2.2.3 Transition Fittings

[2.2.3.1 Steel to Plastic (PE)

As specified for "riser" except designed for steel-to-plastic with tapping tee or sleeve. Coat or wrap exposed steel pipe with heavy plastic coating.

][2.2.3.2 Plastic to Plastic

[Manufacturer's standard bolt-on (PVC to PE) plastic tapping saddle tee, UL listed for gas service, rated for 100 psig, and O-ring seals.] [Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support, O-ring seals, and rated for 150 psig gas service.] [Manufacturer's standard fused tapping (PE-to-PE) tee assembly with shut-off feature.]

]2.3 VALVES, ABOVEGROUND

[Provide lockable valves where indicated.]

2.3.1 Shutoff Valves, Sizes Larger Than 2 Inches

[[Cast-iron] [or] [steel] body ball valve with flanged ends in accordance with ASME B16.38. Provide PTFE seats.] [Cast-iron body plug valve in accordance with ASME B16.38, nonlubricated, wedge-mechanism or tapered lift plug, and flanged ends.]

2.3.2 Shutoff Valves, Sizes 2 Inches and Smaller

[[Bronze] [Steel] body ball valve in accordance with ASME B16.33, full port pattern, reinforced PTFE seals, threaded ends, and PTFE seat.] [[Bronze] [Steel] body plug valve in accordance with ASME B16.33, straightway, taper plug, regular pattern with a port opening at least equal to the internal pipe area or round port full bore pattern, non-lubricated, PTFE packing, flat or square head stem with lever operator, 125 psig rating, threaded ends.]

2.3.3 Pressure Regulator

Self-contained with spring-loaded diaphragm pressure regulator, psig to inches water reduction, pressure operating range as required for the pressure reduction indicated, volume capacity not less than indicated, and threaded ends for sizes 2 inches and smaller, otherwise flanged.

2.3.4 Earthquake Automatic Gas Shutoff Valves

ASCE 25-16 and UL listed or AGA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The valve may be either pendulum or ball construction with [remote [, pneumatic] [electronic] [or] [electric]] actuator.

2.4 GAS METER

[AGA ANSI B109.1] [AGA ANSI B109.2] [AGA ANSI B109.3] [pipe] [pedestal] mounted, [diaphragm] or [bellow] [style], [cast-iron] [enamel-coated steel] [aluminum] case. Provide combined [odometer-type] register totalizer index, UV-resistant index cover, water escape hole in housing, and means for sealing against tampering. Meter will be temperature-compensated type and sized for the required CFM [BTU/HR] flow rate. Provide meters with a pulse switch initiator capable of operating up to speeds of 500 maximum pulses per minute with no false pulses and requiring no field adjustments. Provide not less than one pulse per 100 cubic feet) of gas. Minimum service life will be 30,000,000 cycles.

2.4.1 Energy Monitoring and Control (EMCS) or Automatic Meter Reading Interfaces

Gas meters must be capable of interfacing (output signal equivalent to flow rate) with the existing Energy Management Control System (EMCS) for data gathering in units of CFM. Meters are to to function and deliver data without requiring power. Provide output signal that is either a voltage or amperage signal with can be converted to a flow rate specification.

2.5 HANGERS AND SUPPORTS

MSS SP-58, as required by MSS SP-69.

2.6 WELDING FILLER METAL

ASME B31.8.

2.7 PIPE-THREAD TAPE

Antiseize and sealant tape of polytetrafluoroethylene (PTFE).

2.8 BOLTING (BOLTS AND NUTS)

Stainless steel bolting; ASTM A193/A193M, Grade B8M or B8MA, Type 316, for bolts; and ASTM A194/A194M, Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts are to conform with ASME B18.2.1 and ASME B18.2.2 with coarse threads conforming to ASME B1.1, with Class 2A fit for bolts and studs and Class 2B fit for nuts. Extend bolts or bolt-studs through the nuts, and may have reduced shanks of a diameter not less than the diameter at root of threads. Bolts are to have American Standard regular square or heavy hexagon heads, and nuts will be American Standard heavy semifinished hexagonal.

2.9 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.10 IDENTIFICATION FOR ABOVEGROUND PIPING (INTERIOR)

MIL-STD-101 for legends and type and size of characters. For pipes 3/4 inch OD and larger, provide printed legends to identify contents of pipes and arrows to show direction of flow. Color code label backgrounds to signify levels of hazard. Make labels of plastic sheet with pressure-sensitive adhesive suitable for the intended application. For pipes smaller than 3/4 inch OD, provide brass identification tags 1-1/2 inches in diameter with legends in depressed black-filled characters.

PART 3 EXECUTION

3.1 INSTALLATION

Install gas piping, appliances, and equipment in accordance with NFPA 54. [Install distribution piping in accordance with ASME B31.8.]

3.1.1 Meters

Install meters in accordance with [AGA ANSI B109.1] [AGA ANSI B109.2] [AGA ANSI B109.3]

3.1.2 Piping

Cut pipe to actual dimensions and assemble to prevent residual stress. [Provide supply connections entering the buildings as indicated.] Within buildings, run piping parallel to structure lines and conceal in finished spaces. Terminate each vertical supply pipe to burner or appliance with tee, nipple and cap to form a sediment trap. To supply multiple items of gas-burning equipment, provide manifold with inlet connections at both ends.

3.1.2.1 Cleanliness

Clean inside of pipe and fittings before installation. Blow lines clear using 80 to 100 psig clean, dry compressed air. Rap steel lines sharply along entire pipe length before blowing clear. Cap or plug pipe ends to maintain cleanliness throughout installation.

3.1.2.2 Aboveground Steel Piping

Determine and establish measurements for piping at the job site and accurately cut pipe lengths accordingly. For 2 inch diameter and smaller, use threaded or socket-welded joints. For 2-1/2 inch diameter and larger, use flanged or butt-welded joints.

a. Threaded Joints: Where possible, use pipe with factory-cut threads; otherwise cut pipe ends square, remove fins and burrs, and cut taper pipe threads in accordance with ASME B1.20.1. Provide threads smooth, clean, and full-cut. Apply anti-seize paste or tape to male threads portion. Work piping into place without springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed. Use unions for connections to [valves] [meters] for which a means of disconnection is not otherwise provided.

b. Welded Joints: Weld by the shielded metal-arc process, using covered electrodes and in accordance with procedures established and qualified in accordance with ASME B31.8.

c. Flanged Joints: Use flanged joints for connecting welded joint pipe and fittings to valves to provide for disconnection. Install joints so that flange faces bear uniformly on gaskets. Engage bolts so that there is complete threading through the nuts and tighten so that bolts are uniformly stressed and equally torqued.

d. Pipe Size Changes: Use reducing fittings for changes in pipe size. Size changes made with bushings will not be accepted.

e. Painting: Paint new ferrous metal piping, including supports, in accordance with Section 09 90 00 PAINTS AND COATINGS. Do not apply paint until piping tests have been completed.

f. Identification of Interior Piping: Identify interior piping aboveground in accordance with MIL-STD-101, using adhesive-backed or snap-on plastic labels and arrows. In lieu of labels, identification tags may be used. Apply labels or tags to finished paint at intervals of not more than 50 feet). Provide two copies of the piping identification code framed under glass and install where directed.

3.1.2.3 Wrapping

Where connection to existing steel line is made underground, tape wrap new steel transition fittings and exposed existing pipe having damaged coating. Clean pipe to bare metal. Initially stretch first layer of tape to conform to the surface while spirally half-lapping. Apply a second layer, half-lapped and spiraled as the first layer, but with spirals perpendicular to first wrapping. Use 10 mil minimum thick polyethylene tape. In lieu of tape wrap, heat shrinkable 10 mil) minimum thick polyethylene sleeve may be used.

3.1.3 Regulators and Valves

3.1.3.1 Pressure Regulator

Provide [plug cock] [or] [ball valve] ahead of regulator. [Install regulator outside of building and 18 inches aboveground on riser.] [Install regulator inside building and extend a full-size vent line from relief outlet on regulator to a point outside of building.] [Install gas meter in conjunction with pressure regulator]. On outlet side of [regulator] [meter], provide a union and a 3/8 inch gage tap with plug.

3.1.3.2 Stop Valve and Shutoff Valve

Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

3.1.4 Pipe Sleeves

[Comply with Section 07 84 00 FIRESTOPPING.] Where piping penetrates concrete or masonry wall, floor, or firewall, provide pipe sleeve poured or grouted in place. Make sleeve of steel or cast-iron pipe of such size to provide 1/4 inch) or more annular clearance around pipe. Extend sleeve through wall or slab and terminate flush with both surfaces. Pack annular space with oakum, and caulk at ends with silicone construction sealant.

3.1.5 Piping Hangers and Supports

Ensure selection, fabrication, and installation of piping hangers and supports conform with MSS SP-69 and MSS SP-58, unless otherwise indicated. [Provide seismic restraints in accordance with SMACNA 1981.]

3.2 FIELD QUALITY CONTROL

3.2.1 Metal Welding Inspection

Inspect for compliance with [NFPA 54] [and] [ASME B31.8]. Replace, repair, and then re-inspect defective welds.

3.3 PROTECTIVE COVERING FOR ABOVEGROUND PIPING SYSTEMS

Apply finish painting conforming to the applicable paragraphs of Section 09 90 00 PAINTS AND COATINGS and as follows: for Ferrous Surfaces, touch up shop-primed surfaces with ferrous metal primer of the same type paint as the shop primer. Solvent-clean surfaces that have not been shop primed in accordance with SSPC SP 1. Mechanically clean surfaces that contain loose rust, loose mill scale, and other foreign substances by power wire brushing in accordance with SSPC SP 3 or brush-off blast clean in accordance with SSPC 7/NACE No.4 and primed with ferrous metal primer in accordance with SSPC Paint 25. Finish primed surfaces with two coats of exterior alkyd paint conforming to MPI 9.

-- End of Section --

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SECTION 33 51 15

NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES
08/19

PART 1 GENERAL

1.1 SUMMARY

The gas distribution pipeline includes piping that conveys [natural gas] [manufactured gas] [liquefied petroleum gas (LPG) in its vapor phase] and all appurtenances from point of connection with existing system, to a point approximately [5] [_____] feet from the facility being served. The distribution pipeline, which must comply with 49 CFR 192, terminates at the isolation valve, service pressure regulator, or meter, whichever is the most downstream component before serving the facility gas piping. The facility gas piping that connects to this termination point is specified in Section 23 11 20 FACILITY GAS PIPING and must comply with NFPA 54.

Section 31 10 00 SITE CLEARING, applies to this section unless otherwise specified.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.1	(2000) Diaphragm Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
AGA ANSI B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA ANSI B109.3	(2019) Rotary-Type Gas Displacement Meters
AGA ANSI B109.4	(2016) Self-Operated Diaphragm-Type Natural Gas Service Regulators for Nominal Pipe Size 1¼ inches (32 mm) and Smaller with Outlet Pressures of 2 psig (13.8 kPa) and Less
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.18/CSA 6.3	(2007; R 2017) Gas Appliance Pressure Regulators
ANSI Z21.80/CSA 6.22	(2019) Line Pressure Regulators

AMERICAN PETROLEUM INSTITUTE (API)

API API-ASME CODE	(1951) Unfired Pressure Vessels for

	Petroleum Liquids and Gases
API RP 686	(2009) Recommended Practice for Machinery Installation and Installation Design
API Spec 5L	(2018; 46th Ed; ERTA 2018) Line Pipe
API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves
API Std 617	(2014; 8th Ed; ERTA 1 August 2016) Axial and Centrifugal Compressors and Expander-Compressors
API Std 618	(2007; R 2016) Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services
API Std 619	(2010) Rotary-Type Positive Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries
API Std 1104	(2013; Errata 1-3 2014; Addendum 1 2014; Errata 4 2015; Addendum 2 2016) Welding of Pipeline and Related Facilities

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.25	(2017) Buttwelding Ends
ASME B16.40	(2019) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
ASME B31.8	(2018; Supplement 2018) Gas Transmission and Distribution Piping Systems

ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII	(2010) Boiler and Pressure Vessel Codes: Section VIII Rules for Construction of Pressure Vessel
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 25	(2014) Pressure Relief Devices

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A333/A333M	(2016) Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service and Other Applications with Required Notch Toughness
ASTM A395/A395M	(1999; R 2018) Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM D2513	(2018a) Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
ASTM D2513-99	(1999) Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2517	(2018) Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
ASTM D2683	(2020) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2774	(2021) Underground Installation of Thermoplastic Pressure Piping

ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3839	(2014) Standard Guide for Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3892	(2015) Standard Practice for Packaging/Packing of Plastics
ASTM D4066	(2013) Standard Classification System for Nylon Injection and Extrusion Materials (PA)
ASTM D5685	(2019) Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings
ASTM F1055	(2016a) Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX)Pipe and Tubing
ASTM F1802	(2022) Standard Test Method for Performance Testing of Excess Flow Valves
ASTM F1948	(2015) Standard Specification for Metallic Fittings for Use on Outside Diameter Controlled Thermoplastic Gas Distribution Pipe and Tubing
ASTM F1973	(2013; R 2018) Standard Specification for Factory Assembled Anodeless Risers and Transition Fittings in Polyethylene (PE) and Polyamide 11 (PA11) and Polyamide 12 (PA12) Fuel Gas Distribution Systems
ASTM F2138	(2012; R 2017) Standard Specification for Excess Flow Valves for Natural Gas Service
ASTM F2145	(2013; R 2018) Standard Specification for Polyamide 11 (PA 11) and Polyamide 12 (PA 12) Mechanical Fittings for Use on Outside Diameter Controlled Polyamide 11 and Polyamide 12 Pipe and Tubing
ASTM F2164	(2018) Standard Practice for Field Leak Testing of Polyethylene (PE) and

	Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure
ASTM F2600	(2009; R 2018) Standard Specification for Electrofusion Type Polyamide-11 Fittings for Outside Diameter Controlled Polyamide-11 Pipe and Tubing
ASTM F2620	(2020a; E 2021) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
ASTM F2786	(2010) Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Gaseous Media Under Pressure (Pneumatic Leak Testing)
ASTM F2897	(2015a) Standard Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)
ASTM F2945	(2018) Standard Specification for Polyamide 11 Gas Pressure Pipe, Tubing, and Fittings

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-142	(2012) Excess Flow Valves for Fuel Gas Service, NPS 1 1/2 through 12

MASTER PAINTERS INSTITUTE (MPI)

MPI 9	(2016) Alkyd, Exterior Gloss (MPI Gloss Level 6)
MPI 10	(2016) Latex, Exterior Flat (MPI Gloss Level 1)
MPI 11	(2016) Latex, Exterior Semi-Gloss, MPI Gloss Level 5
MPI 119	(2016) Latex, Exterior, Gloss (MPI Gloss Level 6)

NACE INTERNATIONAL (NACE)

NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE SP0185	(2007) Extruded Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NACE SP0274	(1974; R 2011) High Voltage Electrical Inspection of Pipeline Coatings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
NFPA 58	(2020; TIA 20-1; TIA 20-2; TIA 20-3) Liquefied Petroleum Gas Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4	(2007) Brush-Off Blast Cleaning
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II
SSPC SP 1	(2015) Solvent Cleaning
SSPC SP 3	(2018) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
49 CFR 192.105	Design Formula for Steel Pipe
49 CFR 192.197	Control of the Pressure of Gas Delivered from High-Pressure Distribution Systems

UNDERWRITERS LABORATORIES (UL)

UL 125	(2020) UL Standard for Safety Flow Control Valves for Anhydrous Ammonia and LP-Gas
UL 132	(2015; Reprint Jan 2018) UL Standard for Safety Relief Valves for Anhydrous Ammonia and LP-Gas
UL 144	(2012; Reprint Nov 2014) UL Standard for Safety LP-Gas Regulators
UL 569	(2013; Repring Jul 2017) UL Standard for Safety Pigtails and Flexible Hose Connectors for LP-Gas

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pipe, Fittings, and Associated Materials

SD-03 Product Data

Materials and Equipment; G[, [_____]]

Spare Parts; G[, [_____]]

Pipe and Accessory Coatings; G[, [_____]]

SD-05 Design Data

Connections to Existing Lines; G[, [_____]]

Connection and Abandonment Plan; G[, [_____]]

SD-06 Test Reports

Pressure and Leak Tests

SD-07 Certificates

Welder's training and qualifications

Jointing of Plastic Piping

Utility Work

SD-08 Manufacturer's Instructions

EFV Design and Installation Guide

SD-10 Operation and Maintenance Data

Gas Distribution System and Equipment Operation; G[, [_____]]

Gas Distribution System Maintenance; G[, [_____]]

Gas Distribution Equipment Maintenance; G[, [_____]]

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

1.4.1.1 Welding General

a. Qualification of welding procedures and Welder's training and qualifications, including equipment used, detailed explanation of the procedure, and successfully making joints which pass tests must comply with Subpart E of 49 CFR 192.

b. Submit procedures for welding of metallic piping that comply with API Std 1104 section 5, 12, or App. A; or ASME BPVC SEC IX. Quality of test welds used to qualify a procedure must be determined by destructive test. Submit the results of destructive testing of each procedure qualification for Government record.

c. Submit a certificate of Welder's training and qualifications by test, requalification, or production work testing in conformance with API Std 1104 section 6, 12, or App. A; ASME BPVC SEC IX; or as allowed per 49 CFR 192 Appendix C.

d. Submit a list of names and identification symbols for all qualified welders and welding operators to be used on the project.

e. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

1.4.1.2 Jointing of Plastic Piping

a. Join piping by performance qualified plastic pipe joiners, qualified by a person who has been trained and certified by the manufacturer of the pipe, using manufacturer's pre-qualified joining procedures that have been tested in accordance with 49 CFR 192 Subpart F. Inspect joints by an inspector qualified in the joining procedures being used.

b. Submit manufacturer's pre-qualified joining procedures and the results of testing performed to 49 CFR 192 Section 283.

c. Plastic pipe joiners must be re-qualified at the beginning of each project by making specimen joints using the approve procedures and having those joints inspected by a qualified inspector and tested in accordance with 49 CFR 192 Section 285.

d. Submit a certificate of qualified jointing procedures, training procedures, qualifications of trainer, and training test results for joiners and inspectors. Notify the Contracting Officer at least [24] [_____] hours in advance of the date to qualify joiners and inspectors.

1.4.2 Pre-Installation Conference

1.4.2.1 Shop Drawings

Submit shop drawings, within [30] [_____] days of contract award, containing complete schematic and piping diagrams and any other details required to demonstrate that the system has been coordinated and functions properly as a unit. Show on the drawings proposed layout and anchorage of the system and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

1.4.2.2 Connecting and Abandonment Plan

Submit written notification of the method and schedule for making connections to existing gas lines, to the Contracting Officer at least 10 days in advance. Include gas line tie in, hot taps, abandonment/removal or demolition, purging, and plugging as applicable. ASME B31.8 may be used to help develop these plans, but the connection and abandonment must comply with 49 CFR 192. Include in submittal [connections to existing lines][connection and abandonment plan].

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

Inspect materials delivered to the site for damage, and store with a minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.5.2 Handling

Handle pipe and components carefully to ensure a sound, undamaged condition. Take particular care not to damage pipe coating. Repair damaged coatings to original finish. Do not place pipe or material of any kind inside another pipe or fitting after the coating has been applied, except as specified in paragraph INSTALLATION. Handle coated steel piping in accordance with its listing and the manufacturer's written procedures. Handle plastic pipe in conformance with AGA XR0603.

1.6 EXTRA MATERIALS

Submit spare parts data for each different item of equipment and material specified, after approval of the detail shop drawings and not later than [_____] months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

[2.1 LPG CONTAINERS

Provide containers for LPG that meet NFPA 58 requirements and are designed, fabricated, tested, and marked in accordance with the regulations of the department of transportation (DOT), ASME BPVC SEC VIII, or API API-ASME CODE. Provide LPG containers with all appurtenances as required by NFPA 58, qualified to UL 125, to include vapor shutoff valve, liquid shutoff valve, pressure relief valve, fixed maximum liquid level gauge, filler valve, [and overfilling protection device,][and actuated liquid withdrawal excess-flow valve]. Container appurtenances must have a minimum service pressure rating of 250 psig.

]2.2 PIPE, FITTINGS, AND ASSOCIATED MATERIALS

[Provide only materials that are allowed for [natural gas][manufactured gas] by 49 CFR 192 for the specified distribution pipeline being installed.]

[Provide only materials that are allowed by LPG by NFPA 58 for the specified disbribution pipeline being installed.]

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Provide written verification and point of contact for a supporting service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Mark all valves, flanges, and fittings in accordance with MSS SP-25. Submit a complete list of materials and equipment, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions, including, but not limited to the following:

a. Electrical Isolation Devices and Isolating Flange Kits.
b. Fittings

c. Piping
d. Pipe and Accessory coatings
e. Pressure Reducing Valves.
f. Meters
g. Regulators.
h. Shut-off Valves
i. Excess Flow Valve
[j. LPG Containers]

2.2.1 Steel Pipe for [Natural Gas][Manufactured Gas] Distribution

Provide steel piping that complies with API Spec 5L, Grade [A,] B, or X42; ASTM A53/A53M, Grade[A or] B; ASTM A106/A106M, Grade [A][B or] C; ASTM A333/A333M, Grade [1 or] 3. Determine minimum pipe wall thickness as specified in 49 CFR 192.105 section "Design Formula for Steel Pipe" for the specific design conditions. [Pipe wall thickness less than schedule 80 for pipes less than 2.5 inches diameter is not permitted.]

[2.2.2 Steel Pipe for LPG Distribution

Provide steel piping that is approved within NFPA 58 and complies with ASTM A53/A53M, Grade [A or] B; ASTM A106/A106M, Grade [A,][B, or] C. Provide pipe wall thickness as specified on the design drawings, but in no case less than schedule 40. Provide schedule 80 pipe where threads are to be cut in order to connect threaded valves or appurtenances.

]2.2.3 Corrosion Protection for Steel Pipe for Underground Installation

2.2.3.1 External Coating Systems

Where steel pipe installation below ground is required by design of the gas carrier pipe, or as encasement for plastic pipe, provide pipe with a [factory applied][field plant applied] polyolefin resin coating system conforming to NACE SP0185, Type A. Pipe exterior must be cleaned to a commercial grade blast cleaning finish in accordance with SSPC SP 6/NACE No.3. Apply adhesive compound to the pipe with a nominal thickness of 10 mils (plus or minus 10 percent). Immediately after the adhesive is applied, extrude a seamless tube of polyolefin over the adhesive to produce a bonded seamless coating, with a nominal thickness of 40 mils (plus or minus 10 percent) of polyolefin resin for pipes up to 16 inches in diameter. For pipes 18 inches and larger in diameter, apply a minimum thickness of 60 mils (plus or minus 10 percent) polyolefin resin.

Do not coat pipe and fittings for aboveground lines.

2.2.3.2 Cathodic Protection Systems

Provide cathodic protection system in accordance with NACE SP0169 and the applicable UFGS DIV 26 specification for the designed type of cathodic protection.

2.2.4 Steel and Malleable Iron Fittings, 1-1/2 inches and Smaller

Provide steel butt-weld fittings conforming to ASME B16.9 [or threaded malleable iron fittings for [natural gas][manufactured gas] pipe conforming to ASME B16.11].

[Provide fittings for LPG piping systems that are rated for a minimum of [125 psig][250 psig] and comply with NFPA 58. Threaded fittings must be qualified by the manufacturer for use with LPG. Use threaded fittings in an LPG pipeline only at connecting equipment and appurtenances that are provided by the manufacturer with threaded connections.]

2.2.5 Steel Fittings, 2 inches and Larger

Provide weld neck pipe flanges and flanged fittings, including bolts, nuts, and bolt patterns in accordance with ASME B16.5, Class [150][_____]. Provide buttweld fittings in accordance with ASME B16.9.

[Provide fittings for LPG piping systems that are rated for a minimum of [125 psig][250 psig] and comply with NFPA 58.]

2.2.6 Steel Forged Branch Connections

Provide steel forged branch connections conforming to ASTM A181/A181M, Class 60, carbon steel.

2.2.7 Flange Gaskets

[Provide gaskets for [natural][manufactured] gas systems that are non-asbestos compressed material gaskets in accordance with ASME B16.21, 1/16 inch minimum thickness, full face or self-centering flat ring type, containing aramid fibers bonded with nitrile butadiene rubber (NBR), or glass fibers bonded with polytetrafluoroethylene, suitable for maximum 600 degrees F service.]

[Provide gaskets for LPG systems constructed of metal or confined by metal that has a melting point above 1,500 degrees F and is resistant to the action of LPG and in accordance with NFPA 58.]

2.2.8 Pipe Threads

[Provide pipe threads for [natural][manufactured] gas piping conforming to ASME B1.20.1.]

[Provide only fittings manufactured for the purpose of threaded connections made in LPG piping systems. Design threaded fittings in LPG systems for no less than 250 psig operating pressure.]

2.2.9 Sealants for Steel Pipe Threaded Joints in [Natural][Manufactured] Gas Systems

2.2.9.1 Sealing Compound

Provide joint sealing compound as listed in UL FLAMMABLE & COMBUSTIBLE, Class 20 or less that is qualified for use with [natural gas] [manufactured gas].

2.2.9.2 Tape

Provide polyetrafluoroethylene tape conforming to ASTM D3308 that is qualified for use with [natural gas][manufactured gas].

2.3 PLASTIC PIPE, TUBING, FITTINGS AND JOINTS

2.3.1 Polyethylene Gas Pressure Pipe, Tubing, and Fittings

Provide polyethylene (PE) pipe, tubing, fittings conforming to ASTM D2513, as specified in 49 CFR 192 Appendix B and manufactured using material that complies with ASTM D3350. Pipe wall thickness must comply with the Standard Dimension Ratio, SDR-11, or lower value, meaning thicker wall. The Hydrostatic Design Basis (HDB) of the selected PE material must exceed the Maximum Allowable Operating Pressure (MAOP), at the anticipated operating temperature of the system in which it is installed. Mark pipe, tubing, and fittings as required by ASTM D2513 and with traceability code per ASTM F2897.

Provide polyethylene fittings that are constructed of polyethylene of the same material classification and SDR as the connecting pipe, and comply with ASTM D2513. Provide fittings with [butt-type fusion fittings complying with ASTM D3261][socket-type fusion fittings complying with ASTM D2683][electrofusion-type fittings complying with ASTM F1055].

Where mechanical fittings are specified on the engineering drawings, provide mechanical fittings that comply with ASTM F1948 and are category 1 for pressure integrity, gas tightness, and provide pull-out resistance equivalent to the pipe strength.

Provide heat fusion joints complying with ASTM F2620 and the manufacturer's written procedure approved by the contracting officer. Electro fusion joints fittings must comply with ASTM F1055 and the manufacturer's written procedure approved by the contracting officer. Perform underground installations in conformance with ASTM D2774.

2.3.2 Polyamide-11 Gas Pressure Pipe, Tubing, and Fittings

Use PA-11 pipe to connect only to existing gas distribution pipelines that are constructed of PA-11.

Provide PA-11 pipe, tubing, fittings and joints conforming to [ASTM D2513-99] [ASTM F2945], as specified in 49 CFR 192 Appendix B and manufactured using material that complies with ASTM D4066. Pipe wall thickness must comply with the Standard Dimension Ratio, SDR-11, or lower value, meaning thicker wall. The Hydrostatic Design Basis (HDB) of the selected PA-11 material must exceed the Maximum Allowable Operating Pressure (MAOP), at the anticipated operating temperature of the system in which it is installed. Mark pipe, tubing, and fittings as required by [ASTM D2513-99] [ASTM F2945] with traceability code per ASTM F2897.

Provide PA-11 fittings that are constructed of PA-11 of the same material classification and SDR as the connecting pipe and comply with [ASTM D2513-99] [ASTM F2945]. Provide [butt-type fusion fittings complying with [ASTM D2513-99] [ASTM F2945],[Annex A2] [electro fusion-type fusion fittings complying with ASTM F2600]].

Where mechanical fittings are specified on the engineering drawings, provide mechanical fittings that comply with [ASTM F1948 for metallic mechanical fittings] [ASTM F2145 for PA-11 bodied mechanical fittings] and are category 1 for pressure integrity, gas tightness, and provide pull-out resistance equivalent to the pipe strength.

Make heat fusion joints and electro fusion joints in accordance with the manufacturer's written procedure approved by the contracting officer. Perform underground installations in conformance with ASTM D2774.

[2.3.3 Reinforced Epoxy Resin Gas Pressure Pipe and Fittings

Use reinforced epoxy resin pipe to connect only to existing [natural gas][manufactured gas] distribution pipelines that are constructed of reinforced epoxy resin.

Provide reinforced epoxy resin pipe, tubing, fittings conforming to ASTM D2517 and as specified in 49 CFR 192 Appendix B. Minimum wall thickness must comply with engineering drawings and 49 CFR 192. Mark pipe, tubing, and fittings as required by ASTM D3892.

Provide fittings conforming to ASTM D5685.

Adhesives used to join pipe and fitting must comply with ASTM D2517 and the manufacturer's written procedure approved by the contracting officer. Perform underground installations in conformance with ASTM D3839.

]2.3.4 Mechanical Fittings for use with Plastic Pipe

Use of mechanical fittings in distribution pipelines constructed of plastic requires the approval of Engineering and the Contracting Officer. Mechanical fittings may be approved only where others methods of connecting piping and appurtenances will produce a less reliable gas tight connection.

Mechanical fittings, their use, and installation must comply with 49 CFR 192. Mechanical fittings must meet the requirements of category 1 presented in [ASTM F1948 for metallic mechanical fittings] [ASTM F2145 for PA-11 mechanical fittings] to remain gas tight while resisting pull-out forces.

Mechanical fittings constructed of metal or plastic other than the plastic specified for piping must be approved base on submission of manufacturer's test data and historical service records indicating their acceptability for the intended service.

Submit all traceability information for each mechanical fittings to include, but not limited to, the manufacturer, part number, serial number, and geographic information system coordinates of the installed location.

[2.4 FLEXIBLE METALLIC CONNECTORS FOR LPG SERVICE

Where flexible piping is required for connection of LPG container regulator to the manual shut off valve at the start of the LPG pipeline, provide flexible metallic connectors complying with UL 569, rated for a working pressure not less than 350 psig. Provide hose assembly with approved connectors that is designed for a pressure not less than 700 psig.

]2.5 VALVES

[2.5.1 Carbon Steel Valves for [Natural Gas][Manufactured Gas] Pipelines

Provide valves suitable for shutoff or isolation in [natural] [manufactured] gas pipelines conforming to the requirements of 49 CFR 192. All materials used in valve construction must be resistant to the action of the gas being distributed under the service conditions.

Provide carbon steel valves installed in [natural gas][manufactured gas] pipelines that comply with API Spec 6D. Provide ball, check, gate, and plug valves as specified in the design drawings.

Provide Class [150][_____] steel valves 1-1/2 inches and smaller installed underground with butt-weld ends complying with ASME B16.25, with square wrench operator adaptor and corrosion prevention.

Provide Class [150][_____] steel valves 1-1/2 inches and smaller installed aboveground with butt-weld complying with ASME B16.25 or threaded ends complying with ASME B1.20.1, with hand wheel or wrench operator.

Provide Class [150][_____] steel valves 2 inches and larger installed underground with butt-weld ends complying with ASME B16.25, and square wrench operator adaptor and corrosion prevention coating.

Provide Class [150][_____] steel valves 2 inches and larger installed aboveground with butt-weld complying with ASME B16.25 or flanged ends complying with ASME B16.5, with hand wheel or wrench operator.

Provide valves 8 inches and larger with worm or spur gear operators, totally enclosed, grease packed, and sealed, with operators having Open and Closed stops and position indicators. Provide locking feature where indicated. Wherever the lubricant connections are not conveniently accessible, provide extensions for the application of lubricant. Provide valves with lubricant compatible with gas service.

][2.5.2 Metallic Valves for LPG Pipelines

Provide manual shut-off valves, excess flow valves, and backflow check valves in LPG pipelines conforming to the requirements of NFPA 58 and UL 125. Provide valves constructed from [steel,] [ductile (nodular) iron complying with ASTM A395/A395M,] [malleable iron complying with ASTM A47/A47M,] [brass]. All materials used in valve construction must be resistant to the action of LPG under the service conditions. Valves must have a service pressure rating of [125 psig for pipeline pressure of 125 psig or less] [and] [250 psig for pipelines operating above 125 psig].

[Provide pressure spring loaded relief valves that comply with UL 132 with flow capability to limit the pressure in the pipeline to below the Maximum Allowable Operating Pressure (MAOP) for the system.]

]2.5.3 Plastic Valves for [Natural Gas][Manufactured Gas][LPG] Pipelines

[Provide valves installed in polyethylene distribution pipelines that are constructed of polyethylene of the same material classification and SDR as the connecting pipe. Comply with ASTM D2513 and ASME B16.40 for underground installation only. Provide valves with [butt-type fusion fittings complying with ASTM D3261] [socket-type fusion fittings complying with ASTM D2683][electro fusion-type fittings complying with ASTM F1055].]

[Provide valves installed in PA-11 distribution pipelines that are constructed of PA-11 of the same material classification and SDR as the connecting pipe. Comply with [ASTM D2513-99] [ASTM F2945] and ASME B16.40 for underground installation only. Provide valves with [butt-type fusion fittings complying with [ASTM D2513-99] [ASTM F2945], Annex A2] [electro fusion-type fusion fittings complying with ASTM F2600].]

2.5.4 Excess Flow Valve (EFV)

Provide [bypass type EFV with automatic reset][non-bypass type EFV with manual rest] that conforms to MSS SP-142 and ASTM F2138 and tested to ASTM F1802. Submit an EFV Design and Installation Guide which includes the manufacturer's product design data and installation instructions. Submit all traceability information for each EFV to include, but not limited to, the manufacturer, part number, serial number, and geographic information system coordinates of the installed location. Provide appropriate valve box where access for maintenance or reset is required.

2.5.5 Valve Box

Provide [street valve box with cast-iron cover and two-piece 5-1/4 inch shaft-slip valve box extension][rectangular concrete valve box, sized large enough for removal of valve without removing box]. Cast the word "Gas" into the box cover. Use valve box for areas as follows:

a. Roads and Traffic Areas: Heavy duty, cast iron cover.

b. Other Areas: Standard duty, concrete cover.

[c. Airfields and Special Loadings: As detailed.]

2.6 PRESSURE REGULATORS

Provide ferrous bodied regulators with backflow protection, designed to meet the pressure, temperature, flow and other service conditions.

[2.6.1 LPG Main Regulators

LPG regulators must comply with UL 144 and NFPA 58. Line pressure regulators that comply with ANSI Z21.80/CSA 6.22 are not allowed in the LPG distribution pipeline, but are used in accordance with NFPA 54 to reduce a 2 psig service line pressure to appliance regulator inlet pressure. Appliance regulators that comply with ANSI Z21.18/CSA 6.3 must not be used in an LPG distribution pipeline.

Provide LPG two stage regulator systems as required by NFPA 58:

a. Single stage regulators are not allowed in an LPG pipeline.

[b. Automatic changeover regulator incorporating an integral two stage regulator, with [integral pressure relief to limit second stage outlet pressure to 2 psig when seat disc is remove and inlet pressure is 15 psig][overpressure shutoff with manual reset] on the outlet of the second stage regulator, for use on multiple cylinder installation.]

[c. Integral two-stage regulator with means to determine the outlet pressure of the high pressure regulator, with [integral pressure relief to limit second stage outlet pressure to 2 psig when seat disc is remove and inlet pressure is 15 psig][overpressure shutoff with manual reset].]

[d. High pressure regulator installed on the LPG container with [integral][separate] relief valve, and a first stage regulator, with integral pressure relief, installed downstream of the high pressure regulator to serve multiple second stage regulators with [integral pressure relief to limit second stage outlet pressure to 2 psig when seat disc is remove and inlet pressure is 15 psig][overpressure shutoff with manual reset] on the outlet of the second stage regulator.]

[e. First stage regulator, 10 psig maximum outlet pressure, with integral pressure relief, and a second stage regulator with [integral pressure relief to limit second stage outlet pressure to 2 psig when seat disc is remove and inlet pressure is 15 psig][overpressure shutoff with manual reset].]

[f. Integral 2 psi service regulator, 2.5 psig maximum outlet pressure with [integral pressure relief to limit outlet pressure to 5 psig when seat disc is remove and inlet pressure is 15 psig][overpressure shutoff with manual reset].]

2 psi regulator system including a first stage regulator, 10 psig maximum outlet pressure, with integral pressure relief, and a 2 psi regulator, 2.5 psig maximum outlet pressure with [integral pressure relief to limit 2 psi regulator outlet pressure to 5 psig when seat disc is remove and inlet pressure is 15 psig][overpressure shutoff with manual reset].]

][2.6.2 [Natural][Manufactured] Gas Main Regulators

Provide pressure regulators for main gas distribution pipelines from a qualified manufacture of pipeline regulators. Equip distribution pipelines with regulators where that pipeline is supplied from a source of gas that is at higher pressure than the maximum allowable operating pressure of the distribution pipeline. Provide regulators of adequate capacity that are rated for the inlet pressure of the gas source and the anticipated operating temperature. In addition to the pressure regulating devices, provide a protective method to prevent overpressuring of the system in accordance with 49 CFR 192, Section 195. Suitable protective devices are as follows:

a. Spring-loaded relief valve meeting the provisions of ASME BPVC SEC VIII D1.

b. Pilot-loaded back pressure regulator used as relief valve, so designed that failure of the pilot system causes the regulator to open.

c. Weight-loaded relief valves conforming to ASME PTC 25.

d. Monitoring relief valves conforming to ASME PTC 25.

e. Series regulator installed upstream from the primary regulator, set to limit the pressure on the inlet of the primary regulator continuously to the maximum allowable operating pressure of the system, or less.

f. Automatic shutoff device installed in series with the primary regulator, set to shut off when the pressure on the distribution system reaches the maximum allowable operating pressure of the system, or less, which remains closed until manually reset.

g. Spring-loaded, diaphragm type relief valves.

][2.6.3 [Natural][Manufactured]Service Regulators

Provide ferrous bodied service regulators conforming to AGA ANSI B109.4 with [full capacity internal relief] [downstream pressure relief valve where distribution pipeline pressure does not exceed 125 psig] [downstream automatic overpressure shut-off].

Service regulators must meet each of the following requirements.

a. Capable of reducing distribution line pressure to the safe pressure required by the connected equipment.

b. Capable of limiting, under no flow conditions, the build-up of downstream pressure that would cause unsafe operation of the connected equipment.

c. Pipe connections of 2 inches or less.

d. Single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas pressure at the regulator inlet.

e. Valve seat of resilient materials designed to withstand flow conditions when pressed against the valve port.

f. Self-contained with no external static or control lines.

Set pressure relief at a lower pressure than would cause unsafe operation of any connected and properly adjusted gas utilization equipment.

][2.6.4 Overpressure Protection for Service Lines, Operating Pressure Greater than 60 psig, but Less than 125 psig

Where the gas distribution system is operated at a pressure greater than 60 psig, but less than 125 psig, provide one of the following methods of overpressure protection for the service regulator and facility gas piping system:

a. Additional upstream regulator plus pressure relief or automatic shut-off.

b. Additional upstream monitoring regulator that, in the event of service regulator failure, prevents the pressure of gas supplied to the customer from exceeding a maximum safe value.

c. A service regulator with internal relief or downstream relief valve.

d. An automatic shut-off device with manual reset.

][2.6.5 Overpressure Protection for Service Lines, Operating Pressure Greater than 125 psig

In addition to the required service regulator, provide an additional upstream [regulator that is set to maintain the inlet pressure to the service regulator to 60 psig or less] [monitoring regulator to limit the pressure of gas supplied to the facility gas piping to the lowest, maximum inlet pressure of any appliance regulator connected to the facility gas piping].

]2.7 METERS

Provide gas meters for [natural gas][manufactured gas][liquefied petroleum gas in the vapor phase] that comply with [AGA ANSI B109.1] [AGA ANSI B109.2] [AGA ANSI B109.3] [pipe] [pedestal] mounted, [diaphragm] or [bellow] [style], [cast-iron] [enamel-coated steel] [aluminum] case. Rate meters for a maximum allowable operating pressure of [10 psig][_____ psig] [Provide with a strainer immediately upstream]. Provide [diaphragm-type meter conforming to AGA ANSI B109.1 for required flow rates less than 500 cfh, or AGA ANSI B109.2, for flow rates 500 cfh and above] [rotary-type displacement meter conforming to AGA ANSI B109.3] as required by local gas utility supplier. Provide combined [odometer-type] register totalizer index, UV-resistant index cover, water escape hole in housing, and means for sealing against tampering. Provide temperature-compensated type meters sized for the required volumetric flow rate and suitable for accurately measuring and handling gas at pressures, temperatures, and flow rates indicated. Provide meters with over-pressure protection as specified in 49 CFR 192 and ASME B31.8. Provide meters that are tamper-proof [with] [frost protection] [fungus protection][seismic protection].Provide meters with a pulse switch initiator capable of operating up to speeds of 500 maximum pulses per minute with no false pulses and requiring no field adjustments. Provide not less than one pulse per 100 cubic feet of gas. Minimum service life must be 30,000,000 cycles.

2.7.1 Utility Monitoring and Control System (UMCS) or Automatic Meter Reading Interfaces

Provide gas meters capable of interfacing the output signal, equivalent to volumetric flow rate, with the existing UMCS for data gathering in units of cubic feet. Provide meters that do not require power to function and deliver data. Output signal must be either a voltage or amperage signal that can be converted to volumetric flow by using an appropriate scaling factor. Meters installed must comply with Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS. Meters installed must comply with Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.7.2 Measurement Configuration

For buildings that already have a gas meter with a pulse output, ensure that the pulse output is connected to a data gathering device (i.e. electric meter). For buildings where a natural gas meter already exists but does not have a pulse output, add a pulse kit to the existing meter and tie the output to a data gathering device. If the existing gas meter will not accept a pulse kit or if no meter exists a new natural gas meter must be installed, also requiring a pulse output to a data gathering device. Ensure the pulse frequency and electronic characteristics are compatible with the existing data gathering device, if any.

2.8 TELEMETERING OR RECORDING GAUGES

Equip each distribution system supplied by more than one district pressure regulating station with telemetering or recording pressure gauges to indicate the gas pressure in the district line.

2.9 GAS TRANSITION FITTINGS

Provide manufactured steel-to-plastic gas transition fittings approved for jointing steel and polyethylene pipe, conforming to ASTM F1973 requirements for transition fittings.

Provide anodeless riser on service lines to transition from below grade plastic piping to above grade steel piping in accordance with 49 CFR 192. Polyethylene-to-steel anodeless risers must comply with ASTM F1973 and ASTM D2513 - Category 1 specifications for gas tight seal and pull-out resistance. Protect steel pipe from corrosion by a factory applied coating.

2.10 IDENTIFICATION

Provide pipe flow markings and metal tags for each valve, meter, and regulator as required by the Contracting Officer.

2.11 ELECTRICALLY ISOLATED JOINT MATERIALS

Provide insulating joint materials between flanged or threaded metallic pipe systems to electrically isolate piping that is protected by cathodic protection systems. Devices must comply with NACE requirements.

[2.12 NATURAL GAS COMPRESSORS

Provide natural gas compressors that comply with [API Std 617][API Std 618][API Std 619].

Provide all devices necessary for safe operation and environmental protection to include snubbers, valves, fittings and other appurtenances as shown on the design drawings.

]PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 EXCAVATION AND BACKFILLING

Earthwork is as specified in Section 31 00 00 EARTHWORK.

3.3 LPG CONTAINERS

Install LPG containers in accordance with NFPA 58 requirements for the type and volumetric capacity of the designed tank. Install each container with the required appurtenances as defined in NFPA 58. Mount each LPG tank on a concrete pad with anchor bolts or other tie down devices that provide resistance to tip over, caused by external forces defined in ASCE 7-16 and allow necessary movement to compensate for thermal expansion and contraction. Observe required separation distance from occupied buildings and building openings.

3.4 GAS MAINS

Provide steel pipe for aboveground installation. Provide polyethylene pipe for underground service..

[Where connection is made to an existing distribution pipeline constructed of Polyamide-11 pipe, construct new system using Polyamide-11 pipe or use approved connection fitting to connect new polyethylene pipe.]

[Where connection is made to an existing distribution pipeline constructed of Reinforced Epoxy Resin pipe, construct new system using Reinforced Epoxy Resin pipe or use approved connection fitting to connect new polyethylene pipe.]

3.5 SERVICE LINES

Construct service lines of materials specified for gas mains and extend from a gas main to and including the point of delivery within 5 feet of the building. The point of delivery is the [meter set assembly] [service regulator] [shutoff valve]. Connect the service lines to the gas mains [as indicated] [through service tees, with end of run plugged].

Where indicated, provide service line with an isolation valve of the same size as the service line, located in a valve box. Make the service lines as short and as straight as practicable between the point of delivery and the gas main, without bends or lateral curves unless necessary to avoid obstructions or otherwise permitted. Lay service lines with as few joints as practicable using standard lengths of pipe, use shorter lengths only for closures. Do not install polyethylene service lines aboveground.

3.6 WORKMANSHIP AND DEFECTS

Ensure pipe, tubing, and fittings are clear and free of cutting burrs and defects in structure or threading, and thoroughly brushed and blown free of chips and scale. Do not repair, but replace defective pipe, tubing, or fittings.

3.7 PROTECTIVE COATING

3.7.1 Protective Coating for Underground Steel Pipe

Where steel pipe is installed below grade for either the gas carrier pipe or as a casing for plastic carrier pipe, protect this pipe from corrosion by an extruded polyolefin resin coating system over a soft adhesive applied to the steel pipe. This coating must be either factory applied or applied using a field plant especially equipped for the purpose. Hand apply protective covering to valves and fittings that cannot be coated and wrapped mechanically, preferably at the plant that applies the covering to the pipe. Coat and wrap joints by hand, in a manner and with materials that produce a covering equal in thickness to that of the covering applied mechanically.

3.7.1.1 Field Plant Applied Polyolefin Resin Coating System

Provide a polyolefin resin coating system conforming to NACE SP0185, Type A. Clean the exterior of the pipe to a commercial grade blast cleaning finish in accordance with SSPC SP 6/NACE No.3, and apply adhesive compound to the pipe with a nominal thickness of 10 mils (plus or minus 10 percent). Immediately after the adhesive is applied, extrude a seamless tube of polyolefin over the adhesive to produce a bonded seamless coating, with a nominal thickness of 40 mils (plus or minus 10 percent) of polyolefin resin for pipes up to 16 inches in diameter. For pipes 18 inches and larger in diameter, apply a minimum thickness of 60 mils (plus or minus 10 percent) polyolefin resin.

3.7.1.2 Pipe Joint and Field Repair Coating System

Apply joint coating and field repair material as recommended by the coating manufacturer, consisting of one the following:

a. Heat shrinkable polyethylene sleeves.

b. High density polyethylene/bituminous rubber compound tape.

Inspect the coating system for holes, voids, cracks, and other damage during installation.

3.7.1.3 Inspection of Pipe Coatings

Repair any damage to the protective covering during transit and handling before installation. After field coating and wrapping has been applied, inspect the entire pipe using an electric holiday detector with impressed current set at a value in accordance with NACE SP0274 using a full-ring, spring-type coil electrode. Equip the holiday detector with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Immediately repair all holidays in the protective covering upon detection. The Contracting Officer reserves the right to inspect and determine the suitability of the detector. Furnish labor, materials, and equipment necessary for conducting the inspection.

3.7.2 Protective Covering for Aboveground Piping Systems

Apply finish painting conforming to the applicable paragraphs of Section 09 90 00 PAINTS AND COATINGS and as follows:

3.7.2.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer of the same type paint as the shop primer. Solvent-clean surfaces that have not been shop primed in accordance with SSPC SP 1. Mechanically clean surfaces that contain loose rust, loose mill scale, and other foreign substances by power wire brushing in accordance with SSPC SP 3 or brush-off blast clean in accordance with SSPC 7/NACE No.4 and primed with ferrous metal primer in accordance with SSPC Paint 25. Finish primed surfaces with two coats of exterior alkyd paint conforming to MPI 9.

3.7.2.2 Nonferrous Surfaces

[Do not paint nonferrous surfaces.] [Paint nonferrous surfaces to protect from the exposed corrosive conditions. Solvent-clean the surfaces in accordance with SSPC SP 1. Apply a first coat of MPI 10, and 2 coats of [MPI 119] [or] [MPI 11].]

3.7.3 Protective Covering for Piping in Valve Boxes and Manholes

Apply protective coating to piping in valve boxes or manholes as specified for underground steel pipe.

3.8 INSTALLATION

Install gas distribution system and equipment in conformance with the manufacturer's recommendations and applicable sections of 49 CFR 192.

3.8.1 Abandonment of Natural Gas Distribution Pipelines

Perform abandonment of existing gas piping in accordance with ASME B31.8, the contract drawing details and the requirements of 49 CFR 192, Section 727. Purge natural gas piping so that there is no potential hazard. Provide locking devices for the shut-off valve located at the end of the service line supplying gas to a discontinued customer. Cut the pipe without damaging the pipe. Unless otherwise authorized, use an approved type of mechanical cutter. Use wheel cutters where practicable. On steel pipe 6 inches and larger, an approved gas-cutting-and-beveling machine may be used. Cut plastic pipe in accordance with AGA XR0603. Fill abandoned vaults with suitable compacting material.[Record and submit to the COR the Geographic Information System (GIS) location of any abandoned distribution pipeline that crosses over, under, or through a navigable waterway.]

3.8.2 Installing Pipe Underground

Grade gas mains and service lines as indicated. Grade service lines so as to drain back to the main or into drips as indicated. Weld joints in steel pipe except as otherwise permitted for installation of valves. Provide mains with 24 inch minimum cover; service lines with 18 inch minimum cover; and place both mains and service lines on firmly compacted select material for the full length.

Where indicated, encase, bridge, or design the main to withstand any anticipated external loads as specified in 49 CFR 192. Provide standard weight black steel pipe encasement material with a protective coating as specified. Separate the pipe from the casing by insulating spacers and seal the ends with casing bushings. Excavate the trench below pipe grade, bed with bank sand, and compact to provide full-length bearing. Laying pipe on blocks to produce uniform grade is not permitted. Ensure that the pipe is clean inside before it is lowered into the trench and keep free of water, soil, and all other foreign matter that might damage or obstruct the operation of the valves, regulators, meters, or other equipment. When work is not in progress, securely close open ends of pipe or fittings with expandable plugs or other suitable means. Minor changes in line or gradient of pipe that can be accomplished through the natural flexibility of the pipe material without producing permanent deformation and without overstressing joints may be made when approved.

Make changes in line or gradient that exceed the limitations specified with fittings. When cathodic protection is furnished, provide electrically insulated joints or flanges.

When polyethylene piping is installed underground and not encased in a metallic casing, place a tracer wire or other electrically conductive element above the pipe in accordance with 49 CFR 192 to permit locating with underground detection devices. After laying of pipe and testing, backfill the trench in accordance with Section 31 00 00 EARTHWORK, and in a manner provides firm support under the pipe and prevents damage to the pipe and pipe coating from equipment or from the backfill material.

3.8.3 Installing Pipe Aboveground

Protect aboveground piping against dirt and other foreign matter, as specified for underground piping. Weld joints in steel pipe; however, joints in pipe 1-1/2 inches in diameter and smaller may be threaded; joints may also be threaded to accommodate the installation of valves. Provide flanges of the weld neck type to match wall thickness of pipe.

3.9 PIPE JOINTS

Provide pipe joints complying with the requirements of 49 CFR 192, Subpart E for welding of steel pipelines and Subpart F for joints other than welding. Design and install pipe joints to effectively sustain the longitudinal pullout forces and thrust forces caused by the contraction and expansion of piping or superimposed loads. Make each joint in accordance with the submitted and approved written joining procedure that has been proven to produce strong, gas-tight joints. Each joint must be inspected by the approved inspector.

3.9.1 Threaded Steel Joints

Provide threaded joints in steel pipe with tapered threads evenly cut, made with UL approved joint sealing compound approved for gas service or polytetrafluoroethylene tape approved for gas service applied to the male threads only. Caulking of threaded joints to stop or prevent leaks is not permitted.

3.9.2 Welded Steel Joints

Perform gas pipe weldments, as indicated, in accordance with the submitted and approved welding procedures, and by the approved qualified welders. Make changes in direction of piping by welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Use forged or flared branch outlet fittings for improvement of flow where attached to the run, and reinforced against external strains. Perform all beveling, alignment, heat treatment, and inspection of welds conforming to API Std 1104 and the ASME Boiler and Pressure Vessel Code. Remove weld defects and repair the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect it or store so that its characteristics or welding properties are not affected adversely. Do not use electrodes that have been wetted or have lost any of their coating..

3.9.3 Plastic Pipe Jointing Procedures

Use jointing procedures that have been submitted and approved for this project. Joints in plastic pipe must be made by the qualified personnel submitted and approved for this project, who have the requalification requirements of 49 CFR 192, Section 285. Each joint made must be inspected by the qualified inspector that was submitted and approved for this project.

Heat fusion joining of plastic pipe or fittings made from different plastic resins by classification or by manufacturer are not allowed. If heat fusion joining of similar polyethylene resin classification is required in pipe made by different manufacturers, the procedure must be qualified by test in accordance with 49 CFR 192, Section 283 requirements and AGA XR0603. The personnel making these joints must be qualified using this procedure in accordance with 49 CFR 192, Section 285 requirements. Submit all data: written procedure, test specimens, test results, inspection reports, etc. to show complete jointing qualification per 49 CFR 192 requirements to the COR.

Where joining procedures for plastic pipes by heat fusion cannot be properly qualified, an alternative connection method must be used.

3.9.4 Mechanical Couplings for Plastic Pipe Jointing

Make mechanical joints in accordance with the procedures that have been qualified in accordance with 49 CFR 192, Section 283(b). Submit evidence that the five specimen joints configured and tested in accordance with 283(b)(1), (2) and (3) failed in a manner consistent with 283(b)(4), (5) and (6) as applicable. For the mechanical coupling, obtain the manufacturer's model number, serial number, and date of manufacture, record the date of installation and obtain the Geographical Information System (GIS) location of the installed mechanical coupling. Submit to the COR, this and all other data required by 49 CFR 192 to be submitted to the Pipeline and Hazardous Material Safety Administration (PHMSA).

3.9.5 Connections Between Metallic and Plastic Piping

Only make metallic to plastic connections outside, underground, and with approved transition fittings.

3.10 VALVES

Install valves in locations shown on the drawings and at locations required by 49 CFR 192. Design valve installation in plastic pipe to protect the plastic pipe against excessive torsional or shearing loads when the valve is operated and from other stresses which may be exerted through the valve or valve box.

For systems where the maximum distribution pressure exceeds 60 psig operating pressure, provide a method to regulate and limit the pressure of the gas in the system that complies with 49 CFR 192.197 paragraphs (c)(1) through (4).

3.11 VALVE BOXES

Provide valve boxes of cast iron not less than 3/16 inch thick at each underground valve except where concrete or other type of housing is indicated. Provide valve boxes with locking covers that require a special wrench for removal, and furnish the correctly marked wrench for each box. Cast the word "GAS" in the box cover. When the valve is located in a roadway, protect the valve box by a suitable concrete slab at least 3 square feet and install an access cover that is traffic rate cast iron of ample thickness to support expected traffic loads. When in a sidewalk, provide the top of the box as a removable concrete slab 2 feet square and set flush with the sidewalk. Make the boxes adjustable extension type with screw or slide-type adjustments. Separately support valve boxes to not rest on the pipe, so that no traffic loads can be transmitted to the pipe. Only locate valves in valve boxes or inside of buildings.

3.12 DRIPS

Install drips conforming to the details, provide commercial units of approved type and capacity. Connect a blow off pipe 1-1/4 inches or larger to each drip at its lowest point and extend to or near the ground surface at a convenient location away from traffic. Provide a reducing fitting for each discharge at each drip terminal (outlet), a plug valve, and a 1/2 inch nipple turned down. Locate the discharge terminal (outlet) inside a length of 12 inches or larger vitrified clay pipe, concrete sewer pipe or concrete terminal box [set vertically on a bed of coarse gravel 1 foot thick and3 feet square,] [with concrete bottom to contain liquids and a connection to remove liquids for disposal,] and closed at the ground surface with a suitable replacement cover.

3.13 PRESSURE REGULATOR INSTALLATION

3.13.1 Main Distribution Line Regulators

Install pressure regulators. Install a valve on each side of the regulator for isolating the regulator for maintenance.[Provide a bypass line with bypass valves or 3 way valves and an over-pressurization pressure regulating device.] Install regulators and valves in rectangular reinforced concrete boxes, large enough so that all required equipment can be properly installed, operated, and maintained, with box sidewalls extending above ground line. Provide the boxes with [steel door] [cast iron manhole] covers with locking provisions and 4 inch diameter vents. Furnish one key or other unlocking device with each cover. Locate discharge stacks, vents, or outlet ports of all pressure relief devices where gas can be discharged into the atmosphere without undue hazard. Provide stacks and vents with fittings to preclude entry of water.

3.13.2 Service Line Regulators

Install a shutoff valve,[meter set assembly,] and service regulator on the service line outside the building, 18 inches above the ground on the riser. Where steel service lines are used, install an insulating joint on the inlet side of the [meter set assembly and] service regulator and construct to prevent flow of electrical current. Provide a 3/8 inch tapped fitting equipped with a plug on both sides of the service regulator for installation of pressure gauges for adjusting the regulator. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

3.14 METER INSTALLATION

Install meters in accordance with 49 CFR 192. Install permanent gas meters with provisions for isolation and removal for calibration and maintenance, and suitable for operation in conjunction with an energy monitoring and control system. Connect meter complying with the requirements of the Advanced Metering Program that is applied at the particular Government Installation of this project.

3.15 CONNECTIONS TO EXISTING LINES

Make connections between new work and existing gas lines, where required, in accordance with 49 CFR 192, using proper fittings to suit the actual conditions. When connections are made by tapping into a gas main, provide the same size connecting fittings as the pipe being connected.

3.15.1 Connections to Publicly or Privately Operated Gas Utility Lines

Provide materials for the connections to the existing gas lines. The Utility is to make final connections and turn on the gas. The Utility is to also disconnect, purge and cap, plug or otherwise effectively seal existing lines that are to be a abandoned or taken out of service. Notify the Contracting Officer, in writing, 10 days before final connections and turning on of gas lines. Make necessary arrangements with the Utility for tie in and activation of new gas lines. Only the Operating Agency/Utility Company may reactivate the system after tie in. Furnish a certification by the Operating Agency/Utility Company that all Utility work has been satisfactorily completed.

3.15.2 Connection to Government Owned/Operated Gas Lines

Provide connections to the existing gas lines in accordance with approved procedures. Only perform deactivation of any portion of the existing system at the valve location indicated. Reactivation of any existing gas lines will only be done by the [Government] [local Utility] [Operating Agency]. Submit the approved Connection and Abandonment Plan that is compliant with the requirements of 49 CFR 192, Section 727 prior to making any connections to existing gas lines, manicure the [Operating Agency's] [Utility's] required procedures which may be obtained from [_____]. Notify the Contracting Officer, in writing, 10 days before connections to existing lines are to be made.

For each pipeline that is to be abandoned in place, submit the approved Connection and Abandonment Plan that is compliant with the requirements of 49 CFR 192, Section 727. Ensure the following steps are taken at a minimum:

a. For each pipeline that is to be abandoned in place, physically disconnect that from all sources of gas. Purge, cap, plug or otherwise effectively seal the open ends of all abandoned pipelines. Do not complete abandonment until it has been determined that the volume of gas or condensed hydrocarbons contained within the abandoned section poses no potential hazard. Use air or inert gas for purging, or fill the facility with water or other inert material. If air is used for purging, ensure that a combustible mixture is not present after purging.

b. When a main is abandoned, together with the service lines connected to it, seal the disconnected end of the main and seal the customer's end of each service line as stipulated above.

c. Where service lines are to be abandoned in place, disconnect the abandoned service lines from the active mains as close to the main as practicable. 49 CFR 192 does not require individual service lines to be sealed.

d. Close all valves left in the abandoned segment.

e. Remove all above grade valves, risers, and vault and valve box covers. Fill vault and valve box voids with suitable compacted backfill material.

3.16 CATHODIC PROTECTION

Provide cathodic protection in accordance with NACE SP0169 for all metallic gas piping installed underground and install as specified in [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM] [Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM].

3.17 TESTS

3.17.1 Destructive Tests of Plastic Pipe Joints

Prior to making heat fusion joints in plastic pipelines, make a joint of each size and type to be installed that day by each person performing joining of plastic pipe that day and destructively test. Make the specimen joint per the approved written procedure. Cut at least 3 longitudinal straps from each joint. Visually examine each strap for voids or discontinuities on the cut surfaces of the joint area. Deform each of the 3 straps by bending, torque, or impact. Failures are not permitted in the joint area. If a joint fails the visual or deformation test, the qualified joiner who made that joint is not allowed to make further field joints in plastic pipe on this job until that joiner has been retrained and re-qualified. Record and submit the results of the destructive tests including the date and time of the tests, size and type of the joints, ambient conditions, fusion iron temperature and names of inspectors and joiners.

3.17.2 Pressure and Leak Tests

Test the system of gas mains and service lines after construction and before being placed in service, using a test pressure and test medium approved in 49 CFR 192 Subpart J for the applicable conditions of construction. In the event of conflict between the contract test pressure and medium and the test requirements of 49 CFR 192, refer conflict to the COR before continuing with testing. Follow all testing recommendations and safety precautions as recommended by the piping manufacturer's specifications and 49 CFR 192. Follow a written test procedure that ensures all potentially hazardous leaks are discovered. Submit data in booklet form from all pressure tests of the distribution system.

3.17.2.1 Test Pressure

Test each segment of the installed pipeline at the test pressure listed below for the applicable installation:

a. Strength test steel pipelines operated at a pressure that creates a hoop stress of 30% or more of the Specified Minimum Yield Strength (SMYS), in accordance with 49 CFR 192, Section 505, by hydrostatic testing at a minimum of 125 percent the Maximum Allowable Operating Pressure (MAOP). Maintain strength test pressure for a minimum of 8 hours.

b. For metallic mains operated at or above 100 psig that produces a hoop stress less than 30 percent SMYS, leak test in accordance with 49 CFR 192, Section 507, by [pneumatic][hydrostatic] testing at a pressure between 100 psig and the pressure required to produce a hoop stress of 20 percent of the SMYS. Maintain test pressure for a minimum of 24 hours.

c. For metallic mains operated below 100 psig, leak test in accordance with 49 CFR 192, Section 509. Leak test mains operated below 1 psig to a pressure not less than 10 psig. Leak test mains operated at or above 1 psig to a pressure not less than 90 psig. Maintain test pressure for a minimum of 24 hours.

d. For metallic service lines, leak test in accordance with 49 CFR 192, Section 511. Leak test service lines operated at 40 psig or less to a pressure not less than 50 psig. Leak test service lines operated above 40 psig to a pressure of 90 psig. Ensure that the service line connection to the main is included in this test. Maintain test pressure for a minimum of 24 hours.

e. For plastic mains and service lines, leak test in accordance with 49 CFR 192, Section 513. Leak test to a pressure at least 150% of the Maximum Allowable Operating Pressure (MAOP) or 50 psig, whichever is greater. Where a compressible gas is used as the test medium, perform pneumatic leak testing of polyethylene (PE) piping in accordance with ASTM F2786 observing the determination of Maximum Test Pressure, which is calculated using the PE material hydrostatic design stress, the pipe temperature reduction factor and the leak test duration factor. Submit a test procedure that identifies the MAOP of the pipeline, the temperature dependent maximum test pressure, and a step by step procedure for increasing the pipeline pressure as detailed in ASTM F2786 for pneumatic testing or ASTM F2164 for hydrostatic testing. From the beginning of pipeline pressurization to the depressurization of the pipeline the time duration must not exceed 8 hours. If testing must be restarted after maximum test pressure has been reached, depressurize the pipeline for a minimum of 8 hours before restart of pipeline pressurization.

3.17.2.2 Test Performance

Perform testing as follows:

a. Prior to testing the system, blow-out, clean, and clear the interior of all foreign materials. Remove all meters, regulators, and controls before blowing out and cleaning, and reinstall after clearing of all foreign materials.

b. Perform testing of gas mains and service lines with due regard for the safety of employees and the public during the test. Keep persons not working on the test operations out of the testing area during testing. Perform the test on the system as a whole or on sections that can be isolated.

c. Test joints in sections prior to backfilling when trenches are to be backfilled before the completion of other pipeline sections. Continue the test for at least 24 hours from the time of the initial readings to the final readings of pressure and temperature. Do not take the initial test readings of the instrument for at least 1 hour after the pipe has been subjected to the full test pressure. Do not take initial or final readings at times of rapid changes in atmospheric conditions, and temperatures are representative of the actual trench conditions. No indication of reduction of pressure is allowed during the test after corrections have been made for changes in atmospheric conditions in conformity with the relationship T(1)P(2)=T(2)P(1), in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial and final readings.

d. During the test, completely isolate the the entire system from all compressors and other sources of air pressure. Test each joint by means of soap and water or an equivalent nonflammable solution prior to backfilling or concealing any work. Secure approval of testing instruments from the Contracting Officer. Furnish all labor, materials and equipment for conducting the tests subject to inspection at all times during the tests. Maintain safety precautions for air pressure testing at all times during the tests.

3.17.3 Meter Test

Test meter to verify data transfer to data collection server and validate calibration of both meter and the data that is received by the data collection server.

3.18 NATURAL GAS COMPRESSORS

Natural gas compressors must be installed in accordance with all manufacturer's procedures and recommendation. Installations must comply with the design drawings and API RP 686.

3.19 MAINTENANCE

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, in three separate packages. Submit Data packages, as specified.

3.19.1 Gas Distribution System and Equipment Operation

Include maps showing piping layout, locations of system valves, gas line markers and cathodic protection system test stations; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system maps); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data Package No. 4 per Section 01 78 23.

3.19.2 Gas Distribution System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No. 4 per Section 01 78 23.

3.19.3 Gas Distribution Equipment Maintenance

Include identification of valves and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3 per Section 01 78 23.

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SECTION 33 51 39

MONITORING WELLS
08/17

PART 1 GENERAL

1.1 UNIT PRICES

Payment for each specified item is made at the contract unit price for that item. Payment includes full compensation for equipment, materials and labor for drilling; removal and disposal of temporary casing, cuttings, and drill fluid; preparation of borehole logs; and sample handling, containers, storage, and testing. Measure depth, logging, installation, casing, riser pipe, and well screen by linear distance. Payment is not allowed for test holes or wells abandoned due to construction practices not in accordance with this specification, or for the convenience of the Contractor. Submit catalog data for the well screen (to include the screen slot size), well casing, riser pipe, filter pack material, Bentonite, cement, centralizers, surface protective covers, well vaults, locking caps, airline oil filters for pneumatic drilling, dedicated sampling equipment, and chemical specifications on drill lubricants and tracers, if used. Include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

1.1.1 Test Holes

If the total depth of the test hole is greater than that specified in the contract for "Test Holes and Samples" due to justifiable site specific conditions and other justifiable reasons, the additional depth is paid for at the contract unit price for "Additional Test Hole Depth." If the test hole is developed into the permanent monitoring well, no separate payment is made for the test hole.

1.1.2 Well Drilling and Sampling

If the total depth of the well is greater than that specified in the contract for "Monitoring Wells and Samples," the additional depth is paid for at the contract unit price for "Additional Test Hole Depth."

1.1.3 Geophysical Logging

The "Geophysical Logging" unit price includes interpretation of the logs and their delivery to the Government.

1.1.4 Well Casing and Riser Pipe Selection and Installation

Payment is made for length of blank casing actually installed in the well. Payment includes compensation for decontamination and installation of the casing, riser pipe, cap, tail piece (if any), end cap and centralizers; and for the furnishing and installing of the well identification tag with information recorded thereon, or well marking in accordance with contract.

1.1.5 Monitoring Well Screen

Payment is made for monitoring well screen actually installed in the well.

1.1.6 Filter Pack Construction

Filter pack construction is measured by the cubic foot. Payment includes compensation for furnishing, delivering, storage, decontamination, analytical testing, and installing the filter pack.

1.1.7 Bentonite Seal

The bentonite seal is measured by the cubic foot. Payment includes full compensation for hydrating, and tremieing necessary for the work.

1.1.8 Grout Placement

The cement and/or bentonite grout,used in the annulus above the bentonite seal is paid by the cubic foot used. Payment includes compensation for cement, mixing of the grout, and pumping of grout, bentonite, mixing of bentonite grout, and pumping of bentonite grout, necessary for the work.

1.1.9 Monitoring Well Development

Payment for monitoring well development is made by the hour. Payment includes compensation for pumping, surging, sample photograph, discharge water containers, analysis, and disposal.

1.1.10 Monitoring Well Completion Aboveground

Payment includes compensation for protective covers, keyed-alike padlocks, locking caps, project photographs, concrete well pads, gravel, electrical components, lighting components, fencing, sign(s) and protective steel posts.

1.1.11 Monitoring Well or Test Hole Decommissioning/Abandonment

Permanent decommissioning/abandonment of monitoring wells or test holes is paid for only if it becomes necessary to abandon a well or test hole as specified, and only for work completed and accepted as specified. Payment includes compensation for drilling, casing removal, well sampling, materials, cement, mixing of cement, bentonite, and water, pumping of grout, equipment, removal of foreign objects, and transportation necessary to abandon the well or test hole and for the required well or test hole abandonment records.

1.1.12 Site Cleanup

Separate payment is not made for cleanup of the site. Cleanup means restoring the site to its pre-construction condition. Cleanup is considered part of and incidental to the drilling, construction, and/or decommissioning of the monitoring well.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 306 (2010; R 2015) Standard Specification for Drainage, Sewer, Utility, and Related

Castings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A312/A312M	(2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2021) Standard Specification for Portland Cement
ASTM C387/C387M	(2017) Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar
ASTM D1452/D1452M	(2016) Standard Practice for Soil Exploration and Sampling by Auger Borings
ASTM D1586/D1586M	(2018) Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D1587/D1587M	(2015) Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	(2017; E 2018) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4318	(2017; E 2018) Standard Test Methods for

	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4397	(2016) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM D5088	(2020) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D5092	(2016) Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers
ASTM D5521/D5521M	(2013) Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D5608	(2016) Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites
ASTM D6725/D6725M	(2016) Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers
ASTM F480	(2014; R 2022) Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80
ASTM F883	(2013; R 2022) Standard Performance Specification for Padlocks

FORESTRY SUPPLIERS INC. (FSUP)

FSUP 77341	(2009) Munsell (R) Soil Color Book

GEOLOGICAL SOCIETY OF AMERICA (GeoSA)

GSA RCC00100R	(2009) Geological Rock Color Chart (Munsell)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 530/F-93/004	(1993; Rev O; Updates I, II, IIA, IIB, and III) Test Methods for Evaluating Solid Waste (Vol IA, IB, IC, and II) (SW-846)
EPA 600-4-89-034	(1990) Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells
EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes

EPA SW-846	(Third Edition; Update IV) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

1.3 ADMINISTRATIVE REQUIREMENTS

Ensure each system, including equipment, materials, installation, and performance, is in accordance with local, State, and Federal regulations, ASTM D5092, EPA 600-4-89-034[and DoD policies and standards] except as modified herein. Consider the advisory or recommended provisions to be mandatory. Reference to the "Project Representative" and the "Owner" is interpreted to mean the Contracting Officer. Additional requirements are included under Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS.

1.3.1 Notification

Notify the [Installation Environmental Coordinator (IEC)] [_____] [and] the Contracting Officer [_____] days prior to drilling. The [Contracting Officer] [Contractor] [Installation Environmental Coordinator (IEC)] [_____] [is] [are] responsible for contacting the [State of [_____]] [USEPA] in accordance with the applicable reporting requirements.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Investigation-derived Waste Management Plan; G[, [____]]

Installation Plan; G[, [____]]

Health and Safety Plan; G[, [____]]

Sampling and Analysis Plan; G[, [____]]

Well Construction Permit

Treatment Facility Permit

Qualifications; G[, [____]]

SD-02 Shop Drawings

Survey Maps and Notes; G[, [____]]

Well Construction Drawings; G[, [____]]

SD-03 Product Data

Riser Pipe; G[, [____]]

Cement; G[, [____]]

Centralizers; G[, [____]]

Surface Protective Covers; G[, [____]]

Well Vaults; G[, [____]]

Locking Caps; G[, [____]]

Oil Filters; G[, [____]]

Sampling Equipment; G[, [____]]

Chemical Specifications on Drill Lubricants and Tracers; G[, [____]]

Well Casing; G[, [____]]

Well Screen; G[, [____]]

Filter Pack; G[, [____]]

Neat Cement Grout; G[, [____]]

Bentonite; G[, [____]]

SD-06 Test Reports

Drilling Fluid Additive; G[, [____]]

Well Development Record; G[, [____]]

Filter Pack Material Test Results; G[, [____]]

Sieve Analyses of Sampled Material; G[, [____]]

Water Source Analytical Test Results; G[, [____]]

SD-07 Certificates

Permits

Installation Survey Report

Well Development Report

Borehole Analysis Report

Shipment Manifests

Delivery Certificates

Correspondence

Photographs

Treatment and Disposal Certificates

SD-11 Closeout Submittals

Installation Diagram; G[, [____]]

Well Decommissioning/Abandonment Record

Geophysical Logs

Borehole Logs; G[, [____]]

1.5 QUALITY CONTROL

1.5.1 Qualifications

Submit personnel qualification documentation. Provide an onsite geologist with at least [3] [_____] years experience in hazardous waste projects, soil and rock logging, and monitoring well installation. Ensure the geologist is registered in the State of [_____], and responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities. Provide a driller licensed in the State of [_____], according to State requirements. Perform and provide geophysical log interpretation by a qualified log analyst, demonstrating competence through background, training, and experience when so called upon. Ensure the drill crew is experienced and trained in drilling, and health and safety requirements for contaminated sites.

Furnish documentation proving:

a. A minimum of [_____] years of monitor well installation experience

b. Appropriate health and safety personnel are on staff as specified in Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES

c. That qualified personnel are available to perform the necessary chemical sampling as presented in the approved Sampling and Analysis Plan.

1.5.2 Required Drawings

Submit well construction drawings showing components and details of well casing, well screen, filter pack, annular seal, and associated items. Ensure drawings are prepared and sealed by a State certified professional geologist, hydrogeologist, or a State registered professional civil engineer, hereafter referred to as the Contractor's Professional Consultant(CPC).

1.5.3 Investigation-derived Waste Management Plan

Furnish a material handling plan 15 days prior to initiation of the work that describes the plan for handling the investigation-derived waste, including the following: a schedule to be employed in the well drilling and development stages, a sequence of operations, the method of drilling and development, material hauling, proposed equipment, handling of the investigation-derived waste, testing requirements for the investigation-derived waste.

1.5.4 Health and Safety Plan (HASP)

Describe safety precautions for each phase of the project as specifically related to handling of soil and water removed during well drilling and development operations. Identify appropriate requirements of 29 CFR 1910 and EM 385-1-1. Identify safety equipment and procedures available for use during the project. Furnish the name and qualifications based on education, training, and work experience of the proposed Health and Safety Officer (HASO) and the members of the drill crew. The CPC may perform the responsibilities of the HASO if properly qualified.

1.5.5 Sampling and Analysis Plan (SAP)

Provide a sampling and analysis plan. Describe field sampling methods and quality control procedures. Identify a certified laboratory [approved by the Contracting Officer,]with laboratory methods to be used for contamination testing. Ensure sample reports show sample identification with location, date, time, sample method, contamination level, name of individual sampler, identification of laboratory, quality control procedures, and chain of custody information.

1.5.6 Installation Plan

Submit a plan, describing the drilling methods, sampling, and monitoring well construction and well development [30] [_____] calendar days prior to beginning drilling operations. Mobilization activities may start prior to submittal of the plan. Provide the plan approved and signed by a geologist [experienced in hazardous waste projects] as specified in the paragraph QUALIFICATIONS. Incorporate the following requirements into the Monitoring Well Installation Plan and follow in the field. Conduct sampling and testing in accordance with the guidelines as stated in: "Department of Defense Policy and Guidelines for Acquisitions Involving Environmental Sampling or Testing", November 2007. Include in the plan, but do not limit to a discussion of the following:

a. Description of well drilling methods, and installation procedures, including any temporary casing used, placement of filter pack and seal materials, drill cuttings and fluids disposal, and soil/rock sample disposition.

b. Description of well construction materials, including well screen, riser pipe, centralizers, tailpiece (if used), filter pack and filter pack gradation, bentonite, drilling fluid additives (if used), drilling water, cement, and well protective measures.

c. Description of quality control procedures to be used for placement of filter pack and seals in the boring, including depth measurements.

d. Include sample of forms used for written boring logs, installation diagrams of wells, geophysical logs, well development records, well sampling data records, State well registration forms, and well abandonment records.

e. Description of contamination prevention. Describe decontamination procedures for well materials and equipment.

f. Description of protective cover surface completion procedures, including any special design criteria/features relating to frost heave prevention. Include the maximum frost penetration for the site in this description.

g. Description of well development methods to be used.

h. List of applicable publications, including State and local regulations and standards.

i. List of personnel assignments for this project, and personnel qualifications.

j. Description of well decommissioning/abandonment procedures.

k. Description of in-situ permeability determination techniques, if testing is required.

l. Description and discussion of geophysical techniques to be employed at the site.

1.5.7 Treatment Facility Permit

Submit verification that the proposed treatment facility is permitted to accept the contaminated materials specified, prior to the start of drilling.

1.5.8 Well Development Report

Provide a report, containing the following data[for each well]: project name and location, well designation, date and time of well installation, date and time of well development, static water level from top of well casing before development and 24 hours after development, field measurements of pH, temperature, and specific conductivity, depth of well from top of casing to bottom of well, screen length, description of development methodology size/capacity of pump or bailer, pumping rate, and recharge rate.

1.5.9 Well Construction Permit

Submit a completed permit application and a proposed method of construction to[the appropriate state agency][Contracting Officer] prior to construction of the well. Well construction[s] [is][are] not allowed to start until the Contracting Officer has an approved Well Construction Permit.

1.5.10 Shipment Manifests

[Furnish copies of manifests and other documentation required for shipment of waste materials within 24 hours after removal of waste from the site.][Shipment manifests are signed by the Contracting Officer.]

1.5.11 Delivery Certificates

Submit verification that the wastes were actually delivered to the approved treatment facility, within 7 days of shipment.

1.5.12 Treatment and Disposal Certificates

Submit verification that the wastes were successfully treated and remediated to the levels specified herein.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver materials in an undamaged condition. Unload and store with minimal handling. Store materials in on-site enclosures or under protective coverings. Store [plastic piping and jointing materials, and] rubber gaskets under cover, out of direct sunlight. Store materials off the ground. Keep insides of pipes and fittings free of dirt and debris. Replace defective or damaged materials with new materials.

1.7 PROJECTS/SITE CONDITIONS

Access to each monitoring well site, including any utility clearance, permits, licenses, or other requirements and the payment thereof necessary for execution of the work is the responsibility of the [Contractor] [Government].

Submit a copy of all permits, licenses, or other requirements necessary for execution of the work to the Contracting Officer. Before beginning work,notify local United States Geological Survey office (USGS) [and the] [State Environmental Protection office] [State Geological Agency] [State health department] [local health department] [Department of Natural Resources] of the type and location of wells to be constructed, the method of construction and anticipated schedule for construction of the wells. Furnish a copy of all such well site correspondence to the Contracting Officer.

Obtaining rights-of-entry is the responsibility of the [Contractor] [Government]. Visit each proposed well location to observe any condition that may hamper transporting equipment or personnel to the site.[If clearing or relocation is necessary, the [Contractor,] [Installation Environmental Coordinator,] and the Contracting Officer will agree on a suitable clearing, or relocation plan and the location of any required access road.]

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Construct each monitoring well to yield chemically representative ground water samples from the screened interval for chemical analysis, and to allow for the accurate measurement of ground water depths relative to the top of the well riser, by use of electrical, wetted tape, or acoustical methods. The screened interval is that portion of a monitoring well which is directly open to the host aquifer by way of openings in the well screen and indirectly open to the aquifer by way of the filter pack (or other permeable material) extending continuously below and/or above the screen.

2.2 COMPONENTS

2.2.1 Well Casing

[2.2.1.1 Stainless Steel Pipe

Use ASTM A312/A312M, Type 304, Schedule 40S pipe, with flush threaded joint end fittings. Wrap threaded joints with fluoropolymer tape, and provide with nitrile O-ring gaskets.

][2.2.1.2 PVC Pipe

Use ASTM F480, Type 1, Grade 1, PVC 12454, NSF wc or NSF pw, Schedule [40] [80] pipe, with flush threaded joint fittings. Wrap threaded joints with fluoropolymer tape, and provide with nitrile O-ring gaskets.

]2.2.2 Well Screen

2.2.2.1 Stainless Steel Screens

Provide a well screen consisting of new commercially fabricated flush-joint threaded [4] [_____] inch nominal internal diameter Type [304][316][_____] stainless steel [_____][continuous wrap] [schedule [40] [_____] slotted], non-clogging design. Use screens conforming to ASTM A312/A312M, Type [316][_____], Schedule 40S, with continuous slot construction, wire wound, with flush threaded joint ends. [Provide schedule [40] [_____] end fittings on the continuous wrap screen.] Provide a screen slot size[approved by the Government] [[0.010] [0.020] [_____]-inch], and screen length of [[_____] feet]. Seal the bottom section of the screen watertight by means of a flush threaded end cap of the same material as the well screen, within 6 inches of the open portion of the screen.

2.2.2.2 PVC Screens

Provide a well screen consisting of new commercially fabricated flush-joint threaded [4] [_____] inch nominal internal diameter [polyvinyl chloride (PVC)] [_____][continuous wrap] [schedule [40] [_____] slotted], non-clogging design. Use screens conforming to ASTM D1785, PVC 1120, NSF wc or NSF pw, Schedule [40] [80], screen, Schedule 80, machine-slotted construction, flush threaded joint ends. Ensure slots are even in width, length, and separation. [Provide schedule [40] [_____] end fittings on the continuous wrap screen.] Provide required fittings conforming to ASTM F480, flush thread male by female. Provide a screen slot size[approved by the Government] [[0.010] [0.020] [_____]-inch], and screen length of [[_____] feet]. Seal the bottom section of the screen watertight by means of a flush threaded end cap of the same material as the well screen, within 6 inches of the open portion of the screen.

[2.2.2.3 Prepacked Screen Monitoring Wells

Ensure materials and installation of prepacked screen monitoring wells conform to the requirements of ASTM D6725/D6725M.

]2.2.3 Primary Filter Pack

[Provide clean, durable, well-rounded, and washed quartz or granite, with less than 5 percent non-siliceous material. Ensure the filter pack does not contain organic matter or friable materials and allow free flow of water in the well, and also prevent the infiltration of aquifer materials. Ensure the filter pack has a 30 percent finer than (d-30) grain size of [_____] inch, and a uniformity coefficient less than [2.5] [_____], in accordance with ASTM C117 and ASTM C136/C136M.

][Provide a filter pack consisting of clean, washed, rounded to sub-rounded siliceous material free from calcareous grains or material. Submit filter pack material test results consisting of sieve and chemical analyses. Organic matter, soft, friable, thin, or elongated particles are not permissible. Determine the gradation of the filter pack using the grain size analysis data obtained from test results. Use a uniformity coefficient for the filter pack material not exceeding 2.5. Fill an airtight pint size [plastic] [glass] container with a sample of filter pack material and furnish to the Contracting Officer for each well to serve as a quality control.

]2.2.3.1 Secondary Filter Pack

Ensure gradation is in accordance with ASTM D5092. Provide clean, durable, well-rounded, and washed quartz or granite. Pack cannot contain organic matter or friable materials.

2.2.4 Annular Sealants

2.2.4.1 Bentonite Seal

Provide powdered, granular, pelletized, or chipped [sodium] [calcium] montmorillonite in sealed containers from a commercial source, free of impurities. Ensure pellet size is less than one fifth the diameter of the borehole annular space to prevent bridging. Ensure bentonite base grout is in accordance with ASTM D5092.

If the bentonite seal is located above any borehole fluid levels, place a layer of fine sand at the top of the bentonite seal, to provide an additional barrier to any downward migration of grout.

2.2.4.2 Neat Cement Grout

Provide neat cement grout in accordance with ASTM D5092. Ensure cement is in accordance with ASTM C150/C150M. Quick setting admixtures are not allowed. Do not use drilling mud or cuttings as a sealing material.

2.2.4.3 Cement And Bentonite Grout

Provide cement grout with a mixture of a maximum of 7 gallons of approved water per 94 lb bag of portland cement, conforming to ASTM C150/C150M, Type [I] [_____]. Add no more than 5 percent by weight of bentonite powder to reduce shrinkage and hold the cement in suspension prior to the grout set. Use sodium bentonite powder and/or granules for high-solids bentonite grout.

2.2.5 Bottom Plugs

Provide a flush threaded solid plug at the bottom of the well. Ensure plug material is the same as the well [casing] [screen] to which it is attached. Wrap joints with fluoropolymer tape and provide nitrile O-ring gaskets.

2.2.6 Locking Well Cap

Provide a flush threaded, weatherproof, and non-removable locking well cap on the top of the well. Ensure the well cap is the same material as the well casing to which it is attached.

2.2.7 Protective Outer Casing [and Bollards]

Install a protective outer casing[and bollards] with pipes conforming to ASTM A53/A53M, Type E or S, Grade B.

2.2.8 Polyethylene Sheeting

Ensure polyethylene sheeting conforms to ASTM D4397.

PART 3 EXECUTION

Notify the Contracting Officer at least 15 days prior to commencement of work. Well locations are as indicated. Drilling, installation, and development of the monitoring well[s] is supervised, directed, and monitored by the geologist in charge. Decontaminate equipment used for drilling, sampling, and well development before and after each use in accordance with ASTM D5088.

3.1 PREPARATION

3.1.1 Water Source

If well drilling and installation requires the use of water, prior to its use at the site, locate and obtain water from a source. Sample and test the water source for the constituents specified in the Sampling and Analysis Plan. Submit the water source analytical test results to the Contracting Officer and obtain approval to use the source water. Transport and store the water at the site.

3.1.2 Decontamination

Clean the drill rig, drill rods, drill bits, augers, temporary casing, well developing equipment, tremie pipes, grout pumping lines, and other associated equipment with high-pressure hot water/steam prior to drilling at each monitoring well location. Perform decontamination in accordance with [ASTM D5088][ASTM D5608], at a central decontamination station located in an area that is remote from, and cross- or down-gradient from the well being drilled.

Clean the screen and well casing with high-pressure hot water and detergent cleaning solution immediately prior to installation in the well. The use of factory sealed (plastic wrapped) screen and well casing does not waive this requirement for pre-installation cleaning. Decontaminate samplers in accordance with the Sampling and Analysis Plan.

3.1.3 Decontamination Station

a. Construct a temporary decontamination pad onsite, bermed and slightly inclined towards a sump located in one of the back corners of the pad. Line the pads and berms with plastic sheeting to contain decontamination water. Place exterior-grade plywood sheeting over the plastic sheeting to prevent damage to the plastic and allow the drill rig and heavy equipment to use the pad.

b. Make the minimum dimensions of the pad the length and width of the drill rig, plus 4 feet per side to allow access and steam cleaning. Use yellow ribbon to encircle the decontamination pad.

c. Pump water collected in the sump to a 55 gallon drum labeled "Decontamination Pad Sump Water." Transfer solid waste to a separate 55 gallon drum labeled "Decontamination Pad Sump Sludge."

3.1.4 Containerization Of Development Water, And Drill Cuttings

Furnish D.O.T. approved [polyethylene] [steel] drums or vessels with lids, lid gaskets, bolts, chain of custody forms and drum labels. Mark each drum label in accordance with 49 CFR 172 in addition to the following information:

a. Drum number,

b. Site name,

c. Well name and number,

d. Contents and date,

e. Approximate depth of material contained in each drum, and

f. The name and phone number of the [Installation Environmental Coordinator (IEC)] [Contracting Officer] [_____].

3.2 INSTALLATION

Install the well in accordance with ASTM D5092 and EPA 600-4-89-034, and as indicated on the well construction drawings submitted by the CPC and approved by the Contracting Officer.

Prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical [or horizontal] seepage of surface water adjacent to the well into the subsurface, especially the monitoring well intake zone. Perform work in conformance with EPA 530/F-93/004, EPA 600/4-79/020,[and] EPA SW-846[.][, and][EM 385-1-1.]

Ensure the borehole is stable and verified straight before beginning installation.

Prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical [or horizontal] seepage of surface water adjacent to the well into the subsurface, especially the monitoring well intake zone. Perform work in conformance with EPA 530/F-93/004, EPA 600/4-79/020,[and] EPA SW-846[.][, and][EM 385-1-1.]

3.2.1 Drilling Method

a. Use a drilling method which prevents the collapse of formation material against the well screen and casing during installation of the well. Size the inside diameter of any temporary casing used sufficient to allow accurate placement of the screen, riser, centralizer, filter pack, seal and grout.

b. The use of drilling aids such as bentonite, other clay-based agents, or any other foreign matter capable of affecting the characteristics of the ground water is prohibited. Ensure any drilling fluid additive used is inorganic in nature. Grease or oil on drill rods, casing, or auger joints are not permitted; however, PTFE tape or vegetable oil (in solid phase form) are acceptable. Submit manufacturer's data, if available, including analytical test results of the additive, if not a part of the manufacturer's data.

c. Provide a drill rig free from leaks of fuel, hydraulic fluid, and oil which may contaminate the borehole, ground surface or drill tools. During construction of the wells, use precautions to prevent tampering with the well or entrance of foreign material. Prevent runoff from entering the well during construction. If there is an interruption in work, such as overnight shutdown or inclement weather, close the well opening with a watertight uncontaminated cover. Secure the cover in place or weighted down so that it cannot be removed except with the aid of the drilling equipment or through the use of drill tools.

Advance borehole using conventional [[10] [_____] inch hollow-stem auger] [solid auger] [rotary wash] [_____] drilling methods. If it is the opinion of the geologist in charge that an alternate drilling method is required, submit justification for a boring method change to the Contracting Officer, and receive approval for the change granted prior to drilling.

3.2.2 Test Hole Requirements

Drill one test hole for every monitoring well or well cluster installed. A well cluster, as defined in this specification, is two or more wells completed (screened) to different depths in a single borehole or in a series of boreholes in close proximity (10 feet or less) to each other. The test hole may be converted to the permanent monitor well. Log test holes in accordance with paragraph BOREHOLE LOGS, and if temporary casing is used, use in accordance with paragraph DECONTAMINATION.

3.2.3 Borehole Diameter and Depth

Provide sufficient diameter in borings for monitoring well installation to allow at least 2 inches of annular space between the borehole wall and all sides of the centered riser pipe and screen. Determine depths of individual borings [as specified in the approved Monitoring Well Installation Plan] [as indicated on the drawings] [_____], with actual depth adequate to allow for the collection of representative ground water samples for chemical analysis at the time of initial sampling.

3.2.4 Screen, Well Casing And Riser Pipe Placement

Locate well screens as indicated. Ensure the length of [each] [the] screen is as indicated. Distribute slotted openings uniformly around the circumference of the screen. Ensure the open areas approach the formation's natural porosity.

Ensure personnel wear clean cotton or surgical gloves while handling the assembly. Ensure well casings, screens, plugs, and caps are decontaminated prior to delivery by the manufacturer and certified clean. Deliver, store, and handle materials in such a manner as to ensure that grease, oil, or other contaminants do not contact any portion of the well screen and casing assembly prior to installation.

a. Provide the monitoring well screen in length [as shown on the drawings] [[____] feet long] [as determined by the Contractor and approved by the Government], with specified bottom cap securely attached, set to the appropriate depth.

b. Place the bottom of the well screen no more than 3 feet above the bottom of the drilled borehole.

c. Clean the screen and well casing and riser pipe with high pressure hot water/steam just prior to installation; allowing no foreign material to remain on the screen and well casing before installation. The use of factory-sealed (plastic wrapped) screen, free from painted markings, does not waive requirements for pre-installation cleaning. Place the well screen [as specified on the drawings] [at [_____]]. Ensure the well casing and riser pipe extends upwards from the screen to an elevation appropriate for the surface completion described in paragraph PROTECTIVE COVER PLACEMENT. Do not allow the well screen and riser pipe to drop or fall uncontrolled into the borehole.

d. Join the screen and well casing and riser pipe sections by flush threaded watertight joints and fastenings. Solvent glue or set screws are not permitted.

e. Use centralizers to ensure that the well screen and casing assembly is installed concentrically in the borehole. [Center and plumb the well by the use of a minimum of [_____] stainless steel centralizers, spaced at intervals not exceeding [20] [_____] feet along the length of the casing. Do not place centralizers on the screened interval or within the bentonite seal.]Verify the alignment of the well by passing a 5 foot long section of rigid pipe 1/4 inch smaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well is not accepted. Thoroughly clean the pipe section with high pressure hot water prior to each test. Use temporary casing, hollow stem augers or other measures, as necessary, to prevent collapse of the boring against the well screen and well casing and riser pipe prior to placement of the filter pack and sealing materials. Install a cap on the top of the riser pipe, either vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. Make cap secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

When the assembly has been installed at the appropriate elevation, adequately secure the assembly to preclude movement during placement of the filter packs and annular seals. Cap the top of the well casing during filter pack placement.

3.2.5 Filter Pack Placement

Protect filter pack material from contamination prior to placement by either storing it in plastic lined bags, or in a location protected from the weather and contamination on plastic sheeting. Transport filter pack material to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals.

Prior to commencement of work, receive approval from the Contracting Officer for equipment and methods required to place filters. Place primary and secondary filter packs as indicated on the approved well construction drawings to fill the entire annular space between the screen and casing assembly and the outside wall of the borehole. Place both the primary and secondary filters with a tremie pipe in accordance with EPA 600-4-89-034 and ASTM D5092. Placement of the primary and secondary filters by gravity or free fall methods is not allowed. Control speed of filter placement to prevent bridging and to allow for settlement. Take frequent measurements inside the annulus during tremie pipe retraction to ensure that the filter pack is properly placed.

[After the screen and well casing have been concentrically placed in the hole, construct the approved filter pack around the screen by filling the entire space between the screen and the wall of the hole over the selected screened interval. Place the lowermost [1] [_____] foot of filter pack in the boring prior to installation of the well screen, serving as a base on which to place the screen. Lower a tremie pipe having an inside nominal diameter of not less than 1 inch, to the bottom of the annulus between the hole and well. Clean the tremie pipe with high pressure hot water/steam prior to each use. Arrange the tremie pipe so that water and filter pack material fed at uniform rates are discharged as the filter pack material fills the hole from the bottom up. Raise the tremie pipe at a rate that will keep the bottom of the pipe no more than [5] [_____] feet above the top of the surface of the filter pack level, and no more than [2] [_____] feet below the surface of the filter pack level at all times.

] Dumping filter pack material from the surface of the ground and agitating the well in an effort to settle the filter material is not allowed. Install the filter pack continuously and without interruption until the filter pack has been placed [to a minimum of 3 feet above the top of the screen in the monitoring well] [to a height equal to 20 percent of the length of the screen] [to within no more than [_____] feetof the top of the ground surface]. Directly measure the depth to the top of the filter pack and record. Obtain any additional water required to be added to the filter pack material in accordance with paragraph WATER SOURCE.

3.2.6 Bentonite Seal

3.2.6.1 Bentonite Pellets

Pouring of pellets is acceptable in shallow boreholes less than 40 feet. In order to provide accurate measurement of bentonite pellet thickness in the well boring, tamp the pellet seal during measurement. If not placed in lifts, allow the seal a minimum hydration time of three hours, unless the manufacturer recommends a longer hydration time.

3.2.6.2 Bentonite Chips

Adequate annular space is required in the use of bentonite chips to reduce the risk of bridging. Chips are preferable to use over pellets when installing a seal in a deep water column. In order to provide accurate measurement of bentonite chip seal thickness in the well boring, tamp the seal during measurement. If not placed in lifts, allow the seal a minimum hydration time double the hydration time for pellets.

3.2.6.3 Bentonite Slurry

A bentonite slurry seal can be used when the seal location is too deep for the use of pellets or chips, or within a narrow borehole annulus. The slurry is made from granular or powder sodium bentonite. The specific gravity of cement grout placed atop a slurry seal will be greater than the bentonite slurry. Exercise care to preclude the grout from migrating downward into the slurry.

Mix water from an approved source with granular or powder bentonite to form a thick bentonite slurry, consisting of a mixture of bentonite and the manufacturer's recommended volume of water to achieve an optimal seal. A typical slurry mix contains at least 20 percent solids by weight and has a density of 9.4 lb per gallon of water or greater.

3.2.6.4 Bentonite Seal Thickness And Replacement

Place a minimum [3 foot][5 foot] thick hydrated bentonite seal on top of the filter pack. Control speed of bentonite placement to prevent bridging of pellets or chips, or segregation of slurry. Place Bentonite chips and pellets in lifts of 6 inches to 1 foot with each lift allowed to hydrate for a minimum of 30 minutes prior to placing the next lift. If not placed in lifts, the minimum hydration time for pellets is 3 hours, unless manufacturer recommendations for hydration are longer. The hydration time for chips can require twice the time required for pellets. Directly measure the depth to the top of the bentonite seal and record immediately after placement, without allowance for swelling. Add water to the annular space as directed by the geologist in charge to ensure complete hydration of the bentonite. If the bentonite seal is located above any borehole fluid levels, place a [1] [_____] foot layer of fine sand at the top of the bentonite seal.

3.2.7 Grout Placement

Mechanically mix a [non-shrinking cement] [high-solids bentonite] grout, and place in one continuous operation into the annulus above the bentonite seal to [within [_____] feet of] [the ground surface] [the maximum depth of frost penetration (frost line)]. Make grout injection in accordance with ASTM D5092.[If the casing interval for grouting is less than 15 feet, and without fluids after any drill casing is removed, place the grout either by pouring or pumping.]

Place cement grout in the annular space above the bentonite seal as indicated on the well construction drawings. Place the cement grout as a slurry through a tremie pipe, and inject from the bottom up. [Inject grout in one continuous operation until full strength grout flows out at the ground surface without evidence of drilling cuttings or fluid.][For deep wells, inject grout in lifts to ensure that the casing is not damaged.]Cure grout a minimum of 48 hours before beginning well development operations.

Add additional grout from the surface to maintain the level of the grout at the land surface as settlement occurs. Work is not permitted in the well within [48] [_____] hours after cement grouting.

Thoroughly clean the tremie pipe with high pressure hot water/steam before use in each well.

3.2.8 Concrete or Gravel Pad Placement

Construct a [concrete pad with a minimum radius of [2] [_____] feet from the protective casing and 4 inch] [coarse gravel blanket with a minimum radius of [4] [_____] feet from the protective casing and 6 inch] thick, sloped away from the well around the well casing at the final ground level elevation. [Prior to placement of the gravel blanket, backfill any depression existing around the well borehole to the level of the surrounding ground surface with [near-surface drill cuttings from the well] [clay] [_____].] [Furnish pre-packaged, dry, combined concrete materials for the well pads conforming to ASTM C387/C387M normal weight, normal strength concrete. Combine the dry materials with potable water and mix in an approved mixer or container until uniform in consistency and color. Limit water to the minimum amount possible.]

3.2.9 Protective Cover Placement

Provide all monitoring wells with a [steel] [_____] lockable protective enclosure set in the annular seal over the well casing with keyed-alike locks on the protective covers for all wells.

3.2.9.1 Aboveground Completions

Provide protective outer casing around the well casing extending above grade. The diameter of the protective outer casing is a minimum of 4 inches larger than the well casing diameter. The top of the protective outer casing extends a minimum of 6 inches above the top of the well casing cap. Set the protective outer casing in cement grout and extend the bottom of the protective well casing [below the depth of the frost line] [to the depth indicated]. Drill a 1/4 inch diameter weep hole in the protective outer casing 3 inches above the ground surface. Fill the annular space between the protective outer casing and the well casing with pea gravel or coarse sand to just below the level of the cap on the well casing.

[Provide 6 inch diameter steel pipe bollards, filled with concrete as indicated to protect the exposed well head.

] Provide cap on top of the protective outer casing. Ensure cap is flush threaded and of the same material as the protective outer casing. Wrap threaded joints with fluoropolymer tape and provided with nitrile O-ring gaskets.

Ensure the well cap can accommodate a padlock. Provide a long shackled padlock in accordance with ASTM F883. Provide two padlock keys to the Contracting Officer. [Ensure locks at the well site are keyed alike.]

3.2.9.2 At-Grade Completions

Provide [cast iron] [aluminum] vault box, [30 by 30 inches] [12 inch diameter] [_____], with watertight frame and cover. Select vault loading support for[AASHTO M 306 H-20 loading for traffic areas] [a 100,000 pound loading for a less than a 2 foot span for airfield locations]. Depth of frame is 6 inches. Set the frame in a concrete collar with a minimum thickness of 8 inches, and extending 4 inches beyond the edge of the frame in all directions. Ensure the frame and concrete collar is [set flush with the level of the existing pavement] [set 3 inches above the existing grade]. Provide a locking well cap on top of the well casing, which terminates inside the vault as indicated.

[3.2.9.3 Protective Steel Casing

a. Install a protective steel casing around the well casing and riser pipe by placing the protective casing into the annular seal. Clean the protective casing with high-pressure hot water/steam prior to installation to ensure that it is free of any contamination. Provide a protective casing with an inside diameter of at least 4 inches greater than the nominal diameter of the well riser. Fit the protective casing with a locking cap and install so that there is a maximum 0.2 foot clearance between the top of the in-place inner well casing cap and the bottom of the protective casing locking cap when in the locked position.

b. Position and maintain the protective casing in a plumb position. Extend the bottom of the protective casing a minimum of 2.5 feet below the top of the ground surface; extending a minimum of [2.5] [_____] feet below the maximum depth of frost penetration (frost line); and anchored into the cement grout annular seal; and also extending at least 2.5 feet above the surface of the ground. Seal and immobilize the protective casing in concrete placed around the outside of the protective casing, then place dry bentonite pellets, or granules, in the annular space below ground level within the protective casing.

c. Provide the protective casing with a 1/4 inch diameter drain hole installed just above the top of the [concrete pad] [gravel blanket]. Place coarse sand or pea gravel in the annular space between the protective casing and the riser pipe, above the drain hole, to within 3 inches from the top of the riser pipe. [Install [four] [_____] protective steel posts, located 4 feet from the well, equally spaced around the [concrete pad] [gravel blanket]. Fill the steel posts with cement. Do not install the posts in the concrete pad, but a 0.5-1.0 foot distance from the edge of the concrete pad. Set the posts in cement, and extending a minimum of 3 feet above the ground surface, with at least one third of the posts' total length below ground surface.]

[d. For wells deeper than 200 feet, verify that the well is plumb.

]][3.2.9.4 Flush-to-Ground Utility Vault

Install a flush-to-ground protective steel utility vault or manhole around the well casing and riser pipe which has been cut off below grade. Construct the flush mounted protective utility vault or manhole with a concrete ground surface seal. Extend the ground surface seal to, but not beyond, the total depth of the flush mounted protective utility vault. Install the ground surface seal around the flush mounted protective utility vault but do not place between the flush mounted protective utility vault and the well casing. Do not install the flush mounted protective utility vault in areas subject to ponding or flooding. Provide the wording "ground water monitoring well" on the flush mounted protective cover's lid or manhole cover on its outer surface. Install flush mounted protective utility vaults through an impervious surface such as asphalt or concrete. If an impervious surface does not exist, create one to support the weight of the traffic in the area. Provide a flush mounted protective utility vault consisting of a watertight metal casing with an inside diameter at least 4 inches greater than the inside diameter of the monitoring well casing, made of one continuous metal piece or two metal pieces which are joined with a continuous weld; and a minimum length of [12] [_____] inches. Allow no more than 8 inches between the top of the monitoring well casing and the top of the flush mounted protective utility vault after installation. Provide the flush mounted protective utility vault with an exterior flange or lugs. Do not allow the flush mounted protective utility vault to extend below the top of the cement/bentonite annular space seal. To prevent damage from frost heave, extend the concrete surrounding the utility vault a minimum of 12 inches below the frost line. Provide the flush mounted protective utility vault or the monitoring well with a locking mechanism and a watertight cap.

]3.2.10 Well Identification

Affix a corrosion resistant metal tag to the exterior and interior of the protective cover. [For concrete paved areas, affix the well identification tag to the concrete with four (4) hammer set nails.]Provide the metal tag stamped with the [U.S. Army Corps of Engineers CE [_____]] [_____], well identification number, elevation of the highest point on the rim of the well casing or riser pipe, elevation of the ground surface at the well, well coordinates, date of well installation, and the top of the protective casing elevation in feet as determined according to paragraph SURVEYS. Use identification numbers for the monitoring wells as indicated on the drawings.

Clearly mark and secure the well to avoid unauthorized access and tampering. Cast the words "MONITORING WELL" on the well head cover. Provide a sign reading, "WELL IS FOR MONITORING AND IS NOT SAFE FOR DRINKING." Provide stamped metal identification tag as follows:

DO NOT DISTURB
ID #: Date:
Installed By:
Total Depth:
Screened Interval:
TOC Elevation:
Other:
For Information, Call:

3.3 FIELD QUALITY CONTROL

3.3.1 Temporary Containment of Soil Removed from the Borehole

[Place soil removed from the borehole in the temporary containment area near the well site. Cover containment area with 10 mil reinforced polyethylene sheeting. Place soil removed from the borehole[s] on the impervious barrier and cover with 6 mil reinforced polyethylene sheeting. Provide a [straw bale berm][silt fence]around the outer limits of the containment area and cover with polyethylene sheets. Secure edges of sheets with weights to keep the polyethylene sheeting in place. Divert water runoff from the stockpiled material.

][Stockpile soil in trucks suitable for transporting contaminated soils as specified herein.

][3.3.2 Well Alignment

For wells deeper than 200 feet, verify that the well is plumb.

]3.3.3 Sampling

Obtain soil samples in accordance with ASTM D1452/D1452M, [ASTM D1586/D1586M][ASTM D1587/D1587M], and the Sampling and Analysis Plan. Perform standard penetration tests at the following depths: 0.0 to 1.5 feet; 1.5 to 3.0 feet; 3.0 to 4.5 feet; and 5 foot centers or at changes in soil formation thereafter.

Screen soil samples in the field. Conduct sample screening in accordance with the Sampling and Analysis Plan.

Record boring information in accordance with ASTM D2487 and ASTM D2488. Indicate groundwater elevation in the log.

3.3.4 Sampling for Chemical Analysis

Include sampling requirements for obtaining and preserving samples for chemical analysis in the Sampling and Analysis Plan.

3.3.5 Sampling for Geotechnical Analysis

Take samples of all materials penetrated by each drilled well/test hole. Perform soil sampling with a stainless steel split tube sampler using standard sampling techniques in accordance with ASTM D1586/D1586M. Extract samples from their in-situ environment in as near an intact, minimally disturbed condition as technically practical. Retrieve samples according to ASTM D1586/D1586M at least every [5] [_____] feet from each test hole. Obtain samples continuously through the area expected to be screened.

Provide a sieve analyses of sampled material, conducted in accordance with ASTM C136/C136M. Clean drive sample tools with high-pressure hot water/steam between sampling events within the same boring. Place drive-sampled materials in airtight containers and label as specified in paragraph CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and deliver to the Contracting Officer's designated facility. Test representative soil samples for grain-size distribution by mechanical means (sieves down to the No. 200 size according to ASTM C136/C136M), moisture content according to ASTM D2216 and Atterberg limits according to ASTM D4318. Prepare description and identification of soils in accordance with ASTM D2488, laboratory classification of soils in accordance with ASTM D2487, and perform sampling to allow completion of the documents described in paragraph BOREHOLE LOGS.

The geologist in charge reviews the log data from each borehole and compares the data with the well design requirements. The CPC verifies the adequacy of the well design, or offers a proposed modification to the design based on the geologic and hydrogeologic data obtained from the borehole. This review and analysis is conducted [for each borehole] [for one borehole considered representative of the entire project]. The geologist in charge submits the borehole boring logs, the well design analysis, and any proposed design modifications to the Contracting Officer in a Borehole Analysis Report.

[Any modifications to the well design approved by the Contracting Officer is considered a change to the contract documents and negotiated in accordance with the "CHANGES" clause.

][3.3.5.1 Geophysical Logging

Geophysically log the total depth of each test hole drilled. Document geophysical logging in accordance with Geophysical Logs. Run [one successful natural gamma ray or gamma-gamma for the full depth, (top to bottom of test hole);] [one successful neutron in the fluid filled portion of the hole, (top to bottom of test hole);] [one successful (top to bottom of test hole) spontaneous potential (self-potential);] [and,] [one successful (top to bottom of test hole) resistivity log], for each test hole. Perform log analyses and interpretations by a person qualified in accordance with paragraph QUALIFICATIONS.

]3.3.6 In-Situ Permeability Determination

Determine the in-situ permeability for each well following development but no sooner than [48] [_____] hours after development. After the well is developed and allowed to equilibrate for at least 24 hours, and before in-situ permeability testing, measure and record the static water level in the well. Determine, for each well installed, the in-situ permeability of the screened formation using an appropriate method after the well has been developed. State proposed details of the methods expected to be used and references for those methods in the Well Installation Plan. Except for formation water from the well, do not introduce any other water or liquid into the well.

3.3.7 Well Development

Ensure well development is in accordance with EPA 600-4-89-034 and ASTM D5092 except as modified herein. Surging, and pumping/over pumping/backwashing are acceptable development methods. Air surging and jetting are prohibited. Method of development is chosen by the geologist in charge and approved by the Contracting Officer. Well development does not begin until the well installation is complete and accepted by the Contracting Officer. Conduct well development operations continuously until development water flows clear and free of drilling fluids, cuttings, or other materials. At such time, test representative water samples for pH, temperature, and specific conductivity in accordance with EPA 600/4-79/020. Take samples every 3 hours. When stabilized readings of these parameters, as accepted by the Contracting Officer, have been achieved for 12 consecutive hours, cease well development operations.

Within 7 days of completion of each well, but no sooner than [48] [_____] hours after cement grouting is completed, develop the well. Perform development using only mechanical surging or over pumping or a combination thereof in accordance with ASTM D5521/D5521M. Include details of the proposed development method in the Well Installation Plan. Maintain a well development record in accordance with paragraph WELL DEVELOPMENT RECORDS. Development is complete when:

a. Well water is clear to the unaided eye,

b. Sediment thickness in the well is less than [1 percent of the screen length] [0.1 foot],

c. A minimum of three times the standing water volume in the well plus three times the volume of all added water and drilling fluid lost during drilling and installation of the well is removed, and

d. Stabilization has occurred for the following parameters: temperature, specific conductivity, pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity readings, measured before, twice during and after development operations. Stabilization means [variation of less than 0.2 pH units, variation of plus or minus 1 degree Fahrenheit, plus or minus 3 percent change in specific conductance; plus or minus 10mV for ORP; and plus or minus 10 percent for DO, and turbidity, measured between three consecutive readings with one casing volume of water removed between each reading] [_____]. Determine ORP in accordance with AWWA 10084. Conduct temperature, specific conductance, DO, turbidity, and pH readings in accordance with EPA 600/4-79/020. At completion of well development, collect approximately 1 pint of well water in a clear glass jar. Label the jar with project name, well number and date; and digitally photograph. Suitably backlight the subject in the photograph close-up to show the clarity of the water and any suspended sediment. The photograph is a part of the well development record. [Contain water removed during development and testing operations in D.O.T. approved drums, containers or vessels and dispose of by [_____], in accordance with paragraph CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and DRILLING WASTE DISPOSAL.] [Discharge water removed during development and testing operations to the ground surface at least [_____] feet from the well in a down gradient area.]

3.3.7.1 Well Development Records

Prepare and submit a monitoring well development record for each monitoring well installed under the supervision of the geologist present during well installation operations, within [_____] working days of the completion of development. Include the following information on the well development record, but do not limit to the following:

a. Date, time, and elevation of water level in the well, before development.

b. Depth to bottom of well, name of project and site, well identification number, and date of development.

c. Method used for development, to include size, type and make of equipment, bailer, and/or pump used during development.

d. Time spent developing the well by each method, to include typical pumping rate, if pump is used in development.

e. Volume and physical character of water removed, to include changes during development in clarity, color, particulates, and odor.

f. Volume of water added to the well, if any.

g. Source of any water added to the well.

h. Volume and physical character of sediment removed, to include changes during development in color, and odor.

i. Clarity of water before, during, and after development. Nephelometric turbidity unit (NTU) measurements.

j. Total depth of well from top of the casing and the static water level, immediately after pumping/development, and 24 consecutive hours after development.

k. Readings of pH, specific conductance, DO, ORP, and temperature taken before, during, and after development.

l. Name and job title of individual developing well.

m. Name and/or description of the disposal facility/area, for the waters removed during development.

3.3.8 Surveys

Establish coordinates and elevations for each monitoring well/test hole. Determine horizontal coordinates to the closest 1.0 foot and referenced to the State Plane Coordinate System, or Universal Transverse Mercator (UTM). If the State Plane Coordinate System/UTM is not readily available, use an existing local grid system. Obtain a ground elevation to the closest 0.1 foot at each well. The highest point on the top of the riser pipe serves as a measurement point; reference this elevation and survey to the nearest 0.01 foot using the National Geodetic Vertical Datum of [1929] [1988]. If the datum is not readily available, use the existing local vertical datum.

Plot the location, identification, coordinates, and elevations of the well and monuments on maps by a registered land surveyor licensed in the State of [_____], with a scale large enough to show their location with reference to other structures. Submit this data with a well location map as the Installation Survey Report.

3.3.8.1 Survey Maps and Notes

Prepare and submit a tabulated list of all monitoring wells and monuments, copies of all field books, maps showing the locations, and elevations of all monitoring wells, and all computation sheets, consisting of the designated number of the well or monument, the X and Y coordinates, and all the required elevations within [_____] working days after completion of the survey.

3.3.9 Project Photographs

Submit digital photographs taken before, during, and after completion of the work, of each well installation site. Also take photographs of any rock that is cored at the site; take a minimum of [one view] [[_____] views] of each well installation. If rock is cored at the site, after the core has been logged, dampen the core if it has dried, neatly arrange in the core box, and take color photographs. Document the following information:

Project No. Contract No.

Contractor/Photographer:

Photograph No. Date/Time:

Description:

Direction of View:

3.4 ADJUSTING AND CLEANING

3.4.1 Site Cleanup

After completion of the work, remove tools, appliances, surplus materials, temporary drainage, rubbish, and debris incidental to work. Backfill excavation and vehicular ruts and dress to conform with the existing landscape or terrain. Repair or replace utilities, structures, roads, fences, or any other pre-existing item damaged due to negligence. Accomplish repair or replacement prior to completion of this contract.

3.4.2 Water From Well Development Operations

Water generated during well installation will be containerized and properly characterized in accordance with State and local regulations, the SAP, and as designated by the hazardous waste and wastewater Program Managers. Determine disposal method based on the characterization of the water and recommendations from the Program Managers.

3.4.2.1 Disposal of Containerized Water

Sample and analyze water as described in the SAP.

[a. Water exhibiting TPH less than [0.5] [_____] ppm and BTEX less than [1]

[_____] ppb is considered clean. Dispose water [on-site] [on station] as directed by the Contracting Officer.

][b. If the concentration of total BTEX is greater than [1] [_____] ppb or TPH greater than [0.5] [_____] ppm, treat and dispose the water at a permitted facility.

][c. [_____].

]3.4.3 Drilling Waste Disposal

Dispose of slurry, drill cuttings, rock core; other solid or liquid material bailed, pumped, or otherwise removed from the borehole during drilling, installation, completion, and well development procedures; and fluids from material/equipment decontamination activities by [_____].

a. Soils exhibiting TPH less than [100] [_____] ppm, BTEX less than [10] [_____] ppm, TOX less than [100] [_____] ppm, passing TCLP tests, and testing negative for PCB's are considered clean dispose [on-site] [on station] as directed by the Contracting Officer.

b. Manage soils failing the TCLP test or exhibiting TOX greater than [100] [_____] ppm accordance with [applicable State and local regulations] [_____].

c. If the concentration of total BTEX is greater than [10] [_____] ppm or TPH greater than [100] [_____] ppm, provide disposal and treatment of the soil at at a permitted soil recycling facility.

3.4.4 Transportation Of Contaminated Soil And Water

Comply with Federal, State, and local requirements for transporting contaminated materials through the applicable jurisdictions and bear responsibility and cost for any noncompliance. In addition to those requirements, do the following:

a. Inspect and document vehicles and containers for proper operation and covering.

b. Inspect vehicles and containers for proper markings, manifest documents, and other requirements for waste shipment.

c. Perform and document decontamination procedures prior to leaving the worksite and again before leaving the disposal site.

3.4.5 Disposal of Contaminated Soil And Water

Dispose contaminated materials removed from the site [in accordance with the SAP.][to a treatment/disposal facility permitted to accept such materials.]

3.5 CLOSEOUT ACTIVITIES

3.5.1 Well Acceptance

Properly construct, install, develop, and test all wells according to the requirements of this specification so that they are suitable for the intended purpose. If installed wells are not functional or not in accordance with these specifications, the Contracting Officer will disapprove the well and direct repair or replacement, and instruct abandonment of the disapproved well in accordance with this specification.

3.5.2 Documentation Reports

Submit reports for well construction and development. Establish and maintain documentation reports for well construction and development to record the desired information and to assure compliance with contract requirements, including, but not limited to: borehole logs, well construction diagrams, geophysical logs, and well decommissioning/abandonment records.

3.5.2.1 Borehole Logs

Submit original borehole logs, within [_____] working days after completion of the boring and well installation procedures. Prepare and complete a borehole log for each boring drilled, prepared by the geologist present onsite during all well drilling and installation activities. Provide the log scale at [1] [_____] inch equals [1] [_____] foot. Keep copies current and complete all well logs in the field at each well site and make available at all times for inspection by the Contracting Officer. Include, as a minimum, the following:

a. Name of the project and site.

b. Boring/well identification number.

c. Location of boring (coordinates, if available).

d. Make and manufacturer's model designation of drilling equipment and name of drilling firm.

e. Date boring was drilled.

f. Reference data for all depth measurements.

g. Name of driller and name and signature of geologist preparing log.

h. Nominal hole diameter and depth at which hole diameter changes.

i. Total depth of boring.

j. Method of drilling, including sampling methods and sample depths, including those attempted with no recovery. Indication of penetration resistance such as drive hammer blows given in blows per 6 inchesof driven sample tubes. Include in information hammer weight and drop distance. Record information such as rod size, bit type, pump type, etc.. Also include a description of any temporary casing used, drill fluids and fluid additives used, if any, including brand name and amount used, along with the reason for and start (by depth) of its use, and, if measured, mud viscosities and weight.

k. Depth of each change of stratum. If location of strata change is approximate, so state in the report.

l. Description of the material of which each stratum is composed, in accordance with [ASTM D2488] [_____], and/or standard rock nomenclature, as necessary. Include in soil parameters for logging, but do not limit to: classification, depositional environment and formation, if known, Unified Soil Classification Symbol, secondary components and estimated percentages, color (using FSUP 77341 or GSA RCC00100R), plasticity, consistency (cohesive soil), density (non-cohesive soil), moisture content, structure and orientation, and grain angularity.

m. Include in rock core parameters for logging , but do not limit to: rock type, formation, modifier denoting variety (shaly, calcareous, siliceous, etc.), color (using GSA RCC00100R), hardness, degree of cementation, texture, crystalline structure and orientation, degree of weathering, solution or void conditions, primary and secondary permeability, and lost core.

n. Include the results of any chemical field screening on the boring log. Prepare classification in the field at the time of sampling. Also duly note and record the results of visual observation of the material encountered, and any unusual odor detected.

o. Depth of any observed fractures, with strike and dip, weathered zones, or any abnormalities encountered.

p. Depth and estimated percent of drill fluid loss or lost circulation. Measures taken to regain drill water circulation. Significant color changes in the drilling fluid return.

q. Depth to water, and any non-aqueous phase liquids (NAPLs) and date measured before, during, and after each drilling shift, and prior to well installation. Provide and maintain at each well under construction a portable water, and NAPL level measuring device of sufficient length to measure the water/NAPL level to [165] [_____] foot depth. Make the device onsite at all times and provide graduated measuring wire in 0.01 foot. Take water and NAPL level measurements to the nearest 0.01 foot.

r. Box or sample number. Record depths and the number of the core boxes and/or samples at the proper interval.

s. Percent Rock Core Recovery. If rock is cored, show the percent core recovery for the individual drill runs.

3.5.2.2 Installation Diagrams

Submit as-built installation diagram for each monitoring well installed within [_____] working days of the completion of the installation, prepared by the geologist present during well installation operations. The well will not be accepted by the Contracting Officer before the geologic logs and installation diagrams are received. Clearly illustrate in the diagram the as-built condition of the well and include, but do not limit to the following items:

a. Name of the project and site.

b. Well identification number.

c. Name of driller and name and signature of the geologist preparing diagram.

d. Date of well installation.

e. Description of material from which the well is constructed, including well casing and riser pipe and screen material, centralizer composition, if used, diameter and schedule of casing and screen, gradation of filter pack, lithologic description, brand name (if any), source, and processing method, and method of placement of the filter pack, bentonite seal type (pellets, granules, chips, or slurry), grout type (cement or high-solids bentonite) and type of protective cover (protective casing or flush-to-ground).

f. Total depth of well.

g. Nominal hole diameter.

h. Depth to top and bottom of screen, and filter pack.

i. Depth to top and bottom of any seals installed in the well boring (grout or bentonite).

j. Type of cement and/or bentonite used, mix ratios of grout, method of placement and quantities used.

k. Elevations/depths/heights of key features of the well, such as top of well casing and riser pipe, top and bottom of protective casing, ground surface, the depth of maximum frost penetration (frost line), bottom of well screen, top and bottom of filter pack, and top and bottom of seal.

l. Other pertinent construction details, such as slot size and percent open area of screen, type of screen, and manufacturer of screen.

m. Well location by coordinates. Include a plan sheet showing the coordinate system used and the location of each well. A plan sheet is not required for each well installation diagram; multiple wells may be shown on the same sheet.

n. Static water level upon completion of the well.

o. Special problems and their resolutions; e.g., grout in wells, lost casing, or screens, bridging, etc.

p. Description of surface completion.

3.5.3 Geophysical Logs

Prepare, complete, and submit geophysical logs for each monitoring well/test hole installed, within [_____] working days of the completion of said logging. Include the following information on the logs as a minimum:

a. Project name.

b. Test hole/monitoring well identification number.

c. Location of test hole (coordinates, and state, and county name).

d. Date test hole was drilled.

e. Fluid level in test hole before logging.

f. Fluid type and temperature.

g. Fluid resistance in ohm-m.

h. Casing type, diameter, and elevation (top and bottom).

i. Cement type and elevation (top and bottom).

j. Screen type, diameter, and elevation (top and bottom).

k. Date and time test hole was logged.

l. Reference elevation for all depth measurements.

m. Operator's name.

n. Equipment name and address.

o. Logger type and number.

p. Tool type.

q. Detector type (Nuclear Log only).

r. Source type (Nuclear Log only).

s. Source size (Nuclear Log only).

t. Source spacing (Nuclear Log only).

u. Tool length, cable head to detector.

v. Calibration.

w. Logging speed ft/min.

x. Log vertical scale ft/in.

y. Module settings.

z. Recorder settings.

aa. Document all field problems, including equipment malfunctions. This should include the steps taken to solve the problem and how the log might have been affected.

3.5.4 Well Decommissioning/Abandonment Records

Submit a well decommissioning/abandonment record, for each well, or test hole abandoned, within [_____] working days of the completion of the abandonment procedure. Include in decommissioning/abandonment records, as a minimum, the following:

a. Project name.

b. Well or test hole number.

c. Well/boring location, depth and diameter.

d. Date of decommissioning/abandonment.

e. Method of decommissioning/abandonment.

f. All materials used in the decommissioning/abandonment procedure and the interval in which test materials were placed.

g. Casing, and or other items left in hole by depth, description, and composition.

h. Description and total quantity of grout used initially.

i. Description and daily quantities of grout used to compensate for settlement.

j. Water or mud level (specify) prior to grouting and date measured.

k. The reason for decommissioning/abandonment of the monitoring well/test hole.

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SECTION 33 51 43

INSTRUMENTATION AND PERFORMANCE MONITORING OF STRUCTURES
05/22

PART 1 GENERAL

1.1 DESCRIPTION

Provide all plant, labor, equipment, and materials for the installation and maintenance of performance monitoring instrumentation for the duration of the contract. Provide all labor, equipment, and materials for data collection, data management, interpretation, and reporting unless otherwise specified.

1.1.1 Instrumentation and Monitoring Plan

Develop an Instrumentation and Monitoring Plan that outlines the project performance monitoring requirements, recommended thresholds values and response actions, as well as roles and responsibilities based on the requirements of this scope.

1.1.2 Supervision and Quality Control

Provide supervision and quality control to assure the accuracy, quality, timeliness, and completeness of the work. Provide all related and miscellaneous components and appurtenances to make the specified systems complete and functional. Perform all work in strict accordance with this section of the specifications and the applicable contract drawings.

1.1.3 Scope of Work

The following tables summarize the instrumentation that is currently installed within the project area (Existing Instruments), instrumentation to be installed as part of the contract work (New Instruments), and instrumentation that is currently installed within the project area that is to be modified (Existing Instruments to be Modified).

Existing Instruments					
Instrument	Type	Model No.	Data Collection Method	Data Collection Frequency	Existing Quantity
[Piezometer]	[Vibrating Wire Piezometer]	[_____]	[Automated]	[Hourly]	[12]
[Piezometer]	[Standpipe]	[N/A]	[Manual]	[Monthly]	[5]
[Inclinometer]	[Traversing]	[_____]	[Manual]	[Quarterly]	[3]
[Rain Gauge]	[Tipping Bucket]	[_____]	[Automated]	[Daily]	[1]

New Instruments to be Installed				
Instrument	Type	Data Collection Method	Data Collection Frequency	Existing Quantity
[Piezometer]	[Vibrating Wire Piezometer]	[Automated]	[Hourly]	[20]
[Piezometer]	[Standpipe]	[Manual]	[Monthly]	[5]
[Inclinometer]	[Traversing]	[Manual]	[Quarterly]	[2]
[Tilt Meter]	[Biaxial MEMS]	[Automated]	[Daily]	[1]

Existing Instruments to be Modified		
General Description	Data Collection Method	Quantity
[Retrofit existing standpipe piezometer with vibrating wire transducer]	[Automated]	[3]
[Change riser elevation of standpipe piezometer]	[Manual]	[2]
[Change riser elevation of manual inclinometer]	[Manual]	[2]
[Decommission inclinometer]	[Manual]	[1]

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B40.100 (2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM D1785 (2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120

ASTM D5640 (1995; R 2008) Standard Guide for Selection of Weirs and Flumes for Open-Channel Flow Measurement of Water

ASTM F480 (2014; R 2022) Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA

	20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-1-1002	(2012) Survey Markers and Monumentations
EM 1110-2-1908	(2020) Instrumentation of Embankment Dams and Levees
ER 1110-1-1807	(2014) Drilling in Earth Embankment Dams and Levees

1.3 DEFINITIONS

1.3.1 Automated Data Acquisition System (ADAS)

An Automated Data Acquisition System (ADAS) is a system of electronic devices that automatically collect, process, store, and transmit measurements from instrument sensors. An ADAS may include, but is not limited to the following components: dataloggers, vibrating wire analyzer, LMU/RMU, RIO, multiplexer, power, and communication hardware and service. The system also includes enclosures and mounts, software, and transient voltage surge suppressors.

1.3.2 Readout Unit

A readout unit is a device used to display measurements from an instrument. Some readout units also have data collection capability. The readout unit may be portable and connected to instrument terminals when monitoring is required (e.g. notebook computer, datalogger, or a proprietary system), or may be an on-line connection (fixed line or wireless) to a remote monitoring system.

1.3.3 Data Collector

A data collector is a device used to collect, store, and transfer recorded data from an instrument. A data collector may be a portable device or be located in-place at the instrument location. Data collectors may be equipped with remote data access.

1.3.4 Data Logger

A data logger is a device that can perform measurements at a prescribed interval, process the data from raw values to engineering units, store time-stamped data, and communicate with other devices.

1.3.5 LMU/RMU

Local monitoring unit (LMU) and remote monitoring unit (RMU) are electronic units comprised of a datalogger along with, but not limited to, associated power, communication equipment, and enclosure. They have both inputs to read sensors and outputs to control other devices. LMU/RMU can perform calculations, run programs that have been uploaded to it, and can interface with other LMUs and RMUs and a central control unit via some means of communications. It can hold and store data and then transmit it upon individual data calls or can be retrieved by a remote server via FTP on an as needed basis. LMU and RMU differ only in communication method. RMUs communicate via radio or some other method that designates them as remote from the central control unit.

1.3.6 RIO

A remote input output (RIO) unit is an automated measurement device without onboard data storage. It is comprised of a power supply, communication equipment (for transferring data to LMU/RMU), and enclosure. RIOs report instrumentation readings upon request from a LMU/RMU. A RIO unit may have a multiplexer attached to it.

1.3.7 Multiplexer

A multiplexer is a device used to allow several sensors to share one input channel of the LMU/RMU. This allows many more sensors to be read by one LMU/RMU. A multiplexer is used in conjunction with LMU/RMU software that controls which input channel is being read so that each sensor value is stored in the correct memory location.

1.3.8 Communications

Communications is a method used to allow two devices to "talk" to or exchange information with one another. This can be by wire, fiber optic cable, satellite, radio or other means. In every case there is a preferred "language" for sending the data. This is often referred to as the "protocol". The protocol may be different for each sending method.

1.4 QUALITY ASSURANCE

In addition to using the current state of practice in the field of geotechnical and structural instrumentation and all manufacturer's recommendations for installation and operation; the following Codes, standards, regulations, and references apply for all features of the instrumentation system with the most stringent being applicable: NFPA 70[, EM 1110-2-1908][_____].

1.5 MEASUREMENT AND PAYMENT

1.5.1 Method of Measurement

1.5.1.1 Readout Units

Readout unit quantities will be measured by each complete readout unit provided and any peripheral equipment or materials needed for them to perform their data collection function, such as batteries and terminal clips.

1.5.1.2 Data Collector

Data collector quantities will be measured by each complete data collector provided and any peripheral equipment or materials needed for them to perform their data collection function, such as batteries and terminal clips.

1.5.1.3 Instruments

Instrument quantities will be measured as follows:

a. [Open Tube Piezometer][Observation/Monitoring well]: by the linear foot from the instrument tip to the riser top. Any required length over a foot will be counted to the next foot for measurement. All materials for the installation, to include at a minimum, cap, screen, connectors, [PVC][steel] pipe, [vibrating wire instrument and wiring][_____], sand pack, bentonite for zone sealing, grout fill in rock; and granular fill in soil must be included in the payment per linear foot. Drilling of borehole is a separate pay item. Linear Foot (LF) per borehole location.

b. [Fully Grouted Piezometer][Closed Tube Piezometer] [one] [two]: per borehole, by the linear foot from the bottom of the piezometer to the ground surface. Any required length over a foot will be counted to the next foot for measurement. All materials for the installation, to include at a minimum, the cap, screen, connectors, PVC pipe, vibrating wire instruments and wiring, and grout must be included in the payment per linear foot. Drilling of borehole is a separate pay item. Linear Foot (LF) per borehole location.

For the following instruments a complete installation means: All materials necessary to provide a fully functioning unit to include, but not be limited to, connection to surfaces, wiring and or wireless communication equipment, enclosures, batteries, as required to fully function with the specified readout and/or data collector device.

c. Vibrating wire instrument: by each complete installation. Each (EA)

d. Water level sensor: by each complete installation. Each (EA)

e. Staff gauge: by each complete installation. Each (EA)

f. Pipe Flow Meter: by each complete installation. Each (EA)

g. Weir: by each complete installation. Each (EA)

h. Flume: by each complete installation. Each (EA)

i. Weather station: by each complete installation. Each (EA)

j. Barometer: by each complete installation. Each (EA)

k. Automated Multiparameter Sonde: by each complete installation. Each (EA)

l. pH sensor: by each complete installation. Each (EA)

m. Turbidity meter: by each complete installation. Each (EA)

n. Temperature sensor: by each complete installation. Each (EA)

o. Conductivity meter: by each complete installation. Each (EA)

p. [Probe][Fixed Borehole]Extensometer: by the linear foot from the bottom of the borehole anchor to the top of the extensometer. Any required length over a foot will be counted to the next foot for measurement. Include all installation materials in the payment per linear foot. Drilling of borehole is a separate pay item Linear Foot

(LF)

q. Settlement [Surface Points][Plates]: by each complete installation. Each (EA)

r. Borros Type Anchor: by the linear foot from the bottom of the point to the ground surface. Linear Foot (LF)

s. [Portable (Traversing)][Automated In-Place] Inclinometer Casing: by the linear foot from the bottom cap to the ground surface. Any required length over a foot will be counted to the next foot for measurement. All materials for the installation to include casing, cap, grout, inclinometer, and cable, and covers. Drilling of borehole is a separate pay item. Linear Foot (LF) per borehole location.

t. [Portable (Traversing) Probe][Automated In-Place Sensors]: Each (EA)

u. Crackmeter/Jointmeter: by each complete installation. Each (EA)

v. Tiltmeter: by each complete installation. Each (EA)

w. Terrestrial Positioning System: by each complete installation. Each (EA)

x. Surface Monument: by each complete installation. Each (EA)

y. Survey Prism: by each complete installation. Each (EA)

z. Earth pressure cell: by each complete installation. Each (EA)

aa. Load cell: by each complete installation. Each (EA)

bb. Strain Gauge: by each complete installation. Each (EA)

cc. Signal Cable, Linear Foot (LF)

dd. Outdoor camera: by each complete installation. Each (EA)

ee. Seismograph: by each complete installation. Each (EA)

ff. Time Domain Reflectometer, Linear Foot (LF)

gg. Pendulum, Each (EA)

1.5.1.4 ADAS

The Automated Data Acquisition System (ADAS) will be measured on a lump sum basis. This does not include the individual instruments listed in the prior paragraph. This item includes all equipment, supplies, materials, and programming/configuration necessary for a fully functional ADAS which polls and communicates successfully with those data collection devices identified separately above. This item includes, but is not limited to, the following components:

a. Enclosures and mounts.

b. Data loggers.

c. LMU/RMU.

d. RIO.

e. Multiplexer.

f. Power.

g. Software.

h. Transient voltage surge suppressors.

i. Communication hardware and services.

1.5.1.5 General Instrumentation Requirements

General instrumentation requirements will be measured on a [lump sum][per month] basis.

1.5.1.6 Vibration Monitoring

Vibration monitoring will be measured on a [lump sum][per month] basis.

1.5.2 Basis of Payment

1.5.2.1 Readout Units

Payment will be made at the Base Bid contract line item price for each readout unit listed below, which price will constitute full compensation for providing the readout unit including factory calibrations, pre installation acceptance testing, any peripheral equipment or materials needed for them to perform their data collection function, instruction manuals, and delivery to the Government as specified:

a. [Open tube piezometer][Observation well]: water level indicator.

b. [Fully grouted piezometer][Closed tube Piezometer]: readout unit.

c. Water level sensor: readout unit.

d. pH sensor: readout unit.

e. Turbidity meter: readout unit.

f. Temperature sensor: readout unit.

g. Conductivity meter: readout unit.

h. [Probe][Fixed Borehole] Extensometer: reed switch probe, tape, and reel.

i. [Portable (Traversing)][Automated In-Place] Inclinometer: probe, carrying case, cable, readout unit, and software.

j. Crackmeter/Jointmeter: readout unit.

k. Tiltmeter: readout unit.

l. Earth pressure cells: readout unit.

m. Load cells: readout unit.

n. Strain Gauge: portable readout unit.

o. Signal Cable: readout unit.

p. Seismograph.

1.5.2.2 Data Collector

Payment will be made at the Base Bid contract line item price for each data collector listed below, which price will constitute full compensation for providing the data collector including factory calibrations, any peripheral equipment or materials needed for them to perform their data collection function, instruction manuals, and delivery to the Government as specified:

[_____]

1.5.2.3 Instruments

Payment will be made at the Base Bid contract line item price for each instrument listed below, which price will constitute full compensation for all materials left in place, all cable, labor, tools and equipment, instruction manuals, [drilling,][sampling,]pre installation acceptance testing, installation, post installation acceptance testing, installation of surface and other protection, determination of as-built location, and all incidentals necessary to complete the work in accordance with the plans and in every respect to the satisfaction of the Government:

a. [Open tube piezometer][Observation well]

b. [Fully grouted piezometer][Closed tube Piezometer]

c. Water level sensor

d. Staff gauge

e. Pipe Flow Meter

f. Weir

g. Flume

h. Weather station

i. Barometer

j. pH sensor

k. Turbidity meter

l. Temperature sensor

m. Conductivity meter

n. [Probe][Fixed Borehole] Extensometer

o. Settlement [Surface Points][Plates]

p. Borros Type Anchor

q. [Portable (Traversing)][Automated In-Place] Inclinometer

r. Crackmeter/Jointmeter

s. Tiltmeter

t. High Precision GPS Unit

u. Terrestrial Positioning System

v. Surface Monument

w. Survey Prism

x. Earth pressure cell

y. Load cell

z. Strain Gauge

aa. Signal Cable

bb. Outdoor camera

cc. Seismograph

1.5.2.4 ADAS

The Automated Data Acquisition System (ADAS) will be paid for at the base bid contract lump sum price. This item includes all equipment, supplies, materials, programming/configuration, and labor to have a fully functional ADAS. This system must poll and communicate successfully with those data collection devices identified separately above such as fully grouted piezometers, weather stations, etc. This item includes, but is not limited to, the following components:

a. Enclosures and mounts

b. Data loggers

c. LMU/RMU

d. RIO

e. Multiplexer

f. Power

g. Software

h. Architecture

i. Transient voltage surge suppressors

j. Communication hardware and services

1.5.2.5 General Instrumentation Requirements

General instrumentation requirements provided will be paid for at the base bid contract [lump sum price][line item price per month]. This item includes the following:

a. Protecting and maintaining all instruments.

b. Repairing or replacing damaged instruments.

c. Storing and disposing of instruments.

d. Providing safe access to instruments for data collection by the Government.

e. Monitoring and data collection.

f. Interpreting data.

g. Presenting data.

h. All other items of work specified in this Section for which no separate bid item is provided.

1.5.2.6 Vibration Monitoring

Vibration monitoring will be paid for at the base bid contract [lump sum price][line item price per month] and includes provision of all material, labor, and equipment necessary to meet the requirements in this section, including, but not limited to the following:

a. Vibration Test Program and Report

b. Public meeting

c. Preconstruction and Postconstruction Condition surveys

d. Vibration monitoring and reports

e. Monitoring instruments for structural movement or settlement, vibration, and noise reduction mitigation measures

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Instrumentation Specialist; G[, [_____]], RO

Instrumentation and Monitoring Plan; G[, [_____]], RO

Permit Documentation; G[, [_____]], RO

Backups, Archiving, And Disaster Recovery Plan; G[, [_____]], RO

Seismologist/Vibration Consultant; G[, [_____]], RO

Vibration Monitoring Plan; G[, [_____]], RO

Preconstruction Condition Survey; G[, [_____]], RO

Drilling Program Plan; G[, [_____]], RO

Grounding And Lightning Protection Plan; G[, [_____]], RO

Quick Reference Guide; G[, [_____]], RO

Web Interface; G[, [_____]], RO

SD-02 Shop Drawings

Instrument Modification Report; G[, [_____]], RO

SD-03 Product Data

Factory Test Reports; G[, [_____]], RO

Riser Pipe; G[, [_____]], RO

Filter Pack Material; G[, [_____]], RO

Proprietary Data Determination Request; G[, [_____]], RO

Raw Data; G[, [_____]], RO

SD-05 Design Data

Method Statements; G[, [_____]], RO

Grout Mix Design; G[, [_____]], RO

SD-06 Test Reports

Pre-Installation Acceptance Tests; G[, [_____]], RO

Vibration Test Program And Report; G[, [_____]], RO

Vibration Complaint Report; G[, [_____]], RO

Monitoring Data Reports; G[, [_____]], RO

Deficiency Correction Report; G[, [_____]], RO

Instrument Alert Assessment; G[, [_____]], RO

Action Threshold Exceedance Report; G[, [_____]], RO

Daily Vibration Monitoring Reports; G[, [_____]], RO

Postconstruction Condition Survey; G[, [_____]], RO

Installation Record; G[, [_____]], RO

SD-07 Certificates

Seismologist/Vibration Consultant Qualifications; G[, [_____]], RO

Instrumentation Specialist Qualifications; G[, [_____]], RO

SD-08 Manufacturer's Instructions

Factory Test Reports; G[, [_____]], RO

SD-10 Operation and Maintenance Data

Installation; G[, [_____]], RO

Instrument Modification Report; G[, [_____]], RO

Operations Manual; G[, [_____]], RO

SD-11 Closeout Submittals

Instrument Removal List; G[, [_____]], RO

As-Built Drawings; G[, [_____]], RO

ADAS Final Report; G[, [_____]], RO

1.7 INSTRUMENTATION SPECIALIST

1.7.1 General

Acquisition of reliable and high-quality data is the primary objective of the instrumentation specialist. This individual must be retained by the contractor for the duration of the work. Approval of an equivalent backup is required prior to the start of the work. Duties of the instrumentation specialist include selection of the instruments to be purchased by the Contractor; installation, calibration, and maintenance of that specialized equipment in the field; and acquisition and reporting of readings. Supporting work, which does not require specialized skills, may be performed by the construction contractor. See Section [01 31 20 PROJECT TECHNICAL DATA MANAGEMENT AND VISUALIZAION][_____] for requirements of the [Data Manager][Instrumentation Data Manager][_____] position.

1.7.2 Qualifications

The individual assigned as lead instrumentation specialist must be a registered Professional Engineer (PE) and recognized professional in the field of instrumentation and monitoring of geotechnical and hydraulic structures with over [5][10] years of work experience relevant to the scope and magnitude of work specified in this contract. An experienced alternate individual, not meeting the PE license requirement, may work under the direction and supervision of the PE to carry out all tasks of the instrumentation specialist, with exception of the selection of alert values, analysis of reported instrument readings, and directed response actions. A detailed, concise narrative describing the instrumentation specialist qualifications and relevant work completed by those experienced alternate individuals on a minimum of [3][_____] projects, within the last [7][_____] years, is required for Government review and approval. Likewise, equivalent backups meeting the aforementioned qualifications must be identified and included with the required submittal of the instrumentation specialist(s).

The responsibilities of the instrumentation specialist are selection of the instruments required for purchase for the work; installation, calibration, and performing necessary maintenance of that specialized equipment in the field; and compiling readings and reporting them. Supporting work, which does not require specialized skills, may be performed by the construction contractor, with prior approval of the Government.

1.7.3 Instrumentation and Monitoring Plan

An Instrumentation and Monitoring Plan must be prepared by the Instrumentation Specialist and submitted for Government approval a minimum of 30 days prior to any work being completed at the site. No physical work is to start at the site until this plan is approved by the Government. At a minimum, the Instrumentation and Monitoring Plan must address the following: responsibilities and authority for all phase of the monitoring program; types (including detailed manufacturer data), purpose, and location of each instrument; installation procedures (detailed below) and documentation; instrument reliability and limitations; calibration and maintenance, in accordance with manufacturer's requirements and EM 1110-2-1908; redundancy; backup instruments/parts; baseline data; procedures for ensuring data validity; data collection frequency; visual observation; data processing and reporting including example tables and plots; and threshold values and response actions.

Include detailed method statements for installation of each type of instrument. Method statements must list the sequence of carrying out the work and include such dimensioned sketches, completed using computer-aided design and drafting (CADD) software, as may be required to illustrate the spatial or temporal relationship of the various components of the work. The method statements must include:

a. Method of pre-installation acceptance tests.

b. Description of quality control procedures.

c. Full details of both type and quantity of any equipment to be used.

d. Drillhole diameter, drill casing size, the method and sequence of withdrawing drilling casing.

e. Method of cleaning the inside of casing, where applicable.

f. Specifications for proposed grout mixes, including commercial names, proportions of admixtures and water, mixing sequence, mixing methods and duration, pumping methods and tremie pipe type, size and quantity and means of grout quality control.

g. Depth increments for backfilling drillholes with sand and/ or granular bentonite.

h. Method of overcoming buoyancy of instrumentation components during grouting.

i. Method of sealing joints in pipes, tubes, and inclinometer casing to prevent ingress of grout.

j. Method of conducting post-installation acceptance tests.

k. Method of protecting instruments from damage.

l. Method of determining as-built locations.

m. Method of field calibration and maintenance of each type of instrument.

n. Calibration and maintenance schedule for each type of instrument.

o. Method of supplying power, when applicable.

p. Method of monitoring each type of instrument, including method of identifying and eliminating any reading errors.

q. Method of carrying out temperature corrections and/or barometric pressure corrections, when applicable.

qr Method of data reporting for each type of instrument, including method of transmitting and storing data.

s. Drillhole record forms.

1.8 SEISMOLOGIST/VIBRATION CONSULTANT

1.8.1 General

An independent Seismologist/Vibration Consultant is required to monitor, record, analyze, and report the ground and noise vibrations being generated by construction activities. Such construction activities include, but are not limited to, [hauling,][excavation,][trenching,][blasting,][drilling,][fill and backfill placement,][compaction,][pile driving,]and other activities which may generate ground vibrations and noise. Within [60 calendar][_____] days of the Notice to Proceed, the Contractor must submit the Seismologist/Vibration Consultant along with names and resume of qualifications of the personnel dedicated to this project.

1.8.2 Qualifications

The Seismologist/Vibration Consultant must be a registered Professional Engineer with a minimum of [5][_____] years of experience, including a minimum of four projects of similar magnitude and subsurface conditions. This individual must have experience with assessing vibration monitoring and recording operations, interpreting ground vibration and sound data, determining parameter values for vibration attenuation through soil, analyzing ground motion spectra, and assessing the structural responses to vibrations. The Seismologist/Vibration Consultant qualifications also include experience with pre- and post-construction condition surveys of structures, familiarity with construction methods and materials, and knowledge of structural response to ground vibrations generated by construction activities. The Professional Engineer must sign and seal all reports, results, interpretations, and assessments obtained from vibration monitoring and structural condition surveys. The Professional Engineer must be on site and supervise the initial installation of each vibration monitoring instrument, [the Vibration Test Program][_____], [Public Meeting][_____], and [Preconstruction and Postconstruction Condition Surveys][_____].

A minimum of one on-site technician, working under direct supervision of the Seismologist/Vibration Consultant, must be on site full-time during the construction. The on-site technician must have a minimum of five years of experience in controlling and monitoring vibrations originating from construction activities and be experienced and trained to install and use vibration monitoring instrumentation and interpret the instrumentation data. Their experience and training must also include analyzing ground and sound vibration parameters, implementing proper monitoring and recording methods, knowledge of proper vibration control methods, capability to install and read supplemental instrumentation to monitor movement and settlement of structures.

1.8.3 Vibration Monitoring Plan

A Vibration Monitoring plan must be prepared by the Seismologist/Vibration Consultant and submitted by the Contractor [60 calendar][_____] days prior to any on-site work.

The Vibration Monitoring Plan must include, but is not limited to, the following:

a. A description of the organizations and individuals that will be involved in the vibration monitoring activities, including planned duties, responsibilities and authorities of the organizations and individuals, and contact information for organizations and key individuals.

b. A description of the monitoring equipment in accordance with Paragraph VIBRATION MONITORING INSTRUMENTATION with example data output.

c. List established or estimated vibration limits (peak particle velocity at [25-foot][_____] distance) for the particular construction equipment and methods proposed. Provide evidence or justification that the proposed construction equipment and methods meets the specified vibration limits, in accordance with paragraph CONSTRUCTION VIBRATION CONTROL AND MONITORING.

d. A description of the location, methods, equipment, and procedures that will be used to perform Vibration Test Program on various construction equipment in accordance with paragraph VIBRATION TEST PROGRAM AND REPORT.

e. Provide an initial plan for typical setup and location of vibration monitoring equipment during various construction activities.

f. Provide description of any separate measures or methods required to reduce vibrations.

g. Provide procedure for addressing public complaints pertaining to construction vibrations, noise levels and potential damages. Include an example of a Vibration Complaint Report. Include a vibration screening procedure that includes both defining the problem and actions required to be taken.

1.9 SEQUENCING AND SCHEDULING

1.9.1 Scheduling Work

Install instruments and receive Government concurrence on formal initial readings prior to the start of related construction activities as detailed in paragraph BASELINE READINGS.

1.9.2 Vibration Monitoring Schedule

The frequency and duration of vibration monitoring for any construction activity must be performed in accordance with the approved Vibration Monitoring Plan. The Contractor must make all necessary arrangements for scheduling the Seismologist/Vibration Consultant. Construction activities requiring monitoring must not begin until the approved Seismologist/Vibration Consultant's on-site technician is onsite.

1.10 DATA REQUIREMENTS

1.10.1 Data Ownership

All data generated on site by instrumentation, monitoring, construction equipment, sampling, testing, and other data associated with the construction of the project is the property of the Government. For any data the Contractor wishes to exclude from the system, submit a Proprietary Data Determination Request including detailed justification to the Government for determination of whether data can be classified as proprietary. No data source is exempt from these data requirements unless a specific exemption is requested of and granted by the Government. Do not allow "proprietary data" to impede the Government's ability to monitor construction, perform analyses, or evaluate the effectiveness of construction.

1.10.2 Data Integrity

Maintain the integrity of data such that records are accurate and internally consistent. Ensure that all data and records reflect the quality of the data gathered on the site and that all data is preserved and archived for future use.

1.10.3 Backups, Archiving, and Disaster Recovery

Minimize data loss by backup and archival of all digital and paper data records from the time of data generation until final data turnover. This includes having specific policies, workflows, and infrastructure in place to archive and have redundant backups on servers in either the cloud or multiple locations according to industry standard practice. Detail this information in a Backups, Archiving, and Disaster Recovery Plan submittal for Government review and approval prior to the start of work.

If a data loss occurs, the Contractor is responsible for regeneration of the data. Any data which is re-generated from a non-primary source must be clearly noted in the record shown in the [EDB][_____]. Backup data within [24 hours][_____] of generation. Should a data loss occur, even if it is within this [24-hour][_____] window, the Contractor is responsible for all steps necessary to recover from this data loss and will receive no additional payment for these data recovery efforts.

1.10.4 Disclosure of Data or Advertisement of Project

Do not disclose any project data to third parties, and do not publish any data without prior written approval of the Government. This includes, but is not limited to, published papers or presentations to any third parties not associated with this contract.

1.11 DELIVERY, STORAGE, AND HANDLING

Deliver all instrumentation materials to the site in undamaged condition and store in an indoor, clean, dry, and secure storage space, that is approved by the Government, after receipt at the site and prior to installation. Instrument components must not be exposed to temperatures outside the manufacturer's stated working temperature range. The materials, instruments, and hardware must be stored, handled, and installed in such a manner as to preclude damage. The Contractor must restore or replace, at no cost to the Government, any items damaged or lost during storage, handling, or installation.

PART 2 PRODUCTS

2.1 GENERAL

All products in this section must conform to the requirements indicated on the Drawings, or specified herein, to adequately monitor the condition and record data to ensure performance parameters are met. A summary of existing instruments at [_____], including those to be modified, as well as new instruments to be installed as part of this contract are included in tabular format in paragraph DESCRIPTION above.

All products must be the standard products of a manufacturer regularly engaged in the manufacture of such.

All components provided for connection with an existing automated data acquisition system (ADAS) must function properly with that system, if it's specified to remain in operation, or with a new system, if one is specified for installation.

2.2 MATERIALS

2.2.1 General

All materials must conform to the Buy American Act. They must be new and meeting the requirements indicated on the drawings or referred to herein, and, when not covered thereby, materials and equipment of commercial grade quality suited to the intended use and as approved by the Government must be furnished. All materials must be compatible and match the existing equipment at the project location, if applicable. If multiples of the same instrument are required, use the same manufacturer for each.

2.2.2 Instrument Factory Calibration

A factory calibration must be conducted on all instruments at the place of manufacture prior to shipment. For each factory calibration include a calibration curve with data points clearly marked and a tabulation of the data and required formulae for data reduction. Ensure each instrument is marked with a unique identification number or serial number. Provide the manufacturer's [warranty][extended warranty] for each instrument and readout unit. Submit required factory test reports to the Government for approval.

2.3 PORE-PRESSURE AND GROUNDWATER MONITORING

2.3.1 [Open-Tube Piezometer][Observation/Monitoring Well]

[2.3.1.1 Porous Tip/Casagrande Filter

For porous tip or Casagrande filter, provide high-density polyethylene plastic with 60 micron pores meeting the requirements shown on the drawings. Each porous tube must be free from contamination by dirt, mud, oil, or any other substance which in the Government's opinion may contribute to the reduced performance of the instrument. Porous tips with any oil or mud smears will be considered unsatisfactory for installation and must be replaced at the Contractor's expense. Instruments, which have been contaminated, must be properly abandoned and replaced at the Contractor's expense. Immerse each tip in water for not less than 24 hours before installation. No glues or primers are permitted on the porous portion of the tips.

[2.3.1.1.1 Stainless Steel Screen

Provide [continuous wire-wound non-clogging stainless steel screen][drive-in stainless steel filter] with threaded couplings of the specified screen length, [slot width][opening size] and screen diameter as shown on the drawings. For PVC wire wrapped screen, it must be continuous, wire-wound PVC, non-solvent welded with threaded couplings which must mate with the PVC casing.

][2.3.1.1.2 Slotted Screen

Construct slotted screens of flush-joint Schedule [40][80] PVC conforming to the requirements of ASTM D1785 and ASTM F480. Determine slot diameter, spacing, and screen length based on hydrologic conditions, analysis of formation materials, or interpretation of geotechnical logs, if no specific requirements are included on the drawings.

][2.3.1.1.3 Perforated Screen

Provide perforated screens consisting of Schedule [40][80] high-density polyethylene plastic conforming to the requirements of ASTM D1785 and ASTM F480 and as detailed on the drawings. Each screen must be free from contamination of dirt, mud, oil, or any other substance which in the Government's opinion may contribute to the reduced performance of the instrument. Any screen material with mud smears will be considered unsatisfactory for installation and must be replaced at the Contractor's expense. Instruments, which have been contaminated, must be properly abandoned and replaced at the Contractor's expense.

]]2.3.1.2 Riser Pipe

Provide riser pipe consisting of PVC or stainless-steel well casing. PVC pipe must be watertight, flush-joint schedule [40][80] conforming to the requirements of ASTM D1785 and ASTM F480 and as detailed on the drawings. Provide glue and primer for assembly of the piezometer tip and pipe as recommended by the manufacturer.. Steel well casing must be threaded and coupled black carbon steel pipe with no mill coating and a minimum wall thickness of 0.237 inches.

2.3.1.3 Sump or Cap/Bottom Plug

For bottom plug, provide Schedule [40][80] PVC with a flush-joint coupling, or approved equivalent. For a steel bottom plug, provide a threaded and coupled black carbon steel Schedule 40 with no mill coating. An end cap may also be attached directly to the bottom of the screen or sump.

2.3.1.4 Centralizers

Attach centralizers, constructed of PVC or stainless steel, to the riser pipe with clamps. Centralizer ribs must have sufficient strength to adequately center the riser pipe in the drill hole. Centralizers for steel surface casing may be carbon steel and welded to the casing.

2.3.1.5 Filter Pack Material

Provide filter pack material of uniformly graded silica sand of grade [_____] provided below and dimensioned as shown on the drawings. Filter material must consist of washed, clean, uniform, tough, and durable particles free from any coating. The filter material must not contain any detrimental impurities or soft, friable, thin, or elongated particles. Submit filter pack material source, gradation, and quality test result information to the Government for review and approval prior to installation.

GRADE 6/9 TYPICAL SIEVE ANALYSIS			GRADE 8/12 TYPICAL SIEVE ANALYSIS		
SIEVE	PERCENT RETAINED	PERCENT PASSING	SIEVE	PERCENT RETAINED	PERCENT PASSING
No. 4	0.1	99.9	No. 4	0.49	99.5
No. 6	1.4	98.5	No. 6	23.85	75.7
No. 7	19.2	79.3	No. 7	38.39	37.3
No. 8	64.1	15.2	No. 8	29.94	7.3
No. 10	14.1	1.1	No. 10	6.73	0.6
No. 12	0.9	0.2	No. 12	0.52	0.1
PAN	0.2	0.0	PAN	0.058	0.0

GRADE 8/16F TYPICAL SIEVE ANALYSIS			GRADE 10/20 TYPICAL SIEVE ANALYSIS		
SIEVE	PERCENT RETAINED	PERCENT PASSING	SIEVE	PERCENT RETAINED	PERCENT PASSING
No. 6	0.0	100.0	No. 8	0.0	100.0
No. 8	2.6	97.4	No. 12	0.1	99.9
No. 10	23.5	73.9	No. 14	12.1	87.8
No. 12	29.4	44.5	No. 16	31.4	56.4
No. 14	30.3	14.2	No. 18	32.8	23.6
No. 16	12.5	1.7	No. 20	17.3	6.3
No. 18	1.5	0.2	No. 30	5.9	0.4
PAN	0.2	0.0	PAN	0.4	0.0

GRADE 16/30 TYPICAL SIEVE ANALYSIS			GRADE 20/40 TYPICAL SIEVE ANALYSIS		
SIEVE	PERCENT RETAINED	PERCENT PASSING	SIEVE	PERCENT RETAINED	PERCENT PASSING
No. 12	0.0	100.0	No. 16	0.0	100.0
No. 16	0.4	99.6	No. 20	0.6	99.4
No. 18	4.3	95.2	No. 25	8.1	91.4
No. 20	50.8	44.4	No. 30	40.8	50.6
No. 25	39.3	5.1	No. 35	39.8	10.8
No. 30	4.8	0.4	No. 40	9.3	1.6
No. 40	0.4	0.0	No. 50	1.5	0.1
PAN	0.0	0.0	PAN	0.0	0.0

2.3.1.6 Seal Material

Seal material must be coated bentonite pellets, from naturally occurring sodium bentonite, sized 3/8 to 1/2-inch in diameter. Angular chips, uncoated pellets, or other bentonite products may be used with prior approval from the Government.

2.3.1.7 Backfill Material

Backfill material may be impervious clay, bentonite, or a nonshrinking, low permeability grout, placed by tremie method. Place backfill material to the depth and thickness identified in the drawings. Grout must have a mix specific gravity, prior to placement in the borehole, of between [1.03 and 1.10][_____]. If used, bentonite must be hydrated in accordance with the manufacturer's recommendation.

2.3.1.8 Protective Casing

Provide protective casing of either [eight][twelve]-inch diameter or square steel pipe with a minimum 0.250-inch wall thickness, with threaded and coupled ends with no mill coating and a locking flip cap of either steel or aluminum [square]. Steel protective casing must be painted [_____]. Casings must be cleaned by power tool or wire brush prior to painting. The first coat must be brush or spray applied in the shop or field, as indicated, with a Steel Structures Painting Council Paint 25 (Zinc Oxide, Alkyd, Linseed Oil Primer) and touched up in the field as necessary during installation. Apply second and third coats in the field using P-38 (aluminum, ready mixed) type paint.

2.3.1.9 Protective Bollards

Dome capped protective bollards must be [3-inch][6-inch] diameter [steel] [galvanized] pipe with a minimum 0.250-inch wall thickness. Embed bollards a minimum depth of 30 inches below the final grade. Paint steel bollards [_____].

2.3.2 Fully Grouted Vibrating Wire Piezometer

2.3.2.1 Vibrating Wire Piezometer

Provide quality pore pressure monitoring devices (vibrating wire pore pressure piezometer) including all cables, wiring connections, splice kits, desiccant chambers (if vented sensors are used), vibrating wire transducer, readout unit, and [data logger][data collector] from a reputable manufacturer that has been in the business for [5][_____] years or more. Each vibrating wire transducer must be pressure sized to the expected load range and dimensioned to the specified location. Transducer resolution and accuracy requirements are 0.025 percent (minimum) and plus or minus 0.1 percent, respectively, of full scale range.

2.3.2.2 Grout Mixture

Provide a cement-bentonite grout designed to match the properties of the surrounding in-situ materials, with respect to strength and deformation characteristics, and as recommended by the manufacturer of the vibrating wire transducer. Use Type I or II Portland cement. Marsh Funnel viscosity of the grout prior to placement must be between [50 and 60][_____] seconds. Submit the proposed grout mix design to the Government for review and approval prior to start of the work.

2.3.2.3 Grout/Carrier Pipe (PVC)

Provide sacrificial grout/carrier pipe consisting of PVC conforming to the requirements of ASTM D1785 and as detailed on the drawings. Use PVC 1-1/4 inch Schedule 80 threaded pipe for all grout pipe and connections. Utilize manufacturer recommended materials for securing the vibrating wire transducer and cable to the pipe.

2.3.3 [Uplift Cells][Closed Tube Piezometer]

2.3.3.1 Tubing and Fittings for Tubing

Tubing utilized in the construction of uplift cells must conform to the requirements for [PVC or]Crosslinked Polyethylene (PEX) Tubing. Fittings to be used with PEX tubing must be of the Cold Expansion type for use with PEX Reinforcing Rings. Tubing must be compatible with fittings.

2.3.3.2 Fittings

Fittings must be brass or bronze, and compatible with PEX tubing, as recommended by the manufacturer.

2.3.3.3 Conduit

Conduit for uplift cell tubing must be of a size large enough such that the uplift cell tubing can be pulled through the entire length of conduit without damage to the tubing.

2.3.3.4 Gauges

Gauges for uplift cells must be dual scale, ASME B40.100 Grade 2A, brass process connection, bronze tube, solid case, dry. Mark scales in pounds per square inch (PSI) with a range of [_____] feet of water (FT H_2O). Face diameter must be 4-1/2 inches.

2.3.3.5 Mounting Hardware and Brackets

Hardware and other components necessary to fix uplift cell tubing, gauges, valves, and ancillary fitting securely to the wall must be 300 series stainless steel or approved equal. The clamps must hold the tubing and/or pipes firmly in place without deformation of the tubing or pipe.

2.3.3.6 Valves

Valves for uplift cells must be full port ball valves of either stainless steel or brass.

2.3.3.7 Cable Gland Seals

Cable glands must meet requirements for cable diameter, pressure rating, and mounting hole diameter. Cable gland mounting may include adhesive or compound, flanged or bolted, threaded or nut mount. The Cable gland material must be compatible with cable material to prevent corrosion, excessive wear, or damage and must be liquid tight.

2.4 SURFACE WATER LEVEL

2.4.1 Water Level Sensor

2.4.1.1 Laser Water Level Sensor

Provide water level sensors as indicated in the contract plans. Install all water level sensors in accordance with the manufacturer's recommendations. Perform operation and field calibration checks of all instruments. Factory-calibration curves are required for each laser water level sensor, including individual gage factor and temperature correction factor. Protect each instrument against short-duration, high voltage surges with an external surge protection board, which uses tripolar plasma surge arrestors, transient suppression diodes, and inductors.

2.4.2 Staff Gauges

Provide [porcelain enameled steel][fiberglass] staff gauges graduated to hundredths and marked at every foot and every tenth.

2.5 FLOW MEASUREMENT

2.5.1 Flow Meters

2.5.1.1 Pipe Flow Meter

Provide in line [magnetic flowmeters] [ultrasonic (doppler)] [mechanical-impeller or nutating disk] in accordance with the plans. Accuracy must be [_____] percent. Care must be taken to ensure the pipe is full and flow is not turbulent per manufactures directions. Provide electronic gauges showing flow rate and accumulated flow and with communications to a datalogger. Mechanical meters must show total flow.

2.5.1.2 Open Channel Flow Meter

Open channel flow meter must be [ultrasonic][_____] and use the depth of water along with the flow rate to calculate total flow. The open channel flow meter must communicate with an approved datalogger and include a gauge that shows the flow rate and accumulated flow.

2.5.2 Weirs

Provide a [v-notch][trapezoidal][rectangular] weir plate made of 304 stainless steel meeting the dimension requirements [as specified on the drawings][_____]. Include proper mounting hardware as provided by the manufacturer and meeting requirements of ASTM D5640.

2.5.3 Flumes

Provide a [Parshall][trapezoidal][cutthroat][H] flume made of [fiberglass reinforced plastic][304 stainless steel] for measurement of flow range from [_____] to [_____] meeting the dimension requirements [as specified on the drawings][_____]. The inside of the flume must be smooth and free of any irregularities. Provide all anchorage hardware in accordance with the manufacturer's recommendations and submit documentation showing the proposed flume meets all specified requirements.

2.6 ENVIRONMENTAL MONITORING

2.6.1 Precipitation

Monitor precipitation with a tipping bucket rain gauge with an accuracy of 1 percent up to 2 inches per hour. Rainfall per tip of the bucket is to be 0.01 inch.

2.6.2 Barometer

Provide a barometer with accuracy to 0.6 Hpa or better for correction of sealed vibrating wire pressure transducers. The barometer must be read by the automated data acquisition system.

2.6.3 Water Quality

Monitor water quality parameters such as temperature, pH, turbidity, and conductivity. The readings must be taken by [grab samples] [automated multiparameter sonde] at the specified locations, depths, and frequency.

2.6.3.1 pH

Provide a pH sensor with an accuracy of plus or minus 0.1 units. Calibrate instruments per manufactures directions for the expected range.

2.6.3.2 Turbidity

Provide a turbidity meter that reports in NTUs with an accuracy of plus or minus 2 percent and plus or minus 2 units. Calibrate instruments per manufactures directions for the expected range.

2.6.3.3 Temperature

Provide a temperature sensor that reports in degrees F with an accuracy plus or minus 0.5 degrees.

2.6.3.4 Conductivity

Provide a conductivity meter that reports in µS/cm with an accuracy of plus or minus one percent. Calibrate instruments per manufactures directions for the expected range.

2.7 DEFORMATION/DISPLACEMENT

Monitor for deformation or displacement using the instruments described below:

2.7.1 Extensometer

2.7.1.1 Probe Extensometer

Provide probe extensometers consisting of induction coils or magnet/reed switch transducers. Provide a telescoping access pipe when the predicted vertical strain is greater than about 1 percent

2.7.1.2 Fixed Borehole Extensometer

Select fixed borehole extensometers based on anchor type, transducer type and extensometer head. Provide either a single-point borehole extensometer (SPBX) or multipoint borehole extensometer (MPBX). For MPBX, provide a maximum of six anchors and rods in a 6-inch diameter borehole.

Provide [stainless steel][fiberglass][carbon composite] rods. Provide vibrating wire transducer capable of measuring over a range between 0 - 100 mm to 0 - 300 mm and frequency range between 1200 - 2800 Hz and operable at temperatures ranging from minus 20 to plus 80 degrees Celsius.

2.7.2 Settlement [Surface Points][Survey Monuments][Plates]

2.7.2.1 Surface Points

Provide surface points consisting of [1 inch] long survey nails designed for installation in [concrete][asphalt]. Include a suitable metal washer or plastic disc hub for high visible marking of each surface point.

2.7.2.2 Survey Monuments

Provide survey monument consisting of [3-1/2 inch] diameter domed bronze marker designed for installation in [concrete], unless otherwise provided by the Government.

2.7.2.3 Settlement Plates

Provide 24-inch square settlement plates consisting of a [steel][wood][concrete] base. Provide connectable riser pipes consisting of [galvanized][stainless] steel. Clearly mark and protect the riser pipes from impact during fill operations and other construction activities.

2.7.3 Settlement/Heave Points

2.7.3.1 Borros Type Anchor

Provide [settlement][heave] measurement points consisting of a three-pronged Borros type anchor, 0.25 inch steel inner pipes with couplers, and 1 inch steel outer pipe with couplers. Connect inner and outer pipes using standard couplers as recommended by the manufacturer. Anchors prongs may be manual or hydraulically actuated.

2.7.4 Inclinometers

2.7.4.1 Portable (Traversing) Inclinometer

Provide ABS plastic inclinometer casing in [10-foot][5-foot] long sections with a minimum outside diameter of [1.9 inches][2.75 inches][3.3 inches]. Provide casing section connections in accordance with the inclinometer manufacturer's recommendation. Ensure the casing has high quality flat surface grooves to permit free passage of the probe through curves in the casing without the wheel of the probe coming out of the groove. Casing anchors and grout valves are to be used if required. Grout the casing in place with grout that approximates the subsurface formation strength in accordance with ER 1110-1-1807. At a minimum, equipment and supplies for monitoring and processing inclinometer data must include a probe at wheelbase of 24 inches. The cable must be a [100][200][300]-foot cable graduated into two foot intervals. Other equipment required includes a cable gate system for accurate positioning of the probe, a digital readout device, and graphing software. Calibrate the sensor for plus or minus 30 degree range with a resolution of 0.0002 inch. Submit the selected inclinometer sensor type, including manufacturer and methods for data retrieval, for Government approval a minimum of 30 days prior to inclinometer casing installation. All inclinometer devices and accessories must be on the job site prior to installation of the first inclinometer. Monitoring equipment must be new and maintained in complete, fully functional operating conditions throughout the duration of the contract; this equipment becomes the property of the Government at the conclusion of the contract.

Applicable instruction manuals published by the inclinometer manufacturer are considered part of these specifications. Use these instructions for detailed installation procedures, calibration, and monitoring.

2.7.4.2 Automated In-Place Inclinometer (IPI)

Provide [ABS plastic] inclinometer casing in [10-foot][5-foot] long sections with a minimum outside diameter of [1.9][2.75][3.3] inches. Provide casing section connections in accordance with the inclinometer manufacturer's recommendation. Ensure the casing has high quality flat surface grooves to permit free passage of the probe through curves in the casing without the wheel of the senor coming out of the groove. Casing anchors and grout valves are to be used if required. Grout the casing in place with grout that approximates the formation strength in accordance with ER 1110-1-1807.

Document casing installation with traversing inclinometer and document two baseline readings prior to installation of IPIs. Baseline readings must be performed at least [seven][28] days after grouting the casing. Provide [biaxial MEMS][Triaxial MEMS Shape Accelerometer Array (SAA)][uniaxial VW] IPI sensors with an accuracy of plus or minus one percent of full scale. Replace casing that exceeds the accuracy of [_____] or spiral limitations of [_____] at the contractor's expense.

2.7.4.3 Shape Accelerometer Array

Provide [10][20]-inch segmented shape array sensors of the length(s) shown in the plans. The device must have MEMS sensors and be accurate to approximately plus or minus 1/16th of an inch in 100 feet. They must connect to existing ADAS systems. Casing must be [1][2][4]-inch inside diameter. In accordance with ER 1110-1-1807, select grout strength for backfill which approximates the formation strength.

2.7.5 Crackmeter/Jointmeter

Provide crackmeters consisting of a vibrating wire or potentiometer displacement transducer within a stainless steel telescopic body with two anchoring points. Vibrating wire crackmeters must measure over a range of, with a total accuracy ranging from plus or minus 0.50 percent to 0.30 percent full scale depending on range capability of the instrument. The vibrating wire crackmeter's frequency range must be between 2250 - 3000 Hz and operable at temperatures ranging from minus 20 to plus 80 degrees Celsius. Electrical crackmeters must measure over a range of, with a total accuracy ranging from plus or minus 0.30 percent to 0.15 percent full scale depending on range capability of the crackmeter.

Manual crackmeters must be clear polymer with [+-20mm][+-25mm][-55+105mm] range on the x axis and high contrast grid. They must have a unique serial number for tracking and be attached to the surface with epoxy and screws.

2.7.6 Tiltmeter

Provide a [vibrating wire][MEMS] waterproof [uniaxial][biaxial] tiltmeter. Standard operating range must be [plus or minus 10][plus or minus 20] degrees. Resolution must be [08][_____] arc seconds. Operating temperature must range from minus [20][_____] to plus [80][_____] degrees Celsius.

2.7.7 High Precision GPS Unit

Provide high precision GPS unit, with wireless communication capability, that provides three-dimensional displacement and tilt measurements for deformation monitoring. Units must provide plus or minus [1][2] centimeter positioning accuracy.

2.7.8 Survey

Complete surveys to provide accurate positioning of instrumentation. Use horizontal and vertical datums specific to the project in which instrumentation is being installed. Critical points for surveys at a minimum must include horizontal and vertical data collection at the top of protective casings, interior pipes, and a ground shot near the base of the instrument using equipment that can report collect to within at least plus or minus .01 feet accuracy.

2.7.8.1 Terrestrial Positioning System (TPS)

Provide an automated robotic total station with an aiming range of 1 m to 1000m, distance accuracy of 1mm + 2 ppm, angular accuracy of 1 arcsec (0.3 mgon), and programmable to collect and transmit survey data at [hourly][daily][15 minute][_____] intervals. The TPS must also include any environmental protection and communications necessary.

2.7.8.2 Surface Monuments

Select surface monuments based on the application and need of each project. Select horizontal and vertical control monuments in accordance with EM 1110-1-1002.

Each monument must have a [brass][bronze][aluminum] disk that [will][will not] be provided by the Government. Each monument must be stamped by the Contractor with all corresponding monument details such as project name, monument ID, and elevation. Stamp the majority of information on the cap prior to installation.

2.7.8.3 Survey Prisms

Select surveying prisms, also known as retro-reflectors, based on size, range, holder accuracy and offset. Beam deviation must be less than [5][_____] seconds. Holder accuracy must be [1][_____] mm or less. Prism offset must be [0][minus 17.5][minus 30][minus 34][minus 40] mm.

2.8 LOAD/STRESS

2.8.1 Earth Pressure Cells

Provide [standard][contact][jackout][push-in][pile tip] type pressure cells with a rated load of [_____] [kPa][MPa].

2.8.2 Load Cells

Provide [solid][center hole][vibrating wire][electrical resistance] type load cells with an inside or throat diameter of [_____] inches and a rated load of [_____] to [_____] kips. Alternatively, based on the actual diameter of the object material being monitored, and on the manufacturer recommendations, the throat diameter may be as indicated by the [Contractor][Government]. Provide centralizer bushings to center the load cell, if necessary. The load cell must be specially hardened to withstand embedment in concrete for long-term monitoring requirements.

2.8.2.1 Load Bearing Plates

Provide load cell bearing plates consisting of [_____] inch thick plated ground steel based on the [_____] kip load and the [_____] center hole.

2.8.2.2 Calibration

Calibrate load cells under the following two conditions: 1) normal factory calibration of the load cell itself and 2) group or set calibration of the load cell with the bearing plates and lock-off assembly assigned to that load cell. Switching or transfer of bearing plates/lock-off assemblies is not allowed in the field without factory calibration.

2.8.3 Strain Gauge

Provide [electrical] [vibrating wire] [fiber] strain gauges with a rated load of [_____] to [_____] µ.

2.8.4 Signal Cable

Provide signal cables, as recommended by manufacturer, which are factory-connected to the measuring device in one continuous length. Mark and properly identify all signal cable at the device and at the cable termination as delivered. Each cable connection to the device must be independent of the other. Splicing of cables that are embedded in concrete or otherwise not accessible must have prior approval of the Government. For splices not in a climate-controlled enclosure, use a [stainless steel][plastic] sleeve with [compression fittings][soldered and heat shrink splices] for securing each cable section and use factory supplied epoxy filling materials.

2.8.5 Instrument Readout

Provide required readout device(s) and obtain initial, calibration, and subsequent manual readings of the sensor output. The readout device(s) must be compatible with the instrument and signal cables, and existing sensors and data logging equipment on site. Data formats must be [.csv][.dat] [.json] and compatible with [_____] software.

2.9 VISUAL OBSERVATION

2.9.1 Outdoor Cameras

Provide [HD] [daytime] [nighttime] camera(s) accessible by an Internet-based software and a secure connection. Cameras must provide [color] [color and black and white] images. Cameras must meet or exceed the following:

a. Image Size: [_____] Megapixels [_____] x [_____]

b. Lens: [_____] in., [_____] x optical zoom, F-Stop [_____]

c. Pan/Tilt: Pan Range [_____] degrees Continuous Pan, Tilt: [_____] degrees to [_____] degrees

d. [4K][_____] broadcast quality video

e. [4G][_____] cellular modem

f. [On-Board Data Backup][4 GB (microSD)]

g. Ambient Temperature Range: [_____] degrees F

The Internet based online interface must include the following features:

a. Display project name

b. Real-time live video viewing

c. Daily auto-generated 360 degrees panoramas up to [_____] megapixels

d. Digital pan, tilt and zoom capability within a high definition image

The service must be available for the duration of the contract and allow the viewing of live video and high-definition digital still images captured of the project and stored on both mobile and desktop platforms. Capture and upload images every [30][_____] minutes, 24 hours per day. Provide all service and maintenance, including cleaning of the camera system throughout the life of the project including making appropriate arrangements for camera to remain in operation up to and through project completion.

2.10 VIBRATION MONITORING INSTRUMENTATION

Provide a minimum of [_____] vibration monitoring instruments at the location shown on the drawings or as directed by the authorized representative of the Government. Operate these instruments during construction activities that are within [_____] feet of the construction, or in the opinion of the Government would be a source of ground vibration.

The location of the instrument(s) may vary daily, based on the location of construction activities, condition of structures in the vicinity of construction activities, and response to public and government interest.

2.10.1 Seismograph/Seismometer

Provide [_____] vibration monitoring instruments and in accordance with the following:

a. Capability to measure, display, and provide a digital graph of particle velocity and frequency components.

b. Capability to measure the 3 mutually perpendicular components of particle velocity in directions vertical, radial, and perpendicular to the vibration source.

c. Possess a seismic range of 0.01 in/sec to 4 in/sec with an accuracy of 5 percent of the measured peak particle velocity or better at frequencies between 10 Hz and 100 Hz, and with a resolution of 0.01 in/sec or less.

d. Possess a frequency response range of 2 Hz to 150 Hz.

e. Display the date of the most recent calibration. Calibration must have been performed within the last 12 months to a standard traceable to the National Institute of Standards and Technology.

f. Possess a reliable power source or battery for required duration of recordings, equipment suitable for site and weather conditions, and suitable length of geophone and microphone cables.

g. Continuous monitoring mode must be capable of recording single-component peak particle velocities and frequency of peaks with an interval of 1 minute or less.

h. Capability of measuring continuous sound levels ranging from 30 dBA to 140 dBA with 0.05 dB resolution.

i. Produce plots showing particle velocity and frequency relative to current OSM and USBM standards.

2.11 SURFACE PROTECTION

Provide temporary or permanent surface protection in accordance with the plans. Use caution and provide all means necessary to protect the instrumentation from construction activity performed on the construction site. This includes monitoring settlement of fill material in and around the buried conduits, concrete protective blocks at the instrument heads, concrete pads, and related items. Immediately replace any instrumentation equipment that is damaged by construction activities including damage caused by settlement of fill material due to improper placement or compaction. Access must be maintained to permit periodic measurements and observation by the Government.

2.12 INSTRUMENTATION ENTERPRISE DATABASE (EDB)

Set-up, maintain and update a documented SQL enterprise database (EDB) for the duration of the contract in which to store all automated and manual instrumentation data. This can be the same database as the project database if one is utilized.

Store the EDB on the Contractor's servers or the Contractor's cloud storage account for the duration of the contract.[Update .csv files of the most current version of the database tables to the SFTP site by [midnight daily]. Update the most current version of these .csv files to the SFTP site at any time requested by the COR.]

[Make data available in HTTP (API) or sFTP for automated inclusion in external databases.

][Import relevant hydrologic data using publicly available datasets such as USACE CWMS RADAR or Access2Water APIs.

] Import all data for existing, active instrumentation in place prior to the contract into the EDB. The Government will provide the data for this purpose. Replace all historical survey coordinates and station offsets in the EDB for any instrument locations surveyed as a part of this Contract. Ensure all coordinates in the EDB are in the project coordinate system utilizing the correct datums.

Upon completion of the contract and before final demobilization, submit to the Government the final EDB .csv files and EDB documentation prior to final payment.

2.13 AUTOMATED DATA ACQUISITION SYSTEM (ADAS)

Provide an Automated Data Acquisition System (ADAS) to collect, process, store and communicate data with other systems. This system is generally to be comprised of sensors/transducers, dataloggers, communications devices, and associated accessories - see contract drawings. Automatically read and store instrumentation data at preset time intervals and reading frequencies. Provide the capability to modify reading frequency and provide ability to increase reading frequency during a [storm event]. Automatically scan all instruments for threshold exceedance. Have the ability to trigger alarms based on any of the following types of conditions: static level exceedance, rate of change, moving window rate of change, and time delay with multiple values verification.

Furnish all components and complete installation of all system components, cable, conduit, instruments, transducers, sensors, enclosures, power connections, grounding, and miscellaneous items to make the ADAS completely operational. Submit system design and components for Government approval.

2.13.1 Data Loggers

Provide data loggers that are capable of reading [vibrating wire][MEMs][_____] sensors, store data internally for [10][100][1000][10,000] readings, and communicate with [_____] protocols. Data loggers must be compatible with data collection devices and other data loggers on site and be capable of storing at least [3 months][1 year] data in local memory.

Program the data loggers to read the sensors. Annotate the programs with comments pertaining to its function. Data logger communications may be encrypted for security, but the program must be accessible by the Government on systems that will be owned or operated by the Government. Store programs on the data logger in non-volatile memory.

2.13.2 Enclosures

Provide enclosures to protect ADAS components from the environment. Properly size enclosures so components can be neat and organized. (Check NEC requirement for capacity). Construct enclosures of [fiberglass reinforced polyester][stainless steel] and use water resistant gaskets at all entry points to sealed enclosures. For enclosures housing electronics, maintain a low humidity level within by using desiccants or heaters.

2.13.3 Conduit

Provide [PVC][rigid][EMT] conduit. Surface conduit must be resistant to UV and rugged to minimize or eliminate damage.

2.13.3.1 Underground Conduit

Bury underground conduit [18 inches below the surface][24 inches below the surface][below the frost line]. Install in accordance with NEC regulations.

2.13.4 Locations

[_____]

2.13.5 LMU/RMU

Provide Local Monitoring Unit(s) (LMU)/Remote Monitoring Unit(s) (RMU) as shown in the contract plans. The LMU/RMU must poll sensors at a specified interval, record raw values, be capable of reducing raw values to engineering units, and communicate data to other systems.

2.13.6 RIO

Provide Remote Input Output (RIO) device(s) as shown in the contract plans. The RIO must poll sensors, as requested by a LMU/RMU, and communicate raw values back to the LMU/RMU.

2.13.7 Vibrating Wire Analyzer

Provide vibrating wire analyzers that poll vibrating wire transducers and measure the resulting frequency and associated data. The analyzer may be a stand-alone unit or integrated into a datalogger but must have a communications method for transferring data to other devices. The vibrating wire analyzer must use a [swept frequency method][Fourier transform and spectral analysis method] to determine the frequency of the vibrating wire with an accuracy of plus or minus 0.05 percent or better and read the thermistor of equipped sensors.

2.13.8 Multiplexer

Provide multiplexers that are compatible with the [existing][new] sensors/transducers and measurement devices on site.

2.13.9 Power

Size power supply batteries appropriately to power the equipment for [3 days][10 days][6 months][12 months] without recharge. Power supply batteries are to be comprised of a rechargeable battery or batteries, charge controller, and power source. Power sources can be solar panels, wind turbines, 110 volt wall outlets, or combinations of these sources. Batteries must be of [sealed lead acid][lithium iron phosphate] chemistry.

2.13.10 Grounding

Grounding and lightning protection must be designed by an electrical engineer with experience in lightning protection. Include this design, with Professional Engineer's signature and stamp, in a Grounding and Lightning Protection Plan submitted for Government approved. Ground all enclosures and equipment that have grounding terminals. Install ground rods in accordance with the electrical engineer's recommendations regarding construction, size, spacing and allowable resistance . Install and maintain the transient voltage surge suppressor in accordance with the Electrical Engineer's grounding and lightning protection plan. Special care should be taken to protect sensors that are grouted in a borehole, or other inaccessible sensors.

2.13.11 Communications

Provide [wired][wireless radio][wireless cell modem][fiber optics][satellite] communications between data logging devices and for transferring data files to local and remote Government offices.

2.13.12 Software

[Provide instrumentation software that communicates with the automated data acquisition system [and a windows-based PC][_____]. The software must allow remote retrieval of data, updating of programs and configuration, and viewing of data from the automated systems.

][Provide inclinometer software that communicates with the manual traversing data collection device. The software must plot greater than three cumulative displacement plots referenced back to a baseline survey and allow for corrections of the data for spiral and bias.

]2.13.13 Architecture

The Automated Data Acquisition System Architecture must be [centralized][distributed] at the site.

2.13.14 Wiring Diagram

Submit full color wiring diagrams of the ADAS enclosures in the ADAS Final Report. Conduit, trenching, and cabling locations must be surveyed during installation and survey used in preparation of the required as-built drawings submittal.

2.13.15 Instrumentation Schedule

[_____]

2.13.16 System Maintenance and Spare Parts

Provide all hardware and/or other necessary item(s) required to ensure the entire instrumentation and data acquisition/reporting system is functioning according to manufacturer's specifications, and for maintaining the system in satisfactory working order for the length of the contract. This includes appropriate spares for repairing or replacing inoperable or unreliable components according to the expected replacement rate in the list below, or as otherwise as directed by the contract. All system maintenance must be performed in accordance with the manufacturer's requirements and EM 1110-2-1908.

Before work begins, prepare a list of all extra components required for continuous operation of the system and quantities to be stockpiled on-site according to the estimated replacement rate per the manufacturer. Submit this list to the Government for approval. The items on the approved list must be made available at the site during the entire period of the delivery order. If a stockpiled item is used, it must be replaced immediately. In the event of a malfunction or breakdown beyond the frequency below or beyond the control of the Contractor, notify the Government of the nature of the malfunction or breakdown within [12 hours][_____], and provide an estimate of when that part of the system will be back in service if the Government approves a replacement. Depending upon the status of the construction at that time, the Government will decide whether or not a manual backup system must be implemented by the Contractor.

Sensor or board replacements must be of the same model (manufacturer) and type as installed in the field at award of this contract unless a newer technology can be provided that meets the same or better requirements and performance. All deviations require approval of the Government prior to replacement. Replaced instrumentation components must be programmed and shown to functionally work with the system prior to Government acceptance.

PART 3 EXECUTION

3.1 PRE-INSTALLATION ACCEPTANCE TESTING

Perform pre-installation acceptance tests to ensure sensors and readout units are functioning correctly prior to installation. Blank pre-installation acceptance test record forms for each instrument type must be provided by the Instrumentation Specialist. For pre-installation acceptance tests, include relevant items from the following list:

a. Examine factory calibration curve and tabulated data to verify completeness.

b. Examine manufacturer's final quality assurance inspection checklist to verify completeness.

c. Check cable length.

d. Check serial numbers on instrument and cable.

e. Check, by comparing with procurement document, that model, dimensions, and materials are correct.

f. Perform resistance and insulation testing, according to criteria provided by the instrument manufacturer, using a gage insulation or circuit tester that applies two volts or less for resistance testing and 15 volts or less for insulation testing.

g. Verify that all components fit together in the correct configuration.

h. Check all components for signs of damage in transit.

i. Check that quantities received correspond to quantities ordered.

Repair or replace any instrument that fails the specified pre-installation acceptance test.

3.2 PRODUCT HANDLING

3.2.1 Transportation and Handling

Pack, transport, and handle all monitoring equipment in accordance with the manufacturer's instructions. Arrange deliveries of monitoring equipment with proper sequencing and scheduling in accordance with the approved Project Schedule. Coordinate deliveries to avoid conflict with work, conditions at the site, and availability of personnel and handling equipment.

3.2.2 Storage and Protection

Use all means necessary to protect monitoring equipment before, during, and after installation and to protect installed work and materials including existing instrumentation installed by others. Store all monitoring equipment in strict accordance with the manufacturer's recommendation with all labels and seals intact and legible. Arrange storage of monitoring equipment to permit access for inspection. Periodically inspect to assure monitoring equipment is undamaged and is properly maintained. Replace in kind any equipment lost, damaged or stolen due to negligence on the part of the Contractor at no additional cost to the Government.

3.3 INSTALLATION

3.3.1 General

Provide all labor, equipment, materials, and incidentals required to install and read the instruments as shown on the Contract Drawings. Install instruments in accordance with approved method statements and the manufacturer's recommendations. Upon completion of the installation, test each instrument in accordance with the recommendations of the manufacturer. The Contractor is solely responsible for installation and the performance of the instrumentation after installation. After installation replace any inoperative or poorly performing (not within an acceptable range/calibrations) instrumentation at no additional cost to the Government. Obtain all necessary permits and pay associated fees required to construct the project. Implement the terms and requirements of the permits. Submit Permit Documentation to the Government for record.

3.3.2 Installation Plans

As outlined in paragraph INSTRUMENTATION AND MONITORING PLAN, detailed method statements for installation of each type of instrument must be submitted for Government review and approval prior to commencing installation.

3.3.3 Notification and Documentation

All installations may be monitored by the Government's Representative. Notify the Government Point of Contact at least [24][_____] hours prior to the installation of each instrument. For each instrument installed, prepare, and submit an Installation Record in PDF format, including but not limited to items listed below. Enter all as-built metadata for each instrument into the enterprise database for the project detailed in paragraph AVAILABILITY OF MONITORING DATA.

3.3.4 Instrument Coordinates

Survey final location of all installed instruments utilizing the survey control precision and accuracy requirements required by this Contract. Provide [easting and northing][_____] survey coordinates in accordance with the system and datums for the project. Provide all relevant elevations for installed components and sensing regions, and hole inclination and azimuth as directed by the Government. Ensure all station and offset measurements for new instruments utilize the established station line of the project.

3.3.5 Borehole Installations

Perform borehole drilling in accordance with the [Section 02 32 13 SUBSURFACE DRILLING AND SAMPLING][the Government standard drilling specification provided].[Adhere to ER 1110-1-1807 for any borehole drilling in earthen embankment dams or levees or those with soil foundations. No drilling or excavation can occur on a constructed embankment dam or levee until a Drilling Program Plan has been approved by the Government. Appendix B of ER 1110-1-1807 defines the format of the Drilling Program Plan.]

Installation procedures for instruments in boreholes must be performed in such a manner that all steps in the procedure can be quality assured. For each hole, maintain a detailed log, recording soil/rock and groundwater conditions encountered. Prior to installing any instrument through drill casing or augers, thoroughly remove all cutting and material adhering to the inside of the casing or augers. Instrument installation in a borehole must be completed in a continuous operation. Partially completed instrument installations must not be left in unsupported boreholes overnight. For boreholes in which piezometers are to be installed, bentonitic drilling muds must not be used. For holes where instrument casing is installed, verify that the drilled hole within two degrees of vertical (plumb) throughout its length and is at the correct depth.[When drilling below the water table or when the drill hole must not remain open, advance the drill hole using a steel outer casing and approved drilling fluid. Withdraw outer casing after instrument casing is installed and as the hole is being backfilled. Do not rotate the casing during removal. Steel outer casings remain the property of the Contractor. Fill annular void between drill hole and instrument casing as indicated. Backfill each instrument specifically as indicated in its installation specification below or as indicate on the drawings. Backfill must be brought up in an equal fashion surrounding the instrument and/or casing. Measure the depth to fill surface as the work progresses (at top of each material increment) and confirm the depth reasonably matches the expected depth based on the volume of material placed.] Record the backfill quantities on the installation record.

3.3.6 Pore-Pressure and Groundwater Monitoring

3.3.6.1 [Open Tube Piezometer][Observation/Monitoring Well]

Install the [open tube piezometer][observation well][monitoring well] immediately after each boring is complete to the design depth specified and as close to vertical as possible. Secure the screen to the riser casing by flush-jointed threads and place using centralizers. Before the screen and casing are placed on the bottom of the borehole, place at least 6 inches of filter material at the bottom of the borehole. Place filter material around the screen to at least 2 feet above the top of the screen unless otherwise specified. If hollow stem augers are used, place the filter material in 6 to 12 inch lifts. If the borehole is open, place filter material by tremie methods, using water to wash the sand through the pipe.

After the filter material has been installed, place a minimum 3-foot thick bentonite seal above the filter pack. Granular bentonite must be placed in depth increments not exceeding 1 foot. Check the depth to the top of each increment of sand or granular bentonite after placement. The bentonite seal must be allowed to hydrate a minimum of eight hours or the manufacturer's recommended hydration time, whichever is longer. After the seal has hydrated, pump well-mixed grout by tremie method into the annular space around the casing. Record the volume of grout used and compare to expected to evaluate excessive grout loss. Grout must set for a minimum of 24 hours before surface pad and protective casings are installed. Construct concrete pad or surface completion as shown on drawings. For above ground completions, install a painted lockable protective casing extending a minimum of two feet above the ground surface. For flush mount completions, install a waterproof and watertight protective casing even with the ground surface. All watertight protective hand holes or above ground casing must be the same and use the same locking or unlocking mechanism which must be provided to the Government at the end of construction.

After completion of installation, record an initial reading of the open standpipe piezometer. An initial reading consists of the average of three readings taken with a water level indicator where the indicator is removed from the riser pipe between each reading. Then, conduct a post-installation acceptance test by performing a falling head or rising head permeability test. Conduct the test in accordance with procedures outlined in Appendix C of EM 1110-2-1908, including report of data and results.

3.3.6.2 Fully Grouted Vibrating Wire Piezometer

Install the vibrating wire (VW) transducer immediately after each boring is complete to the depth specified or shown on the drawings. Maintain the VW transducer in a bucket of water to keep the filter saturated for a minimum of 30 minutes until it must be removed to attach to the grout pipe. Immediately prior to attaching the transducer to the PVC grout pipe, remove the transducer porous tip and fill with clean water. After replacing the porous tip, use electrical tape to attach the transducer to the grout pipe upside down with the porous tip facing up. The porous tip must not be covered with electrical tape. Secure the transducer cable to the casing just below the transducer. Loop the cable to run up the casing past the VW transducer and eventually to the surface. The cable must be rotated around the casing to minimize bridging of grout. Avoid sharp bends in the cable. Lower the grout pipe with attached VB transducer and cable into the hole to the required depth. Read the piezometer to ensure it agrees (within plus or minus 0.4 inch) with the water head as determined by a water level indicator, and record the elevation of the diaphragm. Use a drill rig pump or similar to first thoroughly mix the cement into the water for the cement-bentonite grout, and then carefully add the bentonite to ensure that clumps do not form and the required viscosity is attained. Perform a Marsh Funnel viscosity test to verify the target viscosity of [50 to 60][_____] seconds is obtained prior to grout placement. Do not pump grout into the borehole, but place grout using a tremie pipe with side discharge ports that remain submerged in the grout during the entire grouting process. Inject grout to within 1 foot of the ground surface and allow to settle. After settlement has occurred, top off the grout to 1 foot below top of ground surface. Mound natural soil at the ground surface to promote water drainage away from the piezometer.

After completion of installation, take a baseline reading. A baseline reading will consist of the average of a minimum of three stable readings. Construct surface components and piezometer cable routing and burial as specified and/or shown on the drawings. Protect instrument cables from mechanical or weather related damage. Free ends of cables must be protected at all times. Accurately record and clearly mark the position of all buried cables. Include any issues or changes that occurred during the construction in the Installation Record submittal, along with all required installation documentation detailed in paragraph NOTIFICATION AND DOCUMENTATION.

3.3.7 Deformation/Displacement

3.3.7.1 Inclinometer Casing

Install inclinometer casing immediately after each boring is complete to the design depth specified and as close to vertical as possible. Anchor casing prior to grouting to prevent excess deformation. Orient inclinometer casings such that one axis of the internal grooves are perpendicular to the expected direction of movement. Maintain groove orientation throughout installation. During and after installation, casing groove spiral must not exceed one degree per 10 feet of length.

After completion of installation, complete a post-installation acceptance test to verify that there is no grout in the inclinometer casing, that groove orientation, spiral limitations, and verticality satisfy the specifications, and that the inclinometer probe tracks correctly in all four orientations. Perform a vertical survey of the installed inclinometer casing at 2-foot depth intervals using the standard probe, to determine the vertical profile of the casing, and develop an initial data set. Include any issues or changes that occurred during the construction in the Installation Record submittal, along with all required installation documentation detailed in paragraph NOTIFICATION AND DOCUMENTATION.

3.3.8 Load/Stress

3.3.8.1 Load Cells

Conduct a minimum of three sequential lift-off tests to determine the correlation between the actual hydraulic jack load and the measured load in the load cell following lock-off. Following lock-off and lift-off testing, read the load cell twice daily for a period of at least one week to document drift or changes in the load cell readings. If readings do not stabilize within approximately 1 percent of the lock-off load, provide an assessment in writing for approval of the possible reasons for the drift and the results submitted. Contractor must not backfill around the load cells until drift characteristics have been documented, submitted in writing, and approved by the Government.

3.4 DATA COLLECTION

At a minimum, collect the following data as applicable to each type of instrument installed:

a. Instrument ID Name

b. Instrument Type

c. Date and Time

d. Reservoir Pool Elevation

e. Tailwater Elevation

f. Observer

g. Readout unit number and last calibration date if appropriate.

h. Readings

i. Visual Observations (e.g. loose mounting materials, rusting, battery leakage, UV damage to instrument, wire or casing)

j. Other pertinent data, including weather, temperature, construction activities, and any events that could influence change in the data.

3.4.1 Baseline Readings

Obtain initial readings from all instruments immediately after their installation and enough times (see reading frequencies in table of paragraph Frequency of Monitoring) before construction begins in order to verify that the instrument readings have stabilized, and initial (ambient) conditions are established. Collect initial or baseline readings for a minimum of [6 months][1 month][2 weeks]. Evaluate baseline readings and determine the cause of any data anomalies recorded. Those instruments that are to be installed with the purpose of monitoring the effect of the construction works on surrounding structures/ buildings/ utilities or terrain must be installed, tested for acceptance and fully operational at least [10 days][_____] prior to the commencement of the construction works whose effects are to be monitored, with the additional requirements as listed.

3.4.2 Frequency of Monitoring

The minimum frequency of monitoring presented herein (see table below) may be subject to adjustment in accordance with field behavior, or as requested by the Government. The frequency and extent of monitoring are subject to change in accordance with the threshold and limiting levels described herein or as established in the approved Instrumentation and Monitoring Plan.

Instrument Type	Data Collection Method	Reading Frequency (Minimum)
Crack Pins	Manual Automated	Weekly Weekly/Daily
Extensometers	Manual Automated	Weekly Weekly/Daily
Inclinometers	Manual Automated	Weekly Weekly/Daily
Piezometers or Observation Wells	Manual Automated	Daily Every 15 minutes
Pressure Relief Wells or Well Points	Manual Automated	Weekly/Daily Daily
Seepage Measurement Devices	Manual Automated	Weekly Daily
Settlement Gauges	Manual Automated	Monthly N/A
Surface Monuments and Survey Points	Manual Automated	Monthly Daily

Tiltmeters	Manual Automated	Weekly Daily/Hourly

3.4.3 Manual Readings

Collect and reconcile manual instrumentation data to the [instrumentation EDB][_____] within [4][_____] hours of data collection. Digital data collection devices may be used to facilitate rapid input of data without redundant manual data entry.

3.4.4 Instrumentation Metadata

At a minimum, collect the following data for each instrument installed and add to the appropriate table of the instrumentation EDB:

a. Instrument ID

b. Instrument type

c. Instrument manufacturer

d. Date of installation

e. Automation status

f. Instrument easting and northing coordinates in the same coordinate system and datums as existing instrumentation.

g. Instrumentation surface elevation

h. Instrument bottom of installation elevation

i. Top and bottom elevations of all instrument sensing zones (as applicable)

j. Top and bottom elevations of all relevant installed features (i.e. concrete, filter, sensors, standpipe)

3.4.5 Automated Data Acquisition System (ADAS)

3.4.5.1 Cyber Security Compliance (ECB 2018-11)

Automated data acquisition systems collect, process, store and transmit data. They are not SCADA systems and thus they will not control any critical infrastructure including but not limited to gates, valves, utilities, traffic control, security, fire, or life safety systems.

3.4.5.2 Programming

Programming of dataloggers must be performed in a logical, well-annotated way. Data logger communications may be encrypted for security, but the program must be accessible by the Government on systems that will be owned or operated by the Government. Provide a copy of the program with the code annotated. The annotations must be descriptive and explain the different sections and clearly define constants.

3.4.5.3 Testing

Install and test the automation system in the presence of the Government's designated representative.

3.4.5.4 Project Specific Operations Manual

Submit an operations manual including wiring diagrams, photos of the inside of each Data Logger, RIO, LMU, RMU, or other boxed transmission device as well as each instrument location with clear views of the instrument showing wiring and location of all components, cut sheets, calibration sheets, datalogger programs, component configuration settings, troubleshooting, as-built drawings, and maintenance requirements.

3.4.5.5 As-Builts

Provide as-built drawings including installation/construction diagrams as well as instrument locations, datalogger or other readout devices, conduit, trenching and cabling. In addition to full scale drawing as-builts required as part of the construction contract, include 11 x 17-inch size as-builts as an appendix in the Project Specific Operations Manual.

3.5 ANALYSIS, REPORTING, AND PRESENTATION OF MONITORING DATA

If not explicitly stated herein, analysis, reporting, and presentation of monitoring data must be consistent with the guidance provided in EM 1110-2-1908.

3.5.1 Analysis of Monitoring Data

Compare each acquired instrument reading with the previous readings of that instrument and the expected reading based on site conditions and in reference to baseline readings. Interpretation of data also includes making correlations between instrumentation data and specific construction activities. Determine whether the instrumentation response to construction activities is reasonable. Data interpretation and analysis should consider instrument precision levels and errors, data capturing errors and necessary corrections in accordance with the manufacturer's instructions. In addition, data analysis should consider connections to records of construction and weather-related activities at the site. Perform analyses in a timely manner to capture indications of distress development, the possible need for instrument maintenance, and to check for proper functioning. Determine if a threshold value has been exceeded, and if so, proceed in accordance with paragraph RESPONSE ACTIONS. If the comparison indicates that changes are not typical of previous changes, determine whether the reading is erroneous or legitimate. Erroneous readings include readings outside the accuracies, repeatability, standard deviations, and tolerances specified herein or as indicated by the manufacturer. Ensure, and document, proper quality control is being conducted on the analyses and results.

3.5.2 Monitoring Data Reports

Submit monitoring data reports, consisting of all processed instrumentation data converted to standard English units of measure, to the Government's Representative at defined intervals throughout the construction period. Include readings for all instruments. Readings are to be cumulative for the reporting period. NO DAILY AVERAGING OF AUTOMATED DATA WILL BE ALLOWED.

a. For the duration of the contract, submit [monthly][weekly] Monitoring

Data Reports within [24 hours][_____] from the last day covered in the report. Each report must include analysis of that [month's][week's] data collection and findings in relationship to work performed on-site which may impact readings. Provide cumulative plots of data for the reporting period. Plotted values must be discrete - no daily averaging between successive data points. Reports may be requested at a higher frequency by the Government for special instrumentation evaluation purposes. Provide such reports following the same format as [monthy][weekly] reports or as directed by the Government's authorized representative.

b. Ensure all erroneous data is masked from plots, but it must remain in the raw data file and be flagged as erroneous data in the database within a specifically designated field.

c. Reduce all automated sensor readings in accordance with the manufacturer's recommendations and equations.

3.5.3 Presentation of Monitoring Data

3.5.3.1 Web Interface of Interactive and Static Reports of Data

Through the use of a secure web interface, establish interactive and static reports generated from the instrumentation data gathered at the site. Establish the web interface within 30 days following Notice to Proceed. Provide backups for the website in accordance with the requirements stated in paragraph DATA REQUIREMENTS. The interface must be intuitive, easy to navigate, and include all graphical plots and displays as detailed in this section. Within [60][_____] days of the notice to proceed, provide a presentation (for training purposes) of all components of the web interface for submittal approval by the Government.

3.5.3.2 Quick Reference Guide

Within [60][_____] days of the Notice to Proceed, produce and submit a digital and paper Quick Reference Guide for use of the website that meets the following minimum criteria:

a. Describes in detail the website structure and contents.

b. Describes in detail the location and steps to use the features and functionality.

c. Describes in detail how to download plots and other graphical displays.

d. Is designed in a simplified, indexed, and well-organized manner.

e. Includes web addresses of web-hosted sites in use, and POC information for administrators who can provide user-access to the Government.

3.5.3.3 Training

Within [60][_____] days of the Notice to Proceed, provide training sessions, on site or at the Government office - as coordinated with the Government, to familiarize and train Government users on the web interface. Provide [2] sessions, [2 hours] in length each.

3.5.3.4 Graphics

a. Reduce piezometric data to elevation in feet and plot it, along with headwater and tailwater elevations, versus time.. The Y axis showing elevation must not be a dynamic axis. Plot values together on one scale range of the X axis.

b. Reduce alignment pin readings to total horizontal and vertical movement (in inches) from the initial positions and plot versus time.

c. Reduce and plot inclinometer data vs depth.

d. Reduce weir data and plot as a time series.

e. For weekly reports, the data plotted versus time must be shown in plots spanning the one-month report period, one year period, and lifetime period. Indicate on the plots maximum and minimum instrument readings spanning the life of the instrument. Include the following information for the reading data:

(1) instrument location number,
(2) date of reading,
(3) reduced readings,
(4) all remarks from any field observations,
(5) water elevation,
(6) other work completed within the vicinity plotted on the date in which it took place,
(7) excavation elevation near that instrument, and
(8) ambient temperature.

f. Plot Automated Robotic Total Station Monitoring system data as x, y, z and resultant displacement versus time, and provide in tabular format.

3.5.3.5 Discussion

All automated data must include corrections for temperature and/or barometric pressures changes, as recommended by the manufacturer (and necessary for calculations). In all reports generated, include a written description of how the data was reduced, including any equations utilized.

3.6 AVAILABILITY OF MONITORING DATA

3.6.1 Website Access

3.6.1.1 Security Credentials

Provide 24/7 read access to the data to the Government, the Contractor, and any related subcontractors for the duration of this contract. Within 30 days of Notice to Proceed, provide the COR any necessary username and password or other security credential for access. For new personnel requested by the Government throughout the contract, grant access and provide security credentials within 48 hours of the request.

3.6.1.2 Data Update and Display

The website must update all automated data within [10 minutes][_____] of data collection at a specific instrument. Post all manually read instruments and surveyed instrument data to the website within [4 hours][_____] of data collection on that specific instrument. Plot scales, offset, and layouts must be editable by users, with the new selected defaults saved for each user.

Displays must include automatically updated plots from all instrumentation as outlined in ANALYSIS, REPORTING AND PRESENTATION OF DATA.

3.6.1.3 Site Operability and Useability

The website must be fully functional, current, easy to navigate, accessible through Government VPN, and complete with all instrumentation data available for retrieval by both automated and manual methods. Demonstrate the system to the Government prior to System/Website Training. If the website is not functional, with data available and easy to read, pertinent payments will be withheld until the issue is resolved and acceptable to the Government.

3.6.2 Raw Data

Furnish all collected data in a native CSV or TOA5 Data Format. Data must have, at a minimum, Instrument Id, timestamp, and value. Submit raw data files via the [project SFTP][_____] within [24 hours][_____] of generation.

3.7 THRESHOLDS AND RESPONSE ACTIONS

3.7.1 Threshold Values

Monitor instrument readings against the Alert and Action Threshold Values as defined individually for instruments [in the table below] [as outlined in the Instrumentation and Monitoring Plan prepared by the Instrumentation Specialist and approved by the Government]. The actions to be implemented when these Threshold Values are reached are referred to as Response Actions and are explained in paragraph RESPONSE ACTIONS. Threshold values must be identified on respective plots.

THRESHOLD VALUES				
Instrument Type	Instrument IDs	Unit of Measure	Alert Threshold Value	Action Threshold Value
Piezometer	[_____]	ft	[_____] ft, or rate of change	

3.7.2 Response Actions

If an Alert Threshold Value is reached, the Contractor's Instrumentation Specialist must immediately evaluate the instrument response by collecting a manual reading if possible, and also in relation to weather and physical conditions at the location of the instrument and provide an update to the Contractor and Government.

Within [24 hours][_____], analyze the instrument response and submit an Instrument Alert Assessment providing an assessment of the cause of the alert and predict further responses and their effect based on the trend to date. Include recommendation for any corrective action, if needed.

If an Action Threshold Value is reached, the Contractor must immediately stop work, remove personnel from the affected work area, and implement the emergency response actions included in the Instrumentation and Monitoring Plan previously approved by the Government. The Instrumentation Specialist must immediately evaluate the instrument response with respect to physical conditions at the location of the instrument.

Submit a detailed Action Threshold Exceedance Report documenting the site conditions, such as weather, and construction activities when the action threshold value was reached, analysis of the cause(s) for exceedance, and recommendations for any corrective actions needed. Resume suspended activities only after receiving written instruction from the Government.

3.8 VISUAL INSPECTION

Conduct routine visual observations of the site and instruments by selected individuals and at intervals defined in the approved Instrumentation and Monitoring Plan. Submit written and site photo documentation of these routine visual observations to the Government within [48 hours][_____] of completion. Areas that have been identified as potentially concerning should be noted and monitored at prescribed visual observation frequencies. While monitoring instruments, examine installed instrumentation for evidence of damage, malfunction and possible future damage caused by construction activities, and report any such issues, along with photos, to the Government. Submit this information, along with any site photos, to the Government. Also record nearby construction activities, such as pile driving, stockpiling, excavation or water control and environmental conditions, such as the weather or presence of floodwater and all other events that may influence instrumentation data.

Perform visual inspection at the location of any instrument that is producing unexpected or unusual readings. Immediately perform inspection of an instrument that has exceeded an Alert Threshold as further detailed in paragraph THRESHOLD VALUES.

3.9 SYSTEM RELIABILITY

The entire instrumentation system including datalogging equipment, servers, sensors, wiring, etc. must be maintained at all times. If in the Government's opinion the instrumentation system is not functioning properly, as demonstrated by unreliable and/or questionable readings, all construction work must cease immediately and not resume until the system is performing as specified. No additional compensation will be made by the Government for any cessation of work. The Government will determine whether the performance of the instrumentation system is satisfactory to resume work.

3.10 MAINTENANCE AND REPLACEMENT

Before work begins on a delivery order, prepare a list of all extra components that are required for continuous operation of the system and quantities to be stockpiled on-site according to the estimated replacement rate per the manufacturer recommendation. Submit this list to the Government for approval. The items on the approved list must then be available at the site during the entire period of the delivery order. If a stockpiled item is used, immediately replace it with the same item that was used.

If an instrument is repaired, replaced, or moved subsequent to installation, record new: instrumentation type, as-built location, and calibration sheets. Submit an Instrument Modification Report to the Government detailing the reason the original instrument was altered and the date the new instrument was operational.

For the duration of the contract period, maintain all instrumentation installations in progress and all completed instrumentation installations. In the event of a malfunction or breakdown, notify the Government of the nature of the malfunction or breakdown within 12 hours of initial observation of its occurrence, and provide an estimate of when that part of the system will be back in service if the Government approves a replacement. Depending upon the status of the construction at that time, the Government will determine whether a manual backup system must be implemented by the Contractor. If an instrument does not function properly for a cumulative total of [10][_____] calendar days or more within any 30 consecutive calendar day period, the Contractor will not be provided the [monthly][_____] payment for item General Instrumentation Requirements until repairs have been made and approved by the Government.

3.11 PROJECT CLOSEOUT AND RESTORATION

Upon completion of construction, as determined by the Contracting Officer, the Contractor must remove and properly dispose of all instruments and devices from the site, except for those instruments identified for long term monitoring [as detailed on the contract drawings][_____]. Confirm these instruments with the Government prior to initiation of removal activities by submitting an Instrument Removal List for Government review and approval a minimum of [30 days][_____] prior to the removal of any instruments. Retrieve all removable equipment and backfill holes with an approved grout mix. Any protruding parts, which cannot be removed completely without damage to the structure must be cut off flush with the surface. Remove all sharp edges. Repair any damage to existing structures from removal of instrumentation devices to the satisfaction of the Government and at no additional cost to the Government.

3.12 VIBRATION MONITORING

3.12.1 Preconstruction Condition Survey

The Seismologist/Vibration Consultant must conduct a Preconstruction Condition Survey of all existing structures and utilities within the area designated in the plans. The Contractor must have both letter and personal contact with residents, owners and operators of the structures and must notify them a minimum of two weeks prior to performing the survey.

Obtain Right-Of-Entry or permissions for all properties entered as part of this survey. Any owners refusing the Preconstruction Condition Survey must be given the opportunity to sign a statement, produced and provided by the Contractor, stating any reasons for non-participation.

a. The Preconstruction Condition Survey must be performed by an experienced Professional Engineer familiar with construction methods and materials, and structural response to ground vibrations generated by construction activities.

b. The Preconstruction Condition Survey must consist of a description of the interior and exterior condition of each of the structures examined, including: above ground structures, foundations, basements, driveways, walkways, electrical, plumbing, utilities (overhead and buried), transmission lines, drains, wells and water systems. Describe any signs of existing distress, cracks, damage, spalling, settlement, leakage, or other defects. The survey must include such information to make it possible to determine the effect, if any, of the construction operations on the existing defect. Where significant cracks or damage exist, or for defects too complicated to document in words and sketches only, photographs must be taken or a good quality video survey with appropriate audio description of locations, conditions, and defects must be performed to supplement the written description. Survey must include a list of vibration sensitive equipment or furnishings, and potential falling debris hazards.

c. Install crack displacement monitoring gages as appropriate across any significant existing cracks and read [periodically][after the conclusion of blasting][after each blast][_____] to verify if any additional distress should develop. Include the crack gauge readings, recommendations for additional instrumentation types or survey monuments, if needed, in the report. Identify structures or elements that are potentially susceptible to damage and recommend, if warranted, potential: support, repair, vibration mitigation measures, or reduced ground vibration limits.

d. The Seismologist/Vibration Consultant must give written notice to the owner of any inspected structure, tenants, and any representative of local authorities required to be present at the Preconstruction Condition Survey. The notice must state the coordinated dates and time on which surveys are to be made.

e. Owners of the structures must be given a copy of the survey of their particular structure and be given the opportunity to comment on its accuracy. Submit the Preconstruction Condition Survey to the Government 30 days prior to construction activities that, in the opinion of the Government, would be a source of ground vibrations.

3.12.2 Postconstruction Condition Survey

Conduct a Postconstruction Condition Survey within 30 calendar days upon the completion of all construction work that, in the opinion of the Government, generate ground vibration. Postconstruction Condition Surveys must be conducted on all structures and utilities that previously had a Preconstruction Condition Survey, and on any additional properties, structures, and conditions for which complaints of damage have been received or damage claims have been filed. Give notice to all parties, as identified in paragraph PRECONSTRUCTION CONDITION SURVEY, subparagraph d., so that they may be present during the final examination. Distribute records of the final examination in the same manner as the original Preconstruction Condition Survey. The Postconstruction Condition Survey must have the same requirements as the Preconstruction Condition Survey and must consist of a description with any measurements, surveys, photographs, and other information needed to document the postconstruction condition of surveyed structures. Preconstruction and postconstruction comparisons must be made of surveyed areas, including photographs and other measurements. The Seismologist/Vibration Consultant must include an evaluation of whether any noted differences between the Preconstruction and Postconstruction Condition Surveys are the result of construction vibrations or due to other causes.

3.12.3 Vibration Test Program and Report

Upon completion of the Preconstruction Condition Survey, a Vibration Test Program and Report must be directed and completed by the Seismologist/Vibration Consultant. The completed Vibration Test Program and Report must be submitted and approved prior to full production phase of any proposed construction activity that, in the opinion of the Government, could be a source of ground vibration. These construction activities include, but are not limited to: trenching, hauling, backfilling, compacting, and pile driving. The vibration test program must be conducted, in part, to verify vibration levels for proposed construction equipment listed in the Vibration Monitoring Plan.

Obtain ambient or baseline ground vibration values prior to vibration testing of construction equipment. Vibration monitoring must be performed for 12 daylight hours to obtain the ambient or baseline ground vibration values at [_____].

Perform the Vibration Test Program(s) in a remote area of the project, at a distance of at least [100 feet] [_____] from the nearest structure. Components of the Vibration Test Program must be established and directed by the Seismologist/Vibration Consultant. The vibration tests must include, but are not limited to: vibration monitoring at various distances from the vibration source, determination of the ground vibration source level for the construction equipment and methods (minimum requirement includes peak particle velocity and frequency values at various distances from the source), and establishing the attenuation rate through the project soil.

The Vibration Test Programs and Report must state the suitability of the proposed construction equipment and methods to perform within the specified vibration criteria. If it is determined, by the Vibration Consultant or Government, that the proposed construction equipment and methods cannot satisfy the specified vibration criteria, then alternative or supplemental equipment/methods, or vibration mitigation measures must be tested and report resubmitted for approval, at no additional cost to the Government.

The report must also include any recommendations to reduce construction impacts from ground vibrations or noise. Base recommendations on an analysis from the results of the Vibration Test Program, Preconstruction Condition Surveys, and site specific conditions. Recommendations could include, but are not limited to, the following: requirement for additional instrumentation to document potential settlement or displacement; requirement for more restrictive vibration criteria; ground vibration or noise reduction measures.

3.12.4 Seismologist/Vibration Consultant Duties

The Seismologist/Vibration Consultant duties are as follows: direct and instruct the Contractor in operations to control vibrations within specified levels; participate in a public meeting; facilitate and complete the preconstruction and postconstruction surveys; perform Vibration Test Program(s) and complete report; provide, install, and use all necessary equipment to observe and record vibrations to ascertain that acceptable levels of vibrations are not exceeded; and monitor benchmarks, deflections, cracks, and other critical conditions on the existing structures. Obtain Rights-of-entry and permissions from landowners for access to perform vibration monitoring. Monitor vibrations, report findings, and furnish recommendations on a daily basis to the Contractor and Government, determine the level of observed vibrations attributed to the project's construction activities, and determine their subsequent effect on surrounding structures.

If the monitoring equipment can be operated automatically and monitored remotely, the Seismologist/Vibration Consultant must be present at the site for the start of new construction activities that require vibration monitoring, movement and setup of vibration monitoring instruments, monitoring devices for structural movement and settlement, and at other key times in the project as approved in the Vibration Monitoring Plan. Otherwise, the Seismologist/Vibration Consultant must be onsite during all applicable construction activities. The Seismologist/Vibration Consultant must be readily available if issues requiring attention arise during construction. When monitoring is occurring, the Seismologist/Vibration Consultant must check all equipment at the start of each work day to confirm that it is working properly.

3.12.5 Daily Vibration Monitoring Reports

At the end of each day of monitoring, the Seismologist/Vibration Consultant must record the following information on a form developed by the Seismologist/Vibration Consultant, and submit final signed reports electronically to the Government within 24 hours:

a. The name of the Contractor and/or Subcontractors responsible for the primary construction activities generating vibrations.

b. The name of the Seismologist/Vibration Consultant.

c. The name of the operator of the vibration monitoring equipment.

d. A sketch indicating the location of the vibration monitors and the construction activities generating vibrations.

e. Complete details of the particular construction activities which are being monitored, including all related equipment, operating frequencies, piling or excavation depths, distance from the construction activities to the monitoring equipment, and all other related information as requested by the Government.

f. Results of monitored vibrations and noise levels for the particular construction activity, including the frequencies of the measured peak particle velocities.

g. Identification of any activity resulting in the ground vibration or noise limits being exceeded and the time of day that the limits were exceeded. List time of day that the Contractor and Government were notified. List time of day that the construction activity was halted. Include corrective actions taken to reduce ground vibration and noise levels.

h. A summary of any vibration related complaints received during the day.

i. Reports must be reviewed and signed by the Seismologist/Vibration Consultant's experienced Registered Professional Engineer.

3.12.6 Web Interface of Interactive and Static Reports of Data

Through the use of a secure web interface, establish interactive and static reports generated from the vibration monitoring data gathered at the site. Establish the web interface within 30 days following Notice to Proceed. Provide backups for the website in accordance with the requirements stated in paragraph DATA REQUIREMENTS. The interface must be intuitive, easy to navigate, and include real-time monitoring data. Within 60 days of the notice to proceed, provide a presentation of all components of the web interface for submittal approval by the Government.

3.12.7 Adjustments in Construction Procedures

If the Contractor receives complaints by the public during construction, or during the Preconstruction and Postconstruction Condition Survey process, the Contractor must follow a Vibration Screening Procedure and fill out a Vibration Complaint Report, in accordance with the approved Vibration Monitoring Plan. The Contractor must notify the Government of any complaint within 24 hours and must submit a copy of the completed Vibration Complaint Report within one week of the complaint.

If the monitoring data indicates that the ground vibration limits for any of the three mutually perpendicular components, or noise limit, have been exceeded, the construction activity generating those vibrations must be halted immediately. A deficiency correction report, giving corrective actions or mitigation measures to reduce ground vibrations or noise levels, must be submitted by the Contractor. Construction activity may not resume until the report has been approved by the Government and corrective actions or mitigation measures are completed by the Contractor. Vibration or noise mitigation or reduction measures must be constructed or implemented at no additional cost to the Government.

3.12.8 Government Quality Assurance

The Government may check the vibration monitoring operations at any time and may perform independent vibration monitoring.

3.12.9 Ownership

At the end of this contract, on a date specified by the Government's Representative, all instrumentation components become the property of the Government. All data collection and recording devices must be calibrated and certified by the manufacturer or a certified laboratory prior to being delivered to the Government's Representative. The Contractor is responsible for all costs for the recalibration, shipping, and verification of these data recorders.

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SECTION 33 52 10

FUEL SYSTEMS PIPING (SERVICE STATION)
11/18, CHG 1: 11/20

PART 1 GENERAL

1.1 SUMMARY

This section defines the requirements for pipe, piping components, and valves as related to small fuel distribution systems (non-aviation type). Provide the entire fuel distribution system as a complete and fully operational system. Size, select, construct, and install system components to operate together as a complete system. Substitutions of functions specified herein will not be acceptable. Coordinate the work of the system manufacturer's service personnel during construction, testing, calibration, and acceptance of the system. Design system components and piping specified herein to handle a working pressure of 275 psig at 100 deg F. System components specified herein must be compatible with the fuel to be handled. Components must be suitable for outside, unsheltered location, and to function normally in ambient temperatures between [_____] degrees F and [_____] degrees F.

1.1.1 Related Sections

1.1.1.1 Welding

Welding activities for pipe and piping components must be in accordance with Section 33 52 23.15 POL SERVICE PIPING WELDING.

1.1.1.2 Earthwork

Excavate and backfill piping as specified in [Section 31 00 00 EARTHWORK] [Section 31 23 00.00 20 EXCAVATION AND FILL].

1.1.1.3 Cathodic Protection

Provide buried metallic components including pipe, anchors, and conduit with a cathodic protection system as specified in [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM][and][Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM]. Cathodic protection for metal components that attach to a tank must be coordinated and compatible with the tank corrosion control system.

1.1.1.4 Concrete Manholes

Construct manhole of concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 540 (1999; R 2004) Electrical Installations in

	Petroleum Processing Plants
API RP 1110	(2013; R 2018) Recommended Practice for the Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids, or Carbon Dioxide
API RP 2003	(2015; 8th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API STD 600	(2015) Steel Gate Valves-Flanged and Butt-welding Ends, Bolted Bonnets
API STD 608	(2012) Metal Ball Valves - Flanged, Threaded, And Welding End
API Spec 5L	(2018; 46th Ed; ERTA 2018) Line Pipe
API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves
API Spec 6FA	(1999; R 2006; Errata 2006; Errata 2008; R 2011) Specification for Fire Test for Valves
API Spec 17J	(2016; Errata 2 2017; ADD 1 2017) Specification for Unbonded Flexible Pipe
API Std 594	(2017) Check Valves: Flanged, Lug, Wafer and Butt-Welding
API Std 607	(2016) Fire Test for Quarter-turn Valves and Valves Equipped with Non-metallic Seats

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.3	(2020) Process Piping
ASME B40.200	(2008; R 2013) Thermometers, Direct Reading and Remote Reading
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C209	(2019) Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fitting for Steel Water Pipelines
AWWA C215	(2016) Extruded Polyolefin Coatings for Steel Water Pipe
AWWA C216	(2015) Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C217	(2016; Addenda 2017) Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe and Fittings

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A182/A182M	(2021) Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A269/A269M	(2015; R 2019) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A312/A312M	(2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A358/A358M	(2019) Standard Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Stainless Steel Pipe for High-Temperature Service and General Applications
ASTM A403/A403M	(2022) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples

ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B247	(2020) Standard Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings
ASTM B687	(1999; R 2016) Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM D229	(2019) Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM F436	(2011) Hardened Steel Washers
ASTM F844	(2019) Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F1172	(1988; R 2019) Standard Specification for Fuel Oil Meters of the Volumetric Positive Displacement Type

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE 1100	(2005) Emerald Book IEEE Recommended Practice for Powering and Grounding Electronic Equipment
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

NACE INTERNATIONAL (NACE)

NACE SP0185	(2007) Extruded Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe
NACE SP0188	(1999; R 2006) Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2021; TIA 20-1; TIA 20-2) Flammable and Combustible Liquids Code
NFPA 30A	(2021; TIA 20-1) Code for Motor Fuel Dispensing Facilities and Repair Garages
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 77	(2014) Recommended Practice on Static Electricity
NFPA 407	(2022) Standard for Aircraft Fuel Servicing
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1	(2016) Shop, Field, and Maintenance Coating of Metals

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J514	(2012) Hydraulic Tube Fittings

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-PRF-13789	(1999; Rev E; Notice 1 2008; Notice 2 1016; Notice 3 2021) Strainers, Sediment: Pipeline, Basket Type

UNDERWRITERS LABORATORIES (UL)

UL 971	(1995; Reprint Mar 2006) UL Standard for

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Grounding and Bonding

Pipe Supports

SD-03 Product Data

Insulating Flange Kits; G[, [_____]]

Flange Protectors; G[, [_____]]

Fuel Piping Flange Bolts, Nuts, and Washers; G[, [_____]]

Carbon Steel Pipe; G[, [_____]]

Stainless Steel Pipe; G[, [_____]]

Flexible Non-Metallic Pipe; G[, [_____]]

Double Wall Carbon Steel Piping; G[, [_____]]

Steel Reinforced Flexible Pipe; G[, [_____]]

Copper Piping; G[, [_____]]

Joint Compound; G[, [_____]]

Flexible Connector; G[, [_____]]

Strainer; G[, [_____]]

Thermometers; G[, [_____]]

Pressure Gauge; G[, [_____]]

Flexible Ball Joint; G[, [_____]]

Bellows Expansion Joint; G[, [_____]]

Flow Meter; G[, [_____]]

Ball Valves; G[, [_____]]

Plug (Double Block and Bleed) Valves; G[, [_____]]

Swing Type Check Valves; G[, [_____]]

Wafer Type Check Valve; G[, [_____]]

Globe Valve; G[, [_____]]

Thermal Relief Valve; G[, [_____]]

Pressure\Vacuum Relief Valve; G[, [_____]]

Foot Valve; G[, [_____]]

Tank Overfill Prevention Valve (Gravity Fill); G[, [_____]]

Tank Overfill Prevention Valve (Pumped Fuel Receipt); G[, [_____]]

Anti-Siphon Valves; G[, [_____]]

Submersible Pump; G[, [_____]]

ANSI Type Centrifugal Pump; G[, [_____]]

Sliding Vane Rotary Pump; G[, [_____]]

Self-Priming Centrifugal Pump; G[, [_____]]

Pump Control Panel; G[, [_____]]

FRP Containment Sump; G[, [_____]]

Pipeline Markers; G[, [_____]]

SD-06 Test Reports

Exterior Coating Holiday Test

Preliminary Pneumatic Test

Final Pneumatic Test

Hydrostatic Test

Exterior Containment Piping Tests

SD-07 Certificates

Contractor Qualifications; G[, [_____]]

Licensed Personnel

Stage II Vapor Recovery System

Pipeline Inventory; G[, [_____]]

Demonstrations

SD-08 Manufacturer's Instructions

Flexible Ball Joint

Bellows Expansion Joint

SD-10 Operation and Maintenance Data

Insulating Flange Kits; G[, [_____]]

Flange Protectors; G[, [_____]]

Strainer; G[, [_____]]

Thermometers; G[, [_____]]

Flexible Ball Joint; G[, [_____]]

Bellows Expansion Joint; G[, [_____]]

Flow Meter; G[, [_____]]

Ball Valves; G[, [_____]]

Plug (Double Block and Bleed) Valves; G[, [_____]]

Swing Type Check Valves; G[, [_____]]

Wafer Type Check Valve; G[, [_____]]

Globe Valve; G[, [_____]]

Thermal Relief Valve; G[, [_____]]

Pressure\Vacuum Relief Valve; G[, [_____]]

Foot Valve; G[, [_____]]

Tank Overfill Prevention Valve (Gravity Fill); G[, [_____]]

Tank Overfill Prevention Valve (Pumped Fuel Receipt); G[, [_____]]

Anti-Siphon Valves; G[, [_____]]

Submersible Pump; G[, [_____]]

ANSI Type Centrifugal Pump; G[, [_____]]

Sliding Vane Rotary Pump; G[, [_____]]

Self-Priming Centrifugal Pump; G[, [_____]]

Pump Control Panel; G[, [_____]]

1.4 QUALITY ASSURANCE

1.4.1 Contractor Qualifications

Each installation Contractor must have successfully completed at least 3 projects of the same scope and the same size, or larger, within the last 6-years; demonstrate specific installation experience in regard to the specific system installation to be performed; have taken, if applicable, manufacturer's training courses on the installation of piping; and meet the licensing requirements in the state. Experience must include the erection of piping systems in compliance with the requirements of ASME B31.3, NFPA 30, and NFPA 30A. Submit a letter listing prior projects, the date of construction, a point of contact for each prior project, the scope of work of each prior project, and a detailed list of work performed providing in the letter evidence of prior manufacturer's training and state licensing.

1.4.2 Regulatory Requirements

1.4.2.1 Licensed Personnel

Pipe installers must be licensed/certified when the state, city or locality requires licensed installers.

1.4.2.2 Stage II Vapor Recovery System

System must meet the air quality laws of the State of [_____] as well as applicable local regulations. Submit certification of the stage II vapor recovery systems from the California Air Resources Board (CARB). Test and validate the recovery system to be 95 percent efficient in controlling VOC emissions during refueling of motor vehicles.

1.4.3 Design Data

1.4.3.1 Pipeline Inventory

Fuel system volume must be calculated using as constructed pipe lengths, internal diameters, fittings, and components. Totals must be provided for all items containing fuel with the exception of tanks which is covered by other specifications. A certified pipeline inventory with sizes, lengths, quantity, and volumes must be provided for the systems in this project.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect system components and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 PROJECT/SITE CONDITIONS

Fuel required for the testing, flushing and cleaning efforts, as specified in this section, will be provided and delivered by the Contracting Officer. Fuel used in the system will remain the property of the Government. Fuel shortages not attributable to normal handling losses must be reimbursed to the Government.

PART 2 PRODUCTS

2.1 ELECTRICAL WORK

2.1.1 General

Motors, manual or automatic motor control system components except where installed in motor control centers, and protective or signal devices required for the operation specified herein must be provided under this section in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Any wiring required for the operation specified herein, but not shown on the electrical plans, must be provided under this section in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM[, Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION][, Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION].

2.1.2 Grounding and Bonding

Ground and bond in accordance with NFPA 70, NFPA 77, NFPA 407, NFPA 780, API RP 540, API RP 2003, IEEE 142, and IEEE 1100. Provide jumpers to overcome the insulating effects of gaskets, paints, or nonmetallic components.

2.2 MATERIALS AND SYSTEM COMPONENTS

Internal parts and components of system components, piping, piping components, and valves that could be exposed to fuel during system operation must not be constructed of zinc coated (galvanized) metal, brass, bronze, or other copper bearing alloys. Do not install cast iron bodied valves in piping systems that could be exposed to fuel during system operation.

2.2.1 Standard Products

Provide materials and system components that are standard products of a manufacturer regularly engaged in the manufacturing of such products; that are of a similar material, design and workmanship; and that have been in satisfactory commercial or industrial use for a minimum 2-years prior to bid opening. The 2-year period must include applications of the system components and materials under similar circumstances and of similar size. Materials and system components must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.[Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours, exclusive of the manufacturer's factory tests, can be shown.]

2.2.2 Nameplates

Attach nameplates to all specified system components, thermometers, gauges, and valves defined herein. List on each nameplate the manufacturer's name, address, [contract number,] [acceptance date,] component type or style, model or serial number, catalog number, capacity or size, and the system that is controlled. Construct plates of [anodized aluminum] [stainless steel] [melamine plastic, 0.125 inch thick, UV resistance, black with white center core, matte finish surface and square corners] [_____]. Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive. Minimum size of nameplates must be 1 by 2.5 inches. Lettering must be the normal block style with a minimum 0.25 inch height. Accurately align all lettering on nameplates.[For plastic nameplates, engrave lettering into the white core.][Key the nameplates to a chart and schedule for each system. Frame charts and schedule under glass, and locate where directed near each system. Furnish two copies of each chart and schedule. Each nameplate description must identify its function.]

2.2.3 Flange Gaskets, Non-Electrically Isolating

ASME B16.21, composition ring, using a Nitrile Rubber such as Buna-N and NBR, or a fluoro rubber such as FKM, FPM and Viton©. The gasket must be 0.1250-inch thick. Gaskets must be resistant to the effects of aviation and non-aviation hydrocarbon fuels and manufactured of fire-resistant materials. Use fluoro rubber gaskets for biofuel blend fluids. Full-face gaskets must be used for flat-face flanged joints. Ring gaskets must be used for raised-face flanged joints. Gaskets must be of one piece factory cut material. Select a gasket suitable for the working and test pressure of the fluid.

2.3 FLANGED END CONNECTIONS

2.3.1 Flanges

Provide flanged end connections on system components, fittings, piping, piping components, adapters, couplers,and valves that conform to ASME B16.5, Class 150.

2.3.1.1 Carbon Steel

Carbon steel flanges must conform to ASTM A105/A105M.

2.3.1.2 Stainless Steel

Stainless steel flanges must conform to ASTM A182/A182M, Grade F304, forged type.

2.3.1.3 Aluminum

Aluminum flanges must conform to ASTM B247, Alloy 6061-T6.

2.3.2 Insulating Flange Kits, (Electrically Isolating)

Provide ASTM D229 electrical insulating material of 1,000 ohms minimum resistance or 500 Volts per mil (VPM) minimum dielectric strength; material must be resistant to the effects of aviation and non-aviation hydrocarbon fuels. Provide full face insulating gaskets between flanges with fluoroelastomer (FKM), commonly referred to as Viton, O-ring sealing surfaces. Provide full surface 0.03-inch thick wall thickness, spiral-wound mylar insulating sleeves between the bolts and the holes in flanges; bolts may have reduced shanks of a diameter not less than the diameter at the root of threads. Provide 0.125-inch thick high-strength phenolic insulating washers next to flanges and provide flat circular stainless steel washers over insulating washers and under bolt heads and nuts. Provide bolts 0.5-inch longer than standard length to compensate for the thicker insulating gaskets and the washers under bolt heads and nuts. Above grade flanges separated by electrically insulating flange kits must be provided with weatherproof lightning surge arrester devices. The surge arrester must bolt across flanges separated by insulating gasket kits per detail on contract drawings. Provide with flange protector as described in this section. The arrestor must have the following features:

a. Weatherproof NEMA 6P enclosure.

b. Bidirectional and bipolar protection.

c. Constructed of solid state components, no lights, fuses or relays and used without required maintenance or replacement.

d. Withstand unlimited number of surges at 50,000 Amperes.

e. Maximum clamping voltage of 700 Volts based on a IEEE C62.41.2 8x20 microsecond wave form at 50,000 Amperes peak measured at the device terminals (zero lead length).

f. A UL listed arrester for installation in Class 1, Division 1 or Class 1, Division 2, Group D, hazardous areas.

Install the mounting bracket and leads on the flange side of the bolt insulating sleeve and washer, and size in accordance with this schedule:

Line Size	Bolt Size
2 inch	5/8 inch
2.5 inch	5/8 inch
3 inch	5/8 inch
4 inch	5/8 inch
6 inch	3/4 inch
8 inch	3/4 inch
10 inch	7/8 inch
12 inch	7/8 inch
14 inch	1 inch
16 inch	1 inch
Note: Make allowance for the 1/32-inch thickness of the insulating sleeve around the bolts when sizing the mounting lugs.	

2.3.3 Flange Protectors

Protectors must protect the bolts, studs, nuts, and gaskets of a flanged end connection from corrosion or damage due to exposure to the environment. Protectors must be weather and ultraviolet (UV) resistant and constructed with stainless steel bands and rubber lining. Protectors must allow for quick and easy removal and re-installation by maintenance personnel. Provide grease filled bolt caps. Corrosion Prevention grease must be non-expansive and designed for the service.[Provide protectors that allow visual inspection of the flange gasket without requiring removal.][For electrically isolating flange connections, provide protectors with grease fittings that allow the injection of grease into the flange cavity.]

2.3.4 Fuel Piping Flange Bolts, Nuts, and Washers

a. Bolts and nuts for pipe flanges, flanged fittings, valves and accessories must conform to ASME B18.2.1 and ASME B18.2.2, except as otherwise specified.

b. Bolts must be of sufficient length to obtain full bearing on the nuts and must project no more than three full threads and no less than two full threads beyond the nuts with the bolts tightened to the required torque.

c. Bolts must be regular hexagonal bolts conforming to ASME B18.2.1 with material conforming to ASTM A193/A193M, Class 2, Grade B8, stainless steel, when connections are made where a stainless steel flange is involved, and Grade B7, chromium molybdenum alloy, when only carbon steel flanges are involved. Bolts and nuts chosen must have sufficient strength to seat gasket types chosen. Bolts must be threaded in accordance with ASME B1.1, Class 2A fit, Coarse Thread Series, for sizes one inch and smaller and Eight-Pitch Thread Series for sizes larger than one inch.

d. Nuts must conform to ASME B18.2.2, hexagonal, heavy series with material conforming to ASTM A194/A194M, Grade 8, stainless steel for stainless steel bolts, and Grade 7, chromium molybdenum allow for chromium molybdenum alloy bolts. Nuts must be threaded in accordance with ASME B1.1, Class 2B fit, Coarse Thread Series for sizes one inch and smaller and Eight-Pitch Thread Series for sizes larger than one inch.

e. Provide washers under bolt heads and nuts. Use chromium molybdenum alloy washers dimensioned to ASTM F436 flat circular for chromium molybdenum bolts. Stainless steel washer dimensioned similar to ASTM F436 flat circular, use material the same as the bolt.

f. Use torque wrenches to tighten all flange bolts to the torque recommended by the gasket manufacturer. Tighten in the pattern recommended by the gasket manufacturer. Use anti-seize compound on stainless steel bolts.

2.4 PIPE

Pipe must meet the material, fabrication and operating requirements of ASME B31.3, except as modified herein.

2.4.1 Carbon Steel Pipe

Provide carbon steel pipe that complies with one of the following:

a. Pipe must conform to ASTM A53/A53M, Type E or S, Grade B, seamless or electric welded. Pipe smaller than 2-1/2 inches must be Schedule 80. Pipe 2-1/2 inches and larger must be Schedule 40.

b. Pipe must conform to API Spec 5L, Product Specification Level (PSL) 1, Grade B, [submerged-arc welded or gas metal-arc welded] [seamless or electric welded].

End connections for pipe or fittings smaller than 2-1/2 inches must be forged, socket weld type conforming to ASTM A182/A182M and ASME B16.11, unless indicated otherwise. End connections for pipe or fittings 2-1/2 inches and larger must be buttweld type conforming to ASTM A234/A234M, Grade WPB and ASME B16.9 of the same wall thickness as the adjoining pipe.[Where threaded end connections are indicated, provide connections that conform to ASME B16.3, Class 150 or ASME B16.11.]

2.4.2 Stainless Steel Pipe

Provide stainless steel pipe that complies with one of the following:

a. Pipe must conform to ASTM A312/A312M, Type TP304L, seamless only. Pipe smaller than 8 inches must be Schedule 40S. Pipe 8 inches or larger must be Schedule 10S.

b. Pipe must conform to ASTM A358/A358M, Grade 304L, Class 1 or 3, longitudinally welded. Radiographically inspect 100 percent of factory longitudinal welds in accordance with ASME BPVC SEC VIII D1. Minimum pipe wall thickness must be 0.25 inch for pipe 12 inches and smaller; 0.312 inch for pipe larger than 12 inches.

2.4.2.1 Fittings 2-1/2-inch and Larger

Provide buttwelded type fittings that complies with one of the following:

a. Stainless steel conforming to ASTM A403/A403M, Class WP-S, Grade WP 304L, seamless only and ASME B16.9 of the same thickness as the adjoining pipe.

b. Stainless steel conforming to ASTM A403/A403M, Class WP-XX, Grade WP 304L, of wall thickness as indicated. Do not fabricate starting material by the fusion welding process without addition of filler metal. Forming will not be allowed using fusion welding process without addition of filler metal. Radiographically inspect all factory longitudinal welds in accordance with ASME BPVC SEC VIII D1.

2.4.2.2 Fittings 2-inch and Smaller

Socket welded type fittings, unless indicated otherwise, must conform to ASME B16.11. Fitting materials must be stainless steel that conforms to ASTM A182/A182M, Type F304L.

2.4.2.3 Control Tubing

Piping must be seamless, fully annealed stainless steel tubing conforming to ASTM A269/A269M, Grade TP316, with a hardness number not exceeding 80 HRB. For 1/2-inch tubing, provide a minimum 0.049 inch tubing wall thickness.

2.4.2.4 Control Tubing Fittings

Fittings must be the flareless, Type 316 stainless steel type conforming to SAE J514.

2.4.3 Flexible Non-Metallic Pipe

Piping must conform to UL 971. Piping must be installed in manufacturers supplied corrugated, flexible, access piping. Size is limited to 3-inch diameter or less. For piping larger than 3 inches use the carbon steel piping system described in Section 33 52 40 FUEL SYSTEMS PIPING (NON-HYDRANT).

2.4.4 Double Wall Carbon Steel Piping

Piping system must be of pre-engineered double-wall construction with both the internal pipe (primary product pipe) and the exterior pipe (containment pipe) of carbon steel. The exterior containment piping must allow for complete inspection of the primary piping before the exterior piping is sealed. The exterior piping for the secondary containment system for underground piping must be:

a. Pipe material must be carbon steel as specified.

b. Capable of withstanding a minimum 35 kPa air pressure.

c. Evenly separated from the primary pipe using pipe spacers which are designed based on pipe size, pipe and fuel weight, and operating conditions. The supports must be constructed of non-metallic and non-conductive material and must be designed so that no point loading occurs on the primary or exterior pipe. The exterior piping and supports must allow for the installation of any necessary leak detection equipment or cables.

d. Externally coat primary product pipe and containment pipe as specified in Section 33 52 80 LIQUID FUELS PIPELINE COATING SYSTEMS.

[2.4.5 Steel Reinforced Flexible Pipe

Steel Reinforced High Density Polyethylene (HDPE) flexible piping must be manufactured in accordance with API Spec 17J and consist of an inner layer of HDPE material, a steel reinforcing layer and an outer HDPE protective layer.

2.4.5.1 Steel Reinforced Flexible Pipe Fittings

End connections and mid-line connections for steel reinforced high density polyethylene (HDPE) flexible pipe must be of stainless steel swaged onto the pipe ends.

End connections must terminate in flanged end or weld ends as indicated. Mid-line connections must terminate in flanged fittings if they are in a pit or double swage type if they are not.

]2.4.6 Copper Piping

Pipe and tubing must conform to ASTM B88, Type K or L.

2.4.6.1 Fittings and End Connections

Wrought copper and bronze solder-joint pressure fittings must conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy solder-joint pressure fittings must conform to ASME B16.18. Cast copper alloy fittings for flared copper tube must conform to ASME B16.26 and ASTM B62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and system components. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.4.6.2 Solder

Solder must conform to ASTM B32, grade Sb5, tin-antimony alloy for service pressures up to 150 psig. Solder flux must be liquid or paste form, non-corrosive and conform to ASTM B813.

2.4.6.3 Brazing Filler Metal

Filler metal must conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.5 PIPING COMPONENTS

Provide piping components that meet the material, fabrication and operating requirements of ASME B31.3, except as modified herein. Pressure design class for piping components must be Class 150 as defined in ASME B16.5.

2.5.1 Welded Nipples

Nipples must conform to ASTM A733 or ASTM B687 and be constructed of the same material as the connecting pipe.

2.5.2 Steel Couplings

Couplings must conform to API Spec 5L, seamless, extra heavy, wrought steel with recessed ends.

2.5.3 Threaded Unions

Unions must conform to ASME B16.39, Class 150. Unions materials must conform to ASTM A312/A312M, Grade 304 or 316. Dielectric unions must conform to dimensional, strength, and pressure requirements of ASME B16.39, Class 150. Steel parts must be galvanized or plated. Union must have a water-impervious insulation barrier capable of limiting galvanic current to one percent of the short-circuit current in a corresponding bimetallic joint. When dry, union must be able to withstand a 600-volt breakdown test.

2.5.4 Joint Compound

Joint compounds must be resistant to water and be suitable for use with fuel containing 40 percent aromatics.

2.5.5 Flexible Connector

Flexible connectors for fueling pumps must have ANSI Class 300 or 150 flanges to mate directly to the pump and Class 150 flanges to the system flanges. Flanges must be stainless steel and must conform to ASME B16.5. These units must have an inner stainless steel or Inconel, corrugated tube with external stainless steel braid, and all components must be rated for not less than 275 psig @ 100°F. Face by Face dimension must be as recommended by the manufacturer. Use Inconel 625 inner bellows in coastal environments or where chlorides are present in the atmosphere.

For sizes larger than 152 mm 6 inches, connectors must incorporate the use of Lo-corr, multi-ply bellows, without external braid, with bellows rating of 300 psig and overall rating consistent with the flange ANSI class. Flanges must be plate type, Vanstone design, with axial movement control rods.

Fabricate piping to measurements established on the project site and position into place without springing or forcing. Make provisions for absorbing expansion and contraction without undue stress in any part of the system. The use of flexible connectors in permanently mounted pump suction and discharge lines as a method of compensating for piping misalignment is not acceptable.

2.5.6 Strainer

Strainer must be single, basket type, arranged in a [simplex] [duplex] configuration as indicated in compliance with MIL-PRF-13789, except as specified otherwise. Strainer end connections must be designed in accordance with ASME B16.5, Class 150. Strainer body material must be the same as the material specified for manual valves. Strainers must have removable baskets of [7][40][60][100][_____] mesh wire screen with larger wire mesh reinforcement; wire must be stainless steel, Type 316. Pressure drop for clean strainer must not exceed 3 psig at maximum design flow rate. The ratio of net effective strainer area to the area of the connecting pipe must be not less than three to one. Each strainer must be provided with a suitable drain at the bottom, equipped with a ball valve. The strainer must be equipped with a direct-reading, piston type differential pressure gauge that measures the differential pressure across the basket as per Section 33 57 55 FUEL SYSTEM COMPONENTS (NON-HYDRANT).

2.5.7 Thermometers

Analog, dial-type bimetallic actuated type that conforms to ASME B40.200. Thermometer must have a 5 inch diameter dial, a hermetically sealed stainless steel case, a stainless steel stem, a safety glass face, a fixed threaded connection, and a scale range as indicated. Thermometer accuracy must be within one percent of the scale range.

2.5.8 Pressure Gauge

See Section 33 57 55 FUEL SYSTEM COMPONENTS (NON-HYDRANT).

2.5.9 Pipe Supports

Supports must be the adjustable type conforming to MSS SP-58, except as modified herein. Provide hot-dipped galvanized finish on rods, nuts, bolts, washers, hangers, and supports. [Provide Type 316 stainless steel nuts, bolts, washers, and screws when located under a pier.] Provide miscellaneous metal that conforms to ASTM A36/A36M, standard mill finished structural steel shapes, hot-dipped galvanized.

2.5.9.1 Pipe Protection Shields

Shields must conform to MSS SP-58, Type 40, except material must be Type 316 stainless steel. Provide shields at each slide type pipe hanger and support.

2.5.9.2 Low Friction Supports

Supports must have self-lubricating anti-friction bearing elements composed of 100 percent virgin tetrafluoroethylene polymer and reinforcing aggregates, prebonded to appropriate backing steel members. The coefficient of static friction between bearing elements must be 0.06 from initial installation for both vertical and horizontal loads and deformation must not exceed 0.002 inch under allowable static loads. Bonds between material and steel must be heat cured, high temperature epoxy. Design pipe hangers and support elements for the loads applied. Provide anti-friction material with a minimum of 0.09 inch thick. Provide hot-dipped galvanized steel supports. Provide supports that are factory designed and manufactured.

2.5.10 Escutcheon

Escutcheon must be the chrome plated, stamped steel, hinged, split ring type. Inside diameter must closely fit pipe outside diameter. Outside diameter must completely cover the corresponding floor, wall, or ceiling opening. Provided each escutcheon with necessary set screws.

2.5.11 Flexible Ball Joint

Flexible ball joints must be [stainless steel] [carbon steel with electroless nickel-plating to a minimum of 3 mils thickness], capable of 360-degree rotation plus 15-degree angular flex movement, ASME B16.5, Class 150 flanged end connections. Provide either pressure molded composition, PEEK, or polytetrafluoroethylene (PTFM) gaskets designed for continuous operation temperature of 275 degrees F. Joints must be designed for minimum working pressure of ANSI Class 150. Injectable packing will not be allowed.

2.5.12 Bellows Expansion Joint

The expansion joints must be for axial compression and extension with capacity as per the design documents. Units must be[of the externally pressurized design with internal and external integral guides, and] manufactured by an Expansion Joint Manufacturers Association certified manufacturer. They must incorporate multi-ply, Lo-corr bellows of [ASTM A240/A240M 321-304 stainless steel][Inconel 625] if chlorides are present in the atmosphere. Unit must be equipped with travel limit stops, and internal guides vented to reduce the effects of sudden pressure changes. Flanges and housing must be stainless steel or carbon steel to match piping materials. Flanges must conform to ASME B16.5. Dual Expansion Joints must incorporate an intermediate anchor base. Housing must include lifting lug and drain port. Joints must be capable of 10,000 cycles over a period of 20-years.

Cold set joints to compensate for the temperature at the time of installation. Provide initial alignment guides on the connecting piping no more than 4 pipe diameters from the expansion joint. Provide additional alignment guides on the connecting piping no more than 14 pipe diameters from the first guide.

2.5.13 Flow Meter

Provide volumetric positive displacement type meter that conforms to ASTM F1172, except as modified herein. Meter must indicate the fuel oil flow rate in gpm. Meter must be provided with overspeed protection and a water escape hole. If meter is not mounted in-line with the piping, then an appropriate pedestal for mounting must be provided. Install meter in accordance with manufacturer's recommendations. Meter must be capable of providing a 4-20 mA analog output signal for the fuel flow rate.[The output signals must be compatible with the base's existing Energy Monitoring and Control, System (EMCS).]

2.6 MANUAL VALVES

All portions of a valve coming in contact with fuel must be of noncorrosive material. Valves in stainless steel pipe lines or epoxy lined carbon steel pipe lines must be Type 304 or Type 316 stainless steel or carbon steel internally plated with chromium or nickel or internally electroless nickel plated. Valves in unlined carbon steel pipelines must have carbon steel body. Stem and trim must be stainless steel for all valves. Manually operated valves 6 inches and larger must be worm-gear operated and valves smaller than 6 inches must be lever operated or handwheel operated. Valves smaller than 2 inches must have lever-type handles. Handles installed more than 6 feet above finished floor must have chain operators. Valve indicators installed higher than 5 feet must have a position indicator visible from ground level. Sprocket wheel for chain operator must be aluminum.

2.6.1 Ball Valves

Ball valves must be fire tested and qualified in accordance with the requirements of API Std 607 and API STD 608. Seal material for the fire test must be graphite, seal material for the project must be as indicated below. Ball valves must be nonlubricated valves that operate from fully open to fully closed with 90 degree rotation of the ball. Valves 2 inches and larger must conform to applicable construction and dimension requirements of API Spec 6D, ANSI Class 150 and must have flanged ends. Valves smaller than 2 inches must be ANSI class 150 valves with flanged ends, unless noted otherwise. The balls in valves 10 inchesand larger full port and 12 inch and larger regular port and larger must have trunnion type support bearings. Except as otherwise specified or indicated, reduced port or full port valves may be provided at the Contractor's option. Balls must be solid, not hollow cavity.

2.6.1.1 Materials

Ball must be stainless steel. Ball valves must have polytetrafluoroethylene (PTFM) or fluoroelastomer (FKM), commonly referred to as Viton seats, body seals and stem seals. Valves 4 inches and smaller must have a locking mechanism.

2.6.1.2 V-Port Ball Valve

Valve must conform to requirements as specified for BALL VALVES paragraph in this section. Valve must be provided with characterized linear v-port for flow rate control, and with infinite position lever bracket with locking bolt for set position.

2.6.1.3 Electric Valve Actuator

Electric valve actuator must be as indicated for Plug (Double Block and Bleed) Valves, electric valve actuator.

2.6.2 Plug (Double Block and Bleed) Valves

API Spec 6D, API Spec 6FA, ANSI Class 150, non-lubricated, resilient, double seated, trunnion mounted, tapered lift plug capable of two-way shutoff. Valve must have tapered plug of steel or ductile iron with chrome or nickel plating and plug supported on upper and lower trunnions. Sealing slips must be steel or ductile iron, with Viton seals which are held in place by dovetail connections. Valve design must permit sealing slips to be replaced from the bottom with the valve mounted in the piping. Valves must operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. Valves must have weatherproof operators with mechanical position indicators. Indicator shaft must be stainless steel. Minimum bore size must be not less than 65 percent of the internal cross sectional area of a pipe of the same nominal diameter unless bore height of plug equals the nominal pipe diameter and manufacturer can show equal or better flow characteristics of the reduced bore size design.

2.6.2.1 Valve Operation

Rotation of the handwheel toward open must lift the plug without wiping the seals and retract the sealing slips so that during rotation of the plug clearance is maintained between the sealing slips and the valve body. Rotation of the handwheel toward closed must lower the plug after the sealing slips are aligned with the valve body and force the sealing slips against the valve body for positive closure. When valve is closed, the slips must form a secondary fire-safe metal-to-metal seat on both sides of the resilient seal. Plug valves located in Isolation Valve Pits or vaults must be provided with handwheel extensions.

2.6.2.2 Integral Cavity Valves

ANSI Class 150. Provide plug valves with automatic thermal relief valves to relieve the pressure build up in the internal body cavity when the plug valve is closed. Relief valves must open at 25 psi differential pressure and must discharge to the throat of, and to the upstream side, of the plug valve.

2.6.2.3 Bleed Valves

ANSI Class 150, stainless steel body valve. Provide manually operated bleed valves that can be opened to verify that the plug valves are not leaking when in the closed position.

2.6.2.4 Electric Valve Actuator

The actuator, controls and accessories must be the responsibility of the valve-actuator supplier for sizing, assembly, certification, field-testing and any adjustments necessary to operate the valve as specified. The electric valve actuator must include as an integral unit the electric motor, actuator unit gearing, limit switch gearing, position limit switches, torque switches, drive bushing or stem nut, declutch lever, wiring terminals for power, remote control indication connections and handwheel. The electrically actuated plug valve must be set to open and close completely in 30 to 60 seconds against a differential pressure of 275 PSIG. The actuator settings of torque and limit contacts must be adjustable. The valve actuator must be suitable for mounting in a vertical or horizontal position and be rated for 30 starts per hour. The valve actuator must be capable of functioning in an ambient environment temperature ranging from [minus 22 to 158] [_____] degrees F.

a. The electrical enclosure must be specifically approved by UL or Factory Mutual for installation in Class I, Division 1, Group D locations.

b. The electric motor must be specifically designed for valve actuator service and must be totally enclosed, non-ventilated construction. The motor must be capable of complete operation at plus or minus 10 percent of specified voltage. Motor insulation must be a minimum NEMA Class F. The motor must be a removable subassembly to allow for motor or gear ratio changes as dictated by system operational requirements. The motor must be equipped with an embedded thermostat to protect against motor overload and also be equipped with space heaters. It must de-energize when encountering a jammed valve.

c. The reversing starter, control transformer and local controls must be integral with the valve actuator and suitably housed to prevent breathing or condensation buildup. The electromechanical starter must be suitable for 30 starts per hour. The windings must have short circuit and overload protection. A transformer, if needed, must be provided to supply all internal circuits with 24 VDC or 110 VAC may be used for remote controls.

d. The actuator gearing must be totally enclosed in an oil-filled or grease-filled gearcase. Standard gear oil or grease must be used to lubricate the gearcase.

e. The actuator must integrally contain local controls for Open, Close and Stop and a local/remote three position selector switch: Local Control Only, Off, and Remote Control plus Local Stop Only. A metallic handwheel must be provided for emergency operation. The handwheel drive must be mechanically independent of the motor drive. The remote control capability must be to open and close. Rim pull to operate valve manually must not exceed 80 pounds.

f. Position limit switches must be functional regardless of main power failure or manual operation. Four contacts must be provided with each selectable as normally open or normally closed. The contacts must be rated at 5A, 120 VAC, 30 VDC.

g. Each valve actuator must be connected to a PLC supplied by "others".

h. The actuator must have a local display of position even when power has been lost.

i. The actuator must be supplied with a start-up kit comprising installation instruction, electrical wiring diagram and spare cover screws and seals.

j. The actuator must be performance tested and a test certificate must be supplied at no extra charge. The test should simulate a typical valve load with current, voltage, and speed measured.

2.6.3 Swing Type Check Valves

Swing check valves must conform to API STD 600, regular type, ANSI Class 150 with flanged end connections. Discs and seating rings must be renewable without removing the valve from the line. The disc must be guided and controlled to contact the entire seating surface.

2.6.4 Wafer Type Check Valve

Spring assisted, wafer/tapped lug pattern, butterfly check or globe type with FKM or PTFE seat ring, designed to prevent flow reversal slamming of valve, dual plate, and must conform to ASME B16.34, API Std 594, except face to face dimensions may deviate from standard. Valves must be suitable for installation in any orientation. Valve body and trim material must be as previously indicated herein.

2.6.5 Globe Valve

Valve must conform to ASME B16.34, Class 150.

2.6.6 Thermal Relief Valve

2.6.6.1 Valve Materials

Valves must have carbon steel bodies (stainless steel on stainless steel pipelines) and bonnets with stainless steel springs and trim. Valves must be Class 150 flanged end connections.

2.6.6.2 Thermal Relief Valve (ASME Type)

Thermal relief valves must be the fully enclosed, spring loaded, angle pattern, single port, hydraulically operated type with plain caps, and must be labeled in accordance with ASME BPVC (GPM). Valve stems must be fully guided between the closed and fully opened positions. The valves must be factory-set to open at pressures indicated on the drawings. Operating pressure must be adjustable by means of an enclosed adjusting screw. The valves must have a minimum capacity of 20 GPM at 10 percent overpressure. Valves must have a replaceable seat. Relief valves that do not relieve to a zone of atmospheric pressure or tank must be a balanced type relief valve.

2.6.6.3 Thermal Relief Valve (Balanced Type)

Thermal relief valves that do not relieve to a zone of atmospheric pressure or atmospheric tank must be a balanced type relief or regulator valve.

Thermal relief valves must be the fully enclosed, spring loaded, angle pattern, single port, fully balanced type (back pressure must not affect relief pressure) back pressure regulator/relief valve. Set valve at pressure indicated on drawings. Valve body must have one inch (minimum) raised face flange connections unless otherwise indicated. Orifice must have a minimum orifice size of .500 inch in diameter. Valve must have bubble-tight piston and seat design with stainless steel piston and Viton seat. Valve must be selected for the nominal flow condition of: pass a minimum of [5] gallons per minute, at a differential pressure of [55] psig, with a nominal set pressure of [50] psig. Valve must be factory configured to open at required set pressure but must be field adjustable by means of an enclosed adjusting screw.

2.6.7 Pressure\Vacuum Relief Valve

Valve must be the pressure\vacuum vent relief type that conforms to NFPA 30. Valve pressure and vacuum relief settings must be set at the factory. Pressure and vacuum relief must be provided by a single valve. Valve body must be constructed of either cast steel or aluminum. Valve trim must be stainless steel. Inner valve pallet assemblies must have a knife-edged drip ring around the periphery of the pallet to preclude condensation collection at the seats. Pallet seat inserts must be of a material compatible with the fuel specified to be stored. Valve intake must be covered with a 40 mesh stainless steel wire screen.

2.6.8 Foot Valve

Valve must be the self-activating, double-poppet, shutoff type that prevents fuel flow from reversing. Valve must conform to NFPA 30. Valve body must be constructed of either cast steel or aluminum. Valve must be provided with a minimum 20 mesh stainless steel screen on the intake. Valve seats must be the replaceable type. Valve must be capable of passing through a 3 inch pipe or tank flange.

2.6.9 Tank Overfill Prevention Valve (Gravity Fill)

Valve must be the two-stage, float-activated, shutoff type that is an integral part of the drop tube used for gravity filling. The first stage must restrict the flow of fuel into the tank to approximately 5 gpm when the liquid level rises above 87.5 percent of tank capacity. The second stage must completely stop the flow of fuel into the tank when the liquid level rises above 92.5 percent of tank capacity. Valve must be constructed of the same material as the fill tube.

2.6.10 Tank Overfill Prevention Valve (Pumped Fuel Receipt)

Valve must be the two-stage, float-activated, shutoff type that is an integral part of the drop tube used for pressurized fill systems. The valve must completely stop the flow of fuel into the tank, when the liquid level rises above [96.5 percent][_____] of tank capacity. Valve must be constructed of the same material as the fill tube.

2.6.11 Anti-Siphon Valves

2.6.11.1 Solenoid Controlled Anti-Siphon Ball Valve

Anti-siphon valves must be solenoid controlled, normally closed, spring loaded valves. Solenoid must be housed in an integral, watertight, explosion proof housing and suitable for installation in Class I, Division I hazardous area locations. Valve body and trim material must be as previously indicated herein.

2.6.11.2 Anti-Siphon Valve

Anti-siphon valves must be normally closed, spring loaded, angle pattern type valves. Valves must be suitable for installation in any orientation and compatible with suction or pressurized systems. Valve must be UL listed. Valve body and trim material must be as previously indicated herein.

2.7 PUMPS

2.7.1 Submersible Pump

See Section 33 57 55 FUEL SYSTEM COMPONENTS (NON-HYDRANT).

2.7.2 ANSI Type Centrifugal Pump

See Section 33 57 55 FUEL SYSTEM COMPONENTS (NON-HYDRANT).

2.7.3 Sliding Vane Rotary Pump

See Section 33 57 55 FUEL SYSTEM COMPONENTS (NON-HYDRANT).

2.7.4 Self-priming Centrifugal Pump

See Section 33 57 55 FUEL SYSTEM COMPONENTS (NON-HYDRANT).

2.7.5 Pump Control Panel

Panel must include on and off indication lights for each pump. Panel must contain an adjustable control logic for pump operation in accordance with the indicated operation. Panel must also have a manual override switch for each pump to allow for the activation or deactivation of each pump. See Section 33 09 52 FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM (NON-HYDRANT).

2.8 FRP CONTAINMENT SUMP

See Section 33 57 55 FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM (NON-HYDRANT).

2.9 ACCESSORIES

2.9.1 Concrete Anchor Bolts

Concrete anchors must conform to ASTM A307, Grade C, hot-dipped galvanized.

2.9.2 Bolts and Studs

Carbon steel bolts and studs must conform to ASTM A307, Grade B, hot-dipped galvanized. Stainless steel bolts and studs must conform to ASTM A193/A193M, Class 2, Grade 8.

2.9.3 Nuts

Carbon steel nuts must conform to ASTM A563, Grade A, hex style, hot-dipped galvanized. Stainless steel nuts must conform to ASTM A194/A194M, Grade 8.

2.9.4 Washers

Provide flat circular washers under each bolt head and each nut. Washer materials must be the same as the connecting bolt and nut. Carbon steel washers must conform to ASTM F844, hot-dipped galvanized. Stainless steel washers must conform to ASTM A194/A194M, Grade 8.

2.9.5 Polytetrafluoroethylene (PTFE) Tape

Tape must conform to ASTM D3308.

2.9.6 Pipe Sleeves

Provided sleeves constructed of [hot-dipped galvanized steel, ductile iron, or cast-iron pipe] [uncoated carbon steel pipe, conforming to ASTM A53/A53M, [Schedule 30] [Schedule 20] [Standard weight]].

2.9.7 Buried Utility Tape

Provide detectable aluminum foil plastic-backed tape or detectable magnetic plastic tape for warning and identification of buried piping. Tape must be detectable by an electronic detection instrument. Provide tape in minimum 3 inches width rolls, color coded for the utility involved, with warning identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning identification must be at least one inch high and must state as a minimum "BURIED JET FUEL PIPING BELOW". Provide permanent code and letter coloring that is unaffected by moisture and other substances contained in trench backfill material.

2.9.8 Pipeline Markers

Provide pipeline markers constructed of 6 inches diameter, one-half inch thick bronze disk with a 3 inch long bronze headed bolt welded to the back of the disk. Engrave the front of the disk with the words "UNDERGROUND FUEL LINE" in the case of one line and "UNDERGROUND FUEL LINES" in the case of multiple fuel lines.

2.10 FINISHES

Ship, store, and handle coating materials as well as apply and cure coatings in accordance with SSPC PA 1.

2.10.1 Exterior Coating, Direct Buried Piping

2.10.1.1 Factory Coating

Provide direct buried pipe and piping components with a factory-applied, adhesive undercoat and continuously extruded plastic resin coating in accordance with NACE SP0185 or AWWA C215; minimum thickness of plastic resin must be 36 mils for pipe sizes 6 inches and larger.

2.10.1.2 Girth Welds

Coat girth welds using one of the following processes.

a. Heat shrink sleeves in accordance with AWWA C216.

b. Wax tape coatings in accordance with AWWA C217.

c. Cold applied tape coatings in accordance with AWWA C209.

2.10.1.3 Damaged Coatings

Repair damaged coating areas using one of the following processes.

a. Wax tape coatings in accordance with AWWA C217.

b. Cold applied tape coatings in with AWWA C209.

2.10.1.4 Rock Shield

Provide a minimum 3/8 inch thick perforated rock shield around buried piping. Rock shield must consist of a polyethylene outer surface bonded to a closed cell foam substrate with uniform perforations intended for use with cathodic protection systems. Rock shield must overlap on itself no less than 6 inches. Secure rock shield tightly to the pipe using either strapping tape or plastic ties. Air filled cell type rock shields are prohibited.

2.10.2 Exterior Coating, Aboveground Piping

Coat the exterior of aboveground steel piping, flanges, fittings, nuts, bolts, washers, valves, and piping components, as defined in this specification, in accordance with [Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURES][Section 09 90 00 PAINTS AND COATINGS].

2.10.3 New System Components

2.10.3.1 Factory Coating

Unless otherwise specified, provide system components fabricated from ferrous metal with the manufacturer's standard factory finish.[Each factory finish must withstand [125] [500] hours exposure to the salt spray test specified in ASTM B117. For test acceptance, the test specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark immediately after completion of the test.] For system component surfaces subject to temperatures above 120 degrees F, the factory coating must be appropriately designed for the temperature service.

2.10.3.2 Field Painting

Painting required for surfaces not otherwise specified must be field painted as specified in [Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURES][Section 09 90 00 PAINTS AND COATINGS]. Do not paint aboveground stainless steel and aluminum surfaces. Do not coat system components provided with a complete factory coating. Prior to any field painting, clean surfaces to remove dust, dirt, rust, oil, and grease.

PART 3 EXECUTION

3.1 INSTALLATION

Installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with ASME B31.3 and NFPA 30, except as modified herein. Safety rules as specified in NFPA 30 must be strictly observed. Never direct bury threaded connections, socket welded connections, unions, flanges, valves, air vents, or drains. Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible.

3.1.1 Pumps

Properly level, align, and secure pumps in place in accordance with manufacturer's instructions. Support, anchor, and guide so that no strains are imposed on a pump by weight or thermal movement of piping.[Provide floor-mounted pumps with mechanical vibration isolators or a vibration isolation foundation.]

3.1.2 Piping

3.1.2.1 General

Thoroughly clean pipe of all scale and foreign matter before the piping is assembled. Cut pipe accurately to measurements established at the jobsite, and worked into place without springing or forcing. Cut pipe square and have burrs removed by reaming. Install pipe to permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval.

a. Use reducing fittings for changes in pipe sizes. Install system components and piping into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Provide electric isolation fittings between dissimilar metals. Install piping straight and true to bear evenly on supports. Piping must be free of traps, must not be embedded in concrete pavement, and must drain as indicated. Make changes in direction with fittings, except that bending of pipe 4 inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees will not be permitted.

b. The centerline radius of bends must not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. When work is not in progress, securely close open ends of pipe and fittings with an expandable pipe plug so that water, earth, or other substances cannot enter the pipe or fittings. For belowground piping, the full length of each pipe must rest solidly on the underlying pipe bed.

3.1.2.2 Double-Wall Flexible Non-Metallic Piping

Install double-wall flexible non-metallic piping in accordance with manufacturer's instructions.

3.1.2.3 Pipeline Markers

Provide above underground fuel piping spaced every 300 feet, at tees, and at changes in direction. For sections of underground piping less than 300 feet long, place at midpoint. Provide directly above pipe for single lines and between pipes where pipes run in pairs. Provide additional marker over each mid-line fitting connections for steel reinforced flexible pipe. Cast marker into 18-inch diameter, 12-inch thick concrete plug unless it is set in an area with concrete paving in which case it must be cast into the concrete paving.

3.1.2.4 Steel Reinforced Flexible Pipe

Connections between steel pipe and steel reinforced flexible pipe and between separate lengths of steel reinforced flexible pipe must not be made aboveground but must be made either inside a pit or vault, or direct bury them. Where practicable, end-line and mid-line connections must be located inside pit type enclosures of an appropriate size. Where it is not practicable to locate mid-line connections inside pit type enclosures, mid-line connections may be wrapped with a suitable waterproof protective substance and direct buried underground. The location of direct buried mid-line connections must be indicated on the final drawings and provided with a pipeline marker.

3.1.2.5 Welded Connections

Unless otherwise indicated on the drawings, pipe joints must be welded. Construct branch connections with welding tees or forged welding branch outlets. Do not weld stainless steel pipe to carbon steel pipe.

3.1.2.6 Threaded End Connections

Provide threaded end connections only on piping 2 inches in nominal size or smaller and only where indicated on the drawings. Provide threaded connections with PTFE tape or equivalent thread-joint compound applied to the male threads only. Not more than three threads must show after the joint is tighten.

3.1.2.7 Brazed Connections

Provide brazing in accordance with AWS BRH, except as modified herein. During brazing, fill pipe and fittings with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, clean both the outside of the tube and the inside of the fitting with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux. Remove surplus brazing material at all joints. Support piping prior to brazing and do not be spring or force piping.

3.1.2.8 Existing Piping Systems

No interruptions or isolation of an existing fuel handling service or system must be performed unless the actions are approved by the Contracting Officer. Perform initial cutting of existing fuel pipe with a multiwheel pipe cutter, using a nonflammable lubricant. After cut is made, seal interior of piping with a gas barrier plug. Purge interior of piping with carbon dioxide or nitrogen prior to performing any welding process.

3.1.3 Bolted Connections

For each bolted connection of stainless steel components (e.g., pipes, piping components, valves, and system components) use stainless steel bolts or studs, nuts, and washers. For each bolted connection of carbon steel components, use carbon steel bolts or studs, nuts, and washers. Bolts to project no more than three full threads and no less than two full threads beyond the nuts with the bolts tightened to the required torque. Prior to installing nuts, apply a compatible anti-seize compound to the male threads.

3.1.4 Flanges and Unions

Except where threaded end connections [and][or] unions are indicated, provide flanged joints in each line immediately preceding the connection to a system component or material requiring maintenance such as pumps, general valves, control valves, strainers, and other similar items and as indicated. Assemble flanged joints square and tight with matched flanges, gaskets, and bolts. For flanges, provide washers under each bolt head and nut. Torque wrenches must be used to tighten all flange bolts to the torque recommended by the gasket manufacturer. Tightening pattern must be as recommended by the gasket manufacturer. Use anti-seize compound on threads for stainless steel bolts.

3.1.5 Flange Protectors

Provide flange protectors [on each electrically isolating flange connection][on each flanged end connection, including valves and system components][where indicated on the drawings].[Fill the flange cavity of electrically isolating flange connections with corrosion inhibitor type grease.] Provide grease filled bolt caps. Caution should be used when installing stainless steel bands to avoid "grounding out" the insulating flanges.

3.1.6 Valves

Install isolation plug or ball valves on each side of each system component, at the midpoint of looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Install valves with stems vertically up unless otherwise indicated. Provide individual supports and anchors for each valve.

3.1.7 Air Vents

Provide [_____] [1-1/2 inches] air vents at all high points and where indicated to ensure adequate venting of the piping system.

3.1.8 Drains

Provide [_____] [2 inches] drains at all low points and where indicated to ensure complete drainage of the piping. Drains must by schedule 120.Drains must be accessible, and must consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.9 Bellows Expansion Joints

Cold set joints to compensate for the temperature at the time of installation. Provide initial alignment guides on the connecting piping no more than 4 pipe diameters from the expansion joint. Provide additional alignment guides on the connecting piping no more than 14 pipe diameters from the first guide.

3.1.10 Thermometers

Provide thermometers with separable sockets. Install separable sockets in pipe lines in such a manner to sense the temperature of flowing fluid and minimize obstruction to flow.

3.1.11 Pipe Sleeves

Provide a pipe sleeve around any pipe that penetrates a wall, floor, or crosses under a roadway. Do not install sleeves in structural members except where indicated or approved. Install pipe sleeves in masonry structures at the time of the masonry construction. Sleeves must be of such size as to provide a minimum of 1/2 inch all-around clearance between bare pipe and the sleeve. Align sleeve and piping such that the pipe is accurately centered within the sleeve by a nonconductive centering element. Securely anchor the sleeve to prevent dislocation. Closure of the space between the pipe and the pipe sleeve must be by means of a mechanically adjustable segmented elastomeric seal. The seal must be installed so as to be flush. For wall or floor penetrations, extend each sleeve through its respective wall or floor and cut flush with each surface. For roadway crossings, pipe sleeves must be continuous for the entire crossing as well as extend a minimum of 6 inches beyond both sides of the crossing. Seal around sleeves that penetrate through valve or fuel related pits with a Buna-N casing seal. Seal around sleeves that penetrate through non-fire-rated walls and floors in accordance with Section 07 92 00 JOINT SEALANTS. Seal around sleeves that penetrate through fire-rated walls and floors as specified in Section 07 84 00 FIRESTOPPING.

3.1.12 Escutcheons

Except for utility or equipment rooms, provide finished surfaces where exposed piping pass through floors, walls, or ceilings with escutcheons. Secure escutcheon to pipe or pipe covering.

3.1.13 Access Panels

Provide access panels for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels must be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Provide access panels as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.1.14 Buried Utility Tape

Bury tape with the printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

3.1.15 Framed Instructions

Framed instructions must include system components layout, wiring and control diagrams, piping, valves, control sequences, and typed condensed operation instructions. The condensed operation instructions must include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. Frame under glass or laminated plastic the framed instructions and post where directed by the Contracting Officer. Post the framed instructions before the system performance tests.

3.2 PIPE SUPPORTS

Install supports with a maximum spacing as defined in Table 1 below, except where indicated otherwise. In addition to meeting the requirements of Table 1, provide additional supports where concentrated piping loads exist (e.g., valves).

Table 1. Maximum Support Spacing

Nominal Pipe Size (Inches)	One and Under	1.5	2	3	4	6	8	10	12
Maximum Support Spacing (ft)	7	9	10	12	14	17	19	22	23

3.2.1 Seismic Requirements

Support and brace piping and attach valves to resist seismic loads as specified under Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT [and Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL] and as shown on the drawings. Structural steel required for reinforcement to properly support piping, headers, and system components but not shown must be provided under this section. Material used for support must be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.2.2 Structural Attachments

Provide attachments to building structure concrete and masonry by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Apply inserts and anchors with a safety factor not less than 5. Do not attach supports to metal decking. Construct masonry anchors for overhead applications of ferrous materials only. Structural steel brackets required to support piping, headers, and system components, but not shown, must be provided under this section. Material used for support must be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.3 FIELD QUALITY CONTROLS

3.3.1 System Commissioning

System commissioning must conform to Section 33 08 55 FUEL DISTRIBUTION SYSTEM START-UP (NON-HYDRANT).

3.3.2 Tests

Furnish labor, materials, equipment, electricity, repairs, and retesting necessary for any of the tests required herein. Perform piping test in accordance with the applicable requirements of ASME B31.3 except as modified herein. To facilitate the tests, various sections of the piping system may be isolated and tested separately. Where piping sections terminate at flanged valve points, close the line by means of blind flanges in lieu of relying on the valve. Provide tapped flanges to allow a direct connection between the piping and the air compressor [and][or] pressurizing pump. Use tapped flanges for gauge connections. Taps in the permanent line will not be permitted. Gauges will be subject to testing and approval. Provide provisions to prevent displacement of the piping during testing. Keep personnel clear of the piping during pneumatic testing. Only authorized personnel must be permitted in the area during pneumatic and hydrostatic testing. Isolate system components such as pumps, tanks and meters from the piping system during the testing. Do not exceed the pressure rating of any component in the piping system during the testing. Following satisfactory completion of each test, relieve the test pressure and seal the pipe immediately. Piping to be installed underground must not receive field applied exterior coatings at the joints or be covered by backfill until the piping has passed the final pneumatic tests described herein.

3.3.2.1 Exterior Coating Holiday Test

Following installation, test the exterior coating of direct buried piping for holidays using high-voltage spark testing in accordance with NACE SP0188. Repair holidays and retest to confirm holiday-free coating. Text must include all existing underground piping exposed for this project.

3.3.2.2 Preliminary Pneumatic Test

Apply a 25 psig pneumatic test to product piping. Maintain the pressure while soapsuds or equivalent materials are applied to the exterior of the piping. While applying the soapsuds, visually inspect the entire run of piping, including the bottom surfaces, for leaks (bubble formations). If leaks are discovered, repair the leaks accordingly and retest.

3.3.2.3 Final Pneumatic Test

Following the preliminary pneumatic test, apply a 50 psig pneumatic test to all product piping and hold for a period not less than 2-hours. During the test period, there must be no drop in pressure in the pipe greater than that allowed for thermal expansion and contraction. Disconnect the pressure source during the final test period. If leaks are discovered, repair the leaks accordingly and retest.

3.3.2.4 Hydrostatic Test

Testing must comply with the requirements in ASME B31.3, except as modified herein. Hydrostatically test product piping with the fuel to be handled to the lesser of 1-1/2 times operating pressure or 275 psig in accordance with API RP 1110. Maintain the pressure within the piping for 4-hours with no leakage or reduction in gauge pressure. If leaks are discovered, repair the leaks accordingly and retest.

3.3.2.5 Exterior Containment Piping Tests

Apply a minimum pneumatic pressure of 5 psig to the exterior containment piping. Maintain the pressure for at least 1-hour while soapsuds or equivalent materials are applied to the exterior of the piping. While applying the soapsuds, visually inspect the entire run of piping, including the bottom surfaces, for leaks (bubble formations). Repair leaks discovered in accordance with manufacturer's instructions and retest. Perform testing in compliance with the manufacturer's published installation instructions.

3.4 SYSTEM PERFORMANCE TESTS

Conform tests to Section 33 08 55 FUEL DISTRIBUTION SYSTEM START-UP (NON-HYDRANT).

3.5 DEMONSTRATIONS

Conduct a training session for designated Government personnel in the operation and maintenance procedures related to the system components and specified herein. Include pertinent safety operational procedures in the session as well as physical demonstrations of the routine maintenance operations. Furnish instructors who are familiar with the installation/system components/systems, both operational and practical theories, and associated routine maintenance procedures. The training session must consist of a total of [_____] hours of normal working time and must start after the system is functionally completed, but prior to final system acceptance. Submit a letter, at least 14 working days prior to the proposed training date, scheduling a proposed date for conducting the onsite training.

-- End of Section --

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SECTION 33 56 53

COMPRESSED GASES STORAGE TANKS
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.20	(2017) Metallic Gaskets for Pipe Flanges
ASME B31.3	(2020) Process Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC V	(2017) BPVC Section V-Nondestructive Examination
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A182/A182M	(2021) Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A312/A312M	(2021) Standard Specification for

	Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320/A320M	(2021a) Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A370	(2021) Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A376/A376M	(2019) Standard Specification for Seamless Austenitic Steel Pipe for High-Temperature Service
ASTM A403/A403M	(2022) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM E165/E165M	(2018) Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E709	(2021) Standard Guide for Magnetic Particle Testing

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 21	(1982; E 2004) White or Colored Silicone Alkyd Paint (Type I, High Gloss and Type II, Medium Gloss)
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AS598	(2012) Aerospace Microscopic Sizing and Counting of Particulate Contamination for Fluid Power Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation; G[, [_____]]

SD-06 Test Reports

Test

Procedure for Welding Vessels and Manifolds

SD-07 Certificates

Cleaning

PART 2 PRODUCTS

2.1 MATERIALS

Use a nameplate on vessels except when stamping is directly applied. A nameplate plainly stamped in letters not less than 3/8 inch high shall be permanently attached to vessel or vessel assembly structure at a conspicuous location. Attachment to shell or head portions or around the nozzle openings of vessel shall be by welding, brazing, soldering, or by tamper-resistant mechanical fasteners of suitable metal construction. Attachment by pressure sensitive adhesives of any type is not acceptable. Stamping shall show serial number, symbols of the manufacturer, specification number, date of manufacture, design pressure, test pressure, maximum allowable working pressure at operating temperature, minimum working temperature for vessels that operate, and water volume capacity in cubic feet to nearest tenth. Manifolds shall be identified by a stainless steel plate or tag attached by stainless steel bands or clamps and shall show serial number, if any, symbols of the manufacturer, specification number, date of manufacture, design pressure, and test pressure. Vessels shall be code stamped in accordance with ASME BPVC SEC VIII D1. Asbestos and asbestos-containing products will not be allowed.

2.1.1 Piping for Manifolds

Piping for manifolds shall be seamless stainless steel pipe or stainless steel tubing suitable for service and pressure through a temperature range of plus 120 to minus 125 degrees F, in accordance with ASME B31.3. Stainless steel pipe in thicknesses up to and including Schedule 80S shall conform to ASTM A312/A312M, Grade TP 304L or ASTM A376/A376M, Grade TP 304; thicknesses greater than Schedule 80S shall conform to ASTM A376/A376M, Grade TP 304.

2.1.2 Fittings for Manifolds

Fittings for manifolds shall be seamless buttweld or socket-weld type and of material conforming to ASTM A403/A403M, Grade WP 304L, or if tubing is used, fittings shall be stainless steel positive mechanical high-pressure threaded type. Fittings shall be suitable for pressures specified for vessels and shall be compatible with manifold piping or tubing.

2.1.3 Flanges for Manifolds

Flanges for manifolds shall be of forged stainless steel conforming to ASTM A182/A182M, Grades F 304, F 316, or F 347. Flanges shall conform to ASME B16.5 where pressure-temperature ratings fall within limits established therein. For pressure-temperature outside such limits, flanges shall conform to Appendix 2 of ASME BPVC SEC VIII D1.

2.1.4 Bolts, Studs, and Nuts for Flanges

Bolts and studs for flanges for stainless steel manifolds shall be strain hardened and shall conform to ASTM A320/A320M, Grade B8 or equivalent age-hardened material. Nuts shall conform to ASTM A194/A194M, Grade 4, and shall be hexagonal American Standard Heavy Series. For manways and for other than stainless steel flanges, bolts and studs shall conform to ASTM A193/A193M, Grade B7, and nuts shall conform to ASTM A194/A194M, Grade 2H.

2.1.5 Flange Gaskets

Gaskets for ring type joint flanges shall be octagonal, fully annealed stainless steel ring type gaskets with dimensions conforming to ASME B16.20. Gaskets for helium service shall be oval type.

2.1.6 Supports and Attachments

Structural steel for supports or structural attachments shall conform to requirements specified for vessel or to ASTM A36/A36M. Where legs of ASTM A36/A36M steel are attached to stainless steel vessels, pads of ASTM A240/A240M steel shall be used to make the attachment.

2.1.7 Vessels

Vessels shall be constructed of steels which meet the requirements for design pressure and temperatures. No steel shall be used which does not meet the following minimum requirements at room temperature: elongation in 2 inches, minimum 15 percent; reduction of area, minimum 40 percent. Where heat treatment is employed, reheat treatment will be permitted. Supporting information shall be furnished attesting to chemical composition and mechanical properties based on test results of the steel used for the design of the vessels. Where ASME BPVC SEC VIII D1 is applicable to material from which the pressure vessels are fabricated, requirements of ASME BPVC SEC VIII D1 shall be adhered to, except as modified in this section.

2.2 SPECIAL REQUIREMENTS

2.2.1 Multiple-Layered or Banded Vessels

Longitudinally-welded seams in individual layers shall be spaced in an offset pattern so that centers of the welded longitudinal joints of adjacent layers are separated circumferentially by a distance of at least 5 times the layer thickness. Thickness of circumferential welds for attaching heads or flanges, and the combined thickness of circumferential welds for layers, shall not be less than minimum required thickness of a hemispherical head divided by the efficiency of head-to-shell joint. Longitudinal seam welds on inner shell and all intermediate layers shall be ground flush before application of next layer.

2.2.1.1 Slag

Slag shall be removed after each weld layer in both longitudinal and circumferential weld joints, and each layer of weld shall be visually inspected for undercut, lack of fusion, irregularity of weld deposit, slag inclusions, and porosity. Corrections shall be made before next weld layer is deposited.

2.2.1.2 Post-Weld Heat Treatment

Post-weld heat treatment shall be accomplished in accordance with ASME BPVC SEC VIII D1. Heads shall be stress relieved after forming operations and attachments by welding have been completed, and before assembly to vessel. Inner shell shall be stress relieved after completion of longitudinal welds.

2.2.1.3 Inner Shell Thickness Less Than One-Half Head Thickness

Where thickness of inner shell is less than one-half the required head thickness and layers are 3/8 inch thick or less, vessel shall conform to the following:

a. Multiple-layered shells in which layers are welded circumferentially in which each layer may be made of one or more plates shall have holes drilled radially from the outside of vessel to inner shell. Each layer plate shall have at least two vent holes of 1/4 inch minimum diameter. Holes shall not penetrate inner shell of vessel. Drawings shall show such holes in detail.

b. After longitudinal seam of each layer has been welded, the layer shall be hammer tested for contact with layer underneath. A loose area greater than 12 inches circumferentially and 24 inches longitudinally will not be accepted. A maximum single radial gap of 0.120 inch between any two layers, as measured at the ends of the shell sections at right angles to vessel axis, will be acceptable. A gap of 0.060 inch shall be limited to a length of 4 inches; a gap of 0.040 inch shall be limited to 6 inches; a gap of 0.020 inch shall be limited to 12 inches. In event of more than one loose area circumferentially in any 24 inch length, total of such areas shall not exceed the area prescribed by the above limits.

2.2.1.4 Inner Shell Thickness Greater Than One-Half Head Thickness

Where thickness of inner shell is greater than one-half required head thickness, vessel shall conform to one of the following requirements, as applicable.

a. Tightness of layers having a nominal thickness of 3/8 inch and under shall be established as specified.

b. Tightness of vessels with layers over 3/8 inch nominal thickness, in which inner layer is expanded to outer layer, shall be determined by demonstrated elastic behavior as substantiated by pressure volume curve during repressurization, after expansion to the design pressure to demonstrate that the layers act together.

c. The tightness of vessels with layers over 3/8 inch nominal thickness, in which outer layer or layers are shrunk over inner layer or layers, shall be determined by measuring the diameter or circumference of layers in cold condition to show that there is sufficient interference between layers to demonstrate that the layers act together.

2.2.2 Seamless Cylinders

Seamless cylinders shall be of a type and size suitable for manifolding together to meet gaseous-storage volume requirements. Seamless cylinders shall have two outlets, one at each end on longitudinal centerline; each outlet shall be a minimum of 2 inches in diameter for connection to piping or manifold and for inspection purposes. Vessel connections for seamless vessels shall be [adapted for and connected to in accordance with ASME B16.5] [suitable for connection of stainless steel positive mechanical high-pressure threaded type fittings]. Connections shall be suitable for pressures specified for vessels. After fabrication, seamless cylinders shall be normalized or liquid-quenched and tempered.

2.3 DESIGN AND FABRICATION

Design and fabrication of vessels shall conform to ASME BPVC SEC VIII D1, except as modified herein. Vessels shall be welded cylinders or spheres, seamless cylinders, or cylinders of multiple-layered or banded construction. Vessels shall be suitable for stationary, aboveground [horizontal] [vertical] installation, exposed to atmospheric elements. Capacities of vessels shall be as shown.

2.3.1 Design Pressure

Design vessels for a pressure of [_____] psig.

2.3.2 Design Temperature

Design vessels for a temperature range of plus 120 to minus 40 degrees F.

2.3.3 Outlets

2.3.3.1 Nozzles

Nozzles or outlets for welded monobloc, multiple-layered, and banded vessels shall be a minimum of two in number, one at each end on the longitudinal centerline for connection to piping or manifold, and for inspection purposes and shall have a minimum diameter of 2 inches. Nozzles and outlets shall be fully reinforced regardless of size. Flanged outlets shall conform to ASME B16.5 or to ASME BPVC SEC VIII D1. Nozzles or outlets shall be suitable for the pressures specified for vessels. Material for nozzles, outlets and flanges preferably shall be the same as that of the vessel, but may be of any other material that is compatible with vessel material. [Where shown, outlets shall be suitable for connection to stainless steel positive mechanical high-pressure threaded type fittings.]

2.3.3.2 Manholes and Handholes

Manholes and handholes shall conform to the requirements of subsections UG-36 through UG-46 of ASME BPVC SEC VIII D1 as applicable.

2.3.3.3 Drains and Vents

Provide leakproof drains and vents to facilitate cleaning of vessels.

2.3.4 Multiple Vessels

Manifold multiple-vessel assemblies together to furnish required gaseous-storage volume. Terminate manifold at the piping connection point as indicated. The total cross-sectional area of manifold piping in a system must be not less than 1.5 times the cross-sectional area of the piping connection point.

2.3.5 Structural Attachments

Permanent structural attachments, including lifting lugs and erection brackets, shall not be welded to vessel parts subject to pressure stress, unless otherwise approved. If approved, such welds shall be full penetration and shall have welded layers inspected progressively by the magnetic particle method. No welding shall be performed after final stress relief or hydrostatic testing.

2.3.6 Shell and Head Thickness

Shell and head thickness shall be calculated in conformance with ASME BPVC SEC VIII D1.

2.3.7 Procedure for Welding Vessels and Manifolds

Welding procedures shall conform to requirements of ASME BPVC SEC IX and to requirements specified below. Information required by recommended Form QW-483, Article IV, of ASME BPVC SEC IX shall be submitted for approval. Submit certified copies of performance test records indicating that the welders have passed qualification test in conformance with ASME BPVC SEC IX, prior to work on piping or vessel fabrication. Where such test records are not furnished, perform qualification tests witnessed by Contracting Officer. Each welder shall be qualified for the position and type of material assigned. Requalification tests will be required when work of the welder creates a reasonable doubt as to the welder's proficiency. Such a retest may include both radiographic and mechanical tests. Welders failing a requalification test will not be permitted to work. An inert-gas shielded welding process with an inert-gas backup shall be used for the first pass of all manifold welds. Separate qualification tests shall be made on maximum joint thickness of each material and each procedure used in production of double-welded butt joints and single-welded joints. Procedures qualified for thickness greater than those specified shall be acceptable without requalification. Joint design used in test plates shall be the same as for joints used in production. A requalification test shall be made for any change in the nominal weld metal composition and for changes in any essential variables listed in ASME BPVC SEC IX. A separate qualification test shall be made for each joint design. For multiple-layered or banded vessels, the tension and guided-bend tests shall be performed on inner shell and outer layer thicknesses. For girth welds between multiple-layered shells and heads, the test specimen shall include head material as well as layered shell material. In addition to tests specified in ASME BPVC SEC IX, procedure qualification test plates shall be radiographed following the same heat-treating procedure used in production. Using radiographic procedures specified for production welds, radiographs shall conform to requirements specified.

2.3.7.1 Weld Layer Thickness

Individual layer thickness of production welds shall not exceed 1.1 times that of individual layer thickness deposited in the performance qualification.

2.3.7.2 Continuity of Backing Ring

Backing rings shall be permitted only for circumferential weld joints which, due to access limitations, cannot be welded from both sides. If a backing bar, strap, or ring is used on inside of single buttweld joints, ends of backing bar shall be welded to produce a continuous backing element.

2.3.8 Joint Efficiency

A joint efficiency not greater than 0.95 shall be used for staggered buttwelded longitudinal seams of multiple-layered or banded vessels, provided welds in inner shell and adjacent layer are fully radiographed and the finished weld in each of the subsequent layers is fully magnetic-particle inspected and is 9/32 inch or less in thickness. A penetrometer thickness not more than 1 percent of total wall thickness being radiographed shall be used when radiographing adjacent layer. Joint efficiency for other buttwelded seams shall conform to ASME BPVC SEC VIII D1.

2.3.9 Pressure Relief Devices

All vessels, regardless of size or internal pressure, shall be provided with protective pressure relief devices conforming to the design requirements of parts UG-125 through UG-136 of ASME BPVC SEC VIII D1.

2.4 TESTING

Notify the Contracting Officer [_____] days before the performance and fabrication tests are to be conducted. Perform tests in the presence of the Contracting Officer.

2.4.1 Notched-Bar Impact Tests for Material

Materials for shells, heads, nozzles, and other vessel parts subject to stress due to pressure shall be impact tested at minus 40 degrees F in accordance with requirements of ASME BPVC SEC VIII D1, with the following modifications:

2.4.1.1 Impact Specimens

2.4.1.1.1 Test Plates for Welded Vessels

In addition to requirements of ASME BPVC SEC VIII D1, one set of impact specimens shall be taken from the head-to-shell weld with notch in adjacent head metal in heat-affected zone. Test specimens shall be taken from mid-length of test plates.

2.4.1.1.2 Multiple-Layered Plate Material

In multiple-layered vessels which use plates 3/8 inch or less in thickness, exclusive of the inner shell, the requirements for testing plates shall be met by testing at least one set of impact specimens for each 2 feet of cylindrical length of each vessel.

2.4.1.1.3 Seamless Vessels

The requirements for testing impact specimens shall be met by testing one set of specimens from a test sample of the lot it represents. A lot consists of a maximum of six vessels having the same inside diameter and wall thickness in a heat-treat furnace charge from the same heat of steel. Subject the minimum 24 inches long test sample to the same working, normalizing or quenching, and tempering and heat with the lot of production vessels. Cut impact test specimens from the central 12 inchesof the test sample.

2.4.1.2 Minimum Impact Value

In lieu of requirements in ASME BPVC SEC VIII D1, each specimen of the set of three 3/8 by 3/8 inch specimens shall have a specified minimum impact value of 15 foot pounds for material thickness of 1/2 inch or greater. For thinner material, a similar specimen shall be used, except that the dimension along the axis of the notch and the specified minimum impact value shall be reduced to the largest possible of:

12.5 foot pounds minimum.

10 foot pounds minimum.

5 foot pounds minimum.

If the value of only one of the specimen is less than the specified value, a retest will be permitted, in which case all three retest specimens shall have an impact value of not less than the specified value.

2.4.1.3 Additional Tests of Welded and Seamless Vessels

a. Materials and weld metal shall be tested at the lowest temperature at which pressure will be applied to the vessel, or the design temperature, whichever is lower, and shall meet the following:

(1) Specimen shall be in accordance with ASTM A370 for Charpy Impact Test.

(2) Minimum values are as given below:

Size of Speciment	Base Metal and Heat-Affected Zone (foot-pound)	Weld Metal (foot-pound)
10 mm x 10 mm	30	25
10 mm x 7.5 mm	25	20
10 mm x 5 mm	20	16
10 mm x 2.5 mm	10	8
If the value of only one of the specimens is less than the specified value, a retest will be permitted, in which case all three retest specimens shall have an impact value of not less than the specified value.		

b. For welded vessels, one set of Charpy Tests shall be made with notch located in base metal at least 2 inches from weld, one set with notch located in heat-affected zone of shell, and one set with notch located in weld metal.

c. For seamless vessels, tests shall be performed on base metal only, in the same quantities as required above for seamless vessels.

2.4.2 Mechanical Property Tests

2.4.2.1 Welded Vessels

Two tension tests and one bend test shall be made from each parent plate as rolled from a slab or ingot. Plates which are quenched and tempered by steel supplier shall be tested by performing one bend test from each parent plate as rolled from a slab or ingot, and two tension tests from each plate as heat-treated. In addition, one tension test shall be made on each quenched and tempered plate used for vessel shells and heads when the heat-treatment is performed by fabricator.

2.4.2.2 Seamless Vessels

One impact specimen tension test shall be made from test sample for each lot. Test specimen shall be taken from the central 12 inches of test sample.

2.4.3 Hydrostatic Testing

Hydrostatic testing shall be performed after fabrication and heat treatment. Pressure vessels and manifolds shall be hydrostatically tested in accordance with ASME BPVC SEC VIII D1, except that holding time at test pressure shall not be less than 6 hours.

2.5 INSPECTION AND REPAIR OF DEFECTS

2.5.1 Personnel Qualifications

Radiographic, liquid penetrant and magnetic particle inspections of buttwelded pipe joints and welded vessels listed below shall be performed by personnel qualified in accordance with applicable portion of ASME BPVC SEC V as appropriate. Certified test results shall be submitted by the reviewing inspector. Submit test reports for radiographic, magnetic particle, liquid penetrant, impact, and hydrostatic tests performed to prove compliance with specified criteria, upon completion and testing of the installed system.

2.5.2 Radiography of Buttwelded Pipe Joints

Buttwelded pipe joints shall be radiographed 100 percent. Radiographic technique and interpretation shall conform to ASME B31.3, except as modified. The negatives and interpretation report shall be submitted for examination within 24 hours after taking radiographs. Unacceptable areas of joints shall be cut out, remade, and reradiographed. The negatives shall be accessible for examination by the Contracting Officer.

2.5.3 Radiography of Welded Vessels

Extent of radiography shall be based on joint efficiencies used for design purposes. Radiographic technique and interpretation shall conform to ASME BPVC SEC VIII D1. Radiographic film shall be the fine grain or extra fine type. Radiographic negatives and interpretation shall be submitted for approval at fabricator's plant. Unacceptable welds shall be repaired and reradiographed. A complete set of radiographs and records for each vessel or vessel part shall be retained by the manufacturer until the Manufacturer's Data Report has been signed by the inspector.

2.5.4 Magnetic Particle Inspection

Except for inside surface of closing girth seam, accessible surfaces of welds, including all layers of multiple-layered or banded vessels, shall be magnetic-particle inspected during fabrication in accordance with ASTM E709, using dc direct probe only. In addition, inspection of accessible outside surface of welds shall be made after hydrostatic testing. Swaged ends of seamless vessels shall be magnetic-particle inspected after forming and heat treatment. Cracks shall be repaired. Linear defects, except linear inclusions not exceeding 1/4 inch for thicknesses up to 3/4 inch, 1/3 inch for thicknesses 3/4 inch to 2-1/4 inches, and 3/4 inch for thicknesses over 2-1/4 inches, shall be repaired.

2.5.5 Inspection for Laminations

Laminations found at edges of plates shall be chipped or ground out to depth of the lamination or 1/2 inch, whichever is less, and the resulting groove shall be repaired by welding. Linear defects 3 inches or less in length which are parallel to plate surface shall not be considered as laminations and are acceptable. Linear defects over 3 inches in length which are parallel to plate surface shall be considered as laminations and shall be repaired.

2.5.6 Dye Penetrant Inspection

Piping and seal welds shall be liquid-penetrant inspected at the root and final weld layers. Cracks and linear indications, except minor inclusions, shall be eliminated. Inspection procedure shall be in conformance with ASTM E165/E165M.

2.5.7 Repair of Defects

Defects shall be repaired in accordance with approved procedures. Wherever a defect is removed and repair by welding is not required, affected area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners. After a defect is removed, and prior to making repairs, the area shall be examined by suitable methods to ensure that the defect has been eliminated. After repairs have been made, the repaired area shall be re-examined by the same methods that were originally required for the area. Any indication of a defect shall be regarded as a defect unless reevaluation by nondestructive methods and/or by surface conditioning shows that no unacceptable defect is present.

2.6 CLEANING

Submit a certified record of satisfactory cleaning of similar vessels or a record certifying not less than 2 years of experience in chemical cleaning to similar standards and for similar service. No organization performing cleaning will be considered qualified unless such proof of cleaning experience is submitted.

2.6.1 Internal Cleaning

Internal surfaces of each vessel and manifold shall be cleaned until permissible contamination limits are complied with and then shall be dried and protected. Cleaning procedures as necessary to comply with permissible contamination limits specified shall be employed. Cleaning, except during fabrication, shall be performed at place of manufacture or at installation site. Cleaning solvents that contain chlorine shall not be used on stainless steel vessels. Inspection and tests will be witnessed by the Contracting Officer at time of final acceptance.

2.6.2 Permissible Contamination Limits

Permissible contamination limits for vessels and manifolds shall not exceed the following:

a. No hydrocarbon as evidenced by visual and ultraviolet light inspections.

b. No solid or fibrous particle concentration greater than [5] [_____] mg/psf as measured in effluent on final rinse or [10] [_____] ppm by weight of sample.

c. No particles greater than [150] [_____]-micrometer size.

d. No fibers greater in size than [150] [_____]-micrometer diameter by [1,000] [_____]-micrometer length.

2.6.3 Miscellaneous Requirements

2.6.3.1 Nominal-Rated Filters

Filters shall remove 98 percent by weight of particles whose two smallest dimensions are greater than openings in filter media. Filters made by powder metallurgy processes shall not be used.

2.6.3.2 Clean Water

Water shall be color free and shall contain no visible suspended particles or hydrocarbons.

2.6.3.3 Dry Air

Air shall be oil-free air which has been processed through a dehydrator so that the dew point is minus 63.5 degrees F at one atmosphere or a maximum of 26.3 ppm water vapor by volume.

2.6.3.4 Nitrogen

Nitrogen must have been filtered through a 40-micrometer absolute-rated filter with an element constructed of stainless steel dutch twill weave. Filter shall be cleaned so as not to contaminate the system in excess of filter rating.

2.6.3.5 Hydrocarbon

Hydrocarbon must be a combustible compound containing carbon and hydrogen.

2.6.3.6 Solid Particle

Solid particle shall be solid material which cannot be classified as a fiber. Size of a solid particle shall be determined by longest dimension.

2.6.3.7 Fiber

Fiber shall be a threadlike structure composed of any material.

2.6.3.8 White Metal

"White metal" shall have surface of a gray white, uniform metallic color. Surface, when viewed without magnification, shall be found free of visible mill scale, rust, corrosion, oxides, paint, or other foreign matter.

2.6.4 Cleaning Procedures

Cleaning procedures shall be as follows, and additional procedures shall be employed as necessary to comply with the permissible contamination limits.

2.6.4.1 Cleaning During Fabrication

During vessel fabrication, surfaces and welds of vessels and manifolds which will be exposed to gas shall be thoroughly cleaned to white metal. Wire brushes used on stainless steel shall be of stainless steel. Grinding discs that have been used on carbon steel shall not be used on stainless steel vessels. Descaling may be accomplished prior to welding of final seam. When performed after cleaning, stress relieving shall be performed using an inert gas within the vessel.

2.6.4.2 After Cleaning

After cleaning, surfaces shall be treated to inhibit rust.

2.6.5 Drying

Drying of vessels shall be by heating or vacuum evacuation. Manifolds shall be dried by purge with gaseous nitrogen or dry air at a minimum of 140 degrees F. Vessels and manifolds shall be considered dry when the dew point apparatus shows that the purging medium has a dew point no higher than the dew point of influent gas which is not above minus 63.5 degrees F at one atmosphere or 26.3 ppm water vapor by volume. If vacuum evacuation is used, vessel shall be considered dry when pressure is maintained at 0.5 inch of mercury absolute for a minimum of 5 minutes at a temperature of 60 degrees F or higher temperature or at such lower pressure which is 96 percent of the vapor pressure of water for the vessel temperature. For example, for a vessel at 40 degrees F a pressure of 0.238 inch of mercury absolute shall be maintained for 5 minutes. Dry gas used for purging and drying shall be filtered through a 10-micron nominal rated filter.

2.6.6 Testing of Cleaned Vessels and Manifolds

Tests during or after cleaning shall be conducted so as not to contaminate vessels or manifolds. Should testing contaminate vessels and manifolds, recleaning shall be performed.

2.6.7 Inspection

Each vessel and manifold shall be inspected for compliance with permissible contamination limits specified herein. Certified results of such inspections shall be submitted for approval. Inspections, tests, and sampling shall be performed in the order listed below. Any vessel or manifold which is rejected in any one of these inspection procedures shall be recleaned or reworked to the extent necessary to meet requirements specified.

2.6.7.1 Inspection No. 1, Final Rinse

During final rinse and prior to drying operation, a 1-liter sample of effluent shall be examined by Millipore method or equivalent method in accordance with SAE AS598. For this purpose, rinse shall be performed using clean water and a pressure spray nozzle on interior surfaces to ensure dislodgement of particles. Effluents containing contamination in excess of permissible contamination limits shall be cause for recleaning and reinspection.

2.6.7.2 Inspection No. 2, Visual

Vessels and manifolds shall be examined for evidence of corrosion products including rust, metal chips, scale, weld scale, oil, grease, paints, preservatives, decals, or other foreign matter. Special devices such as inspection mirrors or bore scopes shall be used to visually examine inaccessible areas of vessels or manifolds. Contamination in excess of permissible contamination limits shall be cause for recleaning and reinspection.

2.6.7.3 Inspection No. 3, Ultraviolet Light

Visual inspection with aid of an ultraviolet light shall be accomplished on accessible surfaces to determine the presence of petroleum type hydrocarbons. Wipe pads shall also be inspected by ultraviolet light. Inspectors shall be qualified to use the ultraviolet light. Contamination in excess of permissible contamination limits shall be cause for recleaning and reinspection. Ultraviolet light used for this inspection and light-intensity meter shall conform to the following:

a. Light source shall be 100-watt spot mercury and bulb 2500 to 3700 Angstrom units.

b. Transformer shall meet the recommendations of bulb manufacturer.

c. Filter shall be approximately 5 inches in diameter, convex and round.

d. Bulb shall be replaced when intensity of ultraviolet light through filter is less than 550 microwatts per square centimeter when measured 24 inches from outside surface of filter, or after 500 hours of use, whichever occurs first.

2.6.7.4 Inspection No. 4, Wipe Test

Wipe test shall be made at each end of each cleaned section of pipe and on interior surfaces of vessels and manifolds which are accessible with a probe. Clean filter paper shall be used. Interior surfaces are to be wiped on a random basis or as indicated by the results of visual inspection. Test shall consist of a linear movement of filter paper over a distance approximately 2 feet long when large areas are being tested. Smaller areas, such as manifold ends, shall receive a full circular wipe. Filter paper shall then be examined under clean-room conditions. Contamination in excess of permissible contamination limits shall be cause for recleaning and reinspection.

2.7 SEALING

2.7.1 Seals

Vessels and manifolds shall be sealed immediately after passing the cleaning inspections. Seals shall be tight enough to prevent contamination and shall be protected so that they will not be broken or warped. Tape for sealing procedures shall not leave any residue on connections when removed.

2.7.2 Flanged Openings

Flanged openings shall be sealed with a suitable full-face blank gasket 1/8 inch thick or disk at least 1/16 inch thick consisting of polytetrafluorethylene or other nonflammable, noncontaminating material and a bolted blank flange of aluminum or corrosion-resisting steel at least 1/4 inch thick. Stainless steel bolts shall be used in contact with stainless steels. Cadmium-plated bolts maybe used in contact with aluminum but shall not be used in contact with stainless steels. A bolt correctly torqued to correspond to particular blank flange and gasket design shall be placed in each bolt hole. Gaskets and flanges shall be cleaned as specified.

2.7.3 Threaded Openings

Threaded openings shall be sealed with appropriately cleaned caps or plugs made of corrosion-resisting steel.

2.8 CERTIFICATE

Certificate of inspection indicating conformance to requirements specified shall be attached to each item. Certificate shall show the date of inspection and the signature of the Contractor's inspector.

2.9 PRESSURIZING

Vessels shall be pressurized to 15 psig with nitrogen immediately following cleaning inspections and sealing of vessels. Vessels shall be maintained at positive pressure up to and during the time of final acceptance. Vessels shall be equipped with a shutoff valve and gauge for pressurizing. The gauge shall be capable of 15 psig minimum with 1.5 psig increments between 0 to 5 psig. A protective metal cover shall be provided around the gauge and valving. Complete loss of pressure shall be cause for reinspection and recleaning as necessary to meet permissible contamination limits by and at the expense of the Contractor.

2.10 PAINTING

2.10.1 Exterior Surfaces

Exterior surfaces of all vessels, including supports but excluding stainless steel surfaces, shall be cleaned and painted in the shop. Abraded or corroded spots shall be wire brushed and touched up with the same material as the paint coat.

2.10.2 Cleaning and Preparation of Surfaces

Exterior surfaces shall be cleaned before applying paint. Oil, grease, dirt, loose dust, loose mill scale, and other foreign substances shall be removed. Removal of oil and grease shall be accomplished before mechanical cleaning is started, using mineral spirits or other paraffin-free solvents having a flash point higher than 100 degrees F. Cleaning shall be accomplished with clean cloths, fluid emulsions, steam, flame cleaning, high-speed power wire brushing, blast cleaning, or other approved methods. Use of chipping tools that produce cuts, burrs, and other forms of excessive roughness will not be permitted. Tight mill scale that cannot be removed by applying a sharp knife to any edge and minor amounts of residual rust not removable except by thorough blast cleaning will be permitted.

2.10.3 Painting of Surfaces

A primer coat of paint conforming to SSPC Paint 25 shall be applied to exterior surfaces of the vessel. Vessel shall be finished with two coats of gray enamel conforming to SSPC Paint 21. Paint shall be applied under dry and dust-free conditions when an ambient temperature is not below 40 degrees F. Painting shall be done so as to produce an even film of uniform thickness. The three-coat paint system shall be applied so that their dry film thickness at any point shall be not less than 4.0 mils, with the primer having a minimum dry film thickness of 1.5 mils. Edges, corners, crevices, and joints shall be thoroughly cleaned and painted.

PART 3 EXECUTION

3.1 FOUNDATIONS

Foundations shall be designed by the Contractor. Design shall be based on the soils investigation provided by the Government. Any additional information required shall be specified by the Contractor and obtained by the Government. Foundations for the pressure vessel [and manifold] shall be constructed of [3000] [_____] psi concrete, reinforced where necessary, and constructed in conformance with the applicable requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE, except as shown or specified herein.

3.1.1 Excavation, Filling, and Grading

Excavating, filling, and grading shall conform to the applicable requirements of Section 31 00 00 EARTHWORK.

3.1.2 Anchor Bolts

Anchor bolts shall be set accurately and shall be of adequate length to install the pressure vessel. When embedded in concrete, anchor bolts shall be provided with plates welded on the head and shall be protected against damage until the equipment is installed.

3.2 INSTALLATION

Submit drawings showing the locations of weld seams, sizes and types of welds, piping arrangements, nozzle reinforcement, method of nozzle attachment, plate and head thicknesses, vessel weights, details of gas relief holes in multiple-layered shells, lifting lugs [manways] [details of drains and vents] details required for fabrication of the vessels, and a complete list of materials. Include design calculations for vessels and manifolds with the drawings, including chemical composition and mechanical properties of the steels used, and including reference to ASME BPVC SEC VIII D1. Loading, lifting, shipping, unloading, field testing, and installation instructions, prior to completion of fabrication. [Installation drawings for piping manifolds showing field piece markings.] [The pressure vessel foundation design drawings.]

3.2.1 Equipment

All tanks and equipment shall be installed in accordance with fabricator's instructions and recommendations. All vessels shall be bolted in place on concrete foundations. Care shall be exercised during the placement of vessel on foundation so as not to scratch or dent vessel, or crack foundation.

3.2.2 Piping

All interconnecting piping shall be assembled in accordance with fabricator's drawings and instructions. All piping shall conform to the requirements of ASME B31.3. Adequately support interconnecting piping to avoid producing large stresses on the pipe or the vessel nozzles. Pipe hangers and supports shall conform to MSS SP-58. Piping supports shall allow for movement of the pipe from thermal expansion or contraction. Pipe support spacing and installation shall conform to the requirements of MSS SP-58.

3.3 FIELD TESTING

Upon completion of all related work and prior to acceptance, subject the pressure vessel and associated piping and instrumentation to a pressure test to demonstrate system performance. Notify the Contracting Officer [_____] days prior to conducting the test. The Contracting Officer shall be present during the testing.

3.3.1 Testing Materials

Furnish all equipment, instruments, materials, and personnel required to perform the test. The Government will supply the utilities to perform the test such as [nitrogen,] [water,] [and] electric power.

3.3.2 Procedure

The test medium shall be clean, dry nitrogen. Piping test pressure shall be not less than 1.2 nor more than 1.5 times the design pressure. The test pressure shall be continuously maintained for a minimum of 10 minutes, and the required test procedure shall be in accordance with ASME B31.3. To pass the pressure test, the piping system shall show no evidence of leaking at all joints and connections by soap bubble or equivalent method. If system does not pass the pressure test, the problem will be corrected and the system will be retested. Any retesting will be performed by the Contractor at the Contractor's expense. If piping test pressure is above the pressure vessel test pressure, the pressure vessel will be isolated from the piping test.

3.4 TOUCHUP PAINTING

Perform touchup painting to equipment [and piping manifold] as required from the inspection of the Contracting Officer. Painting materials and procedure shall conform to the requirements of paragraph PAINTING.

-- End of Section --

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SECTION 33 57 55

FUEL SYSTEM COMPONENTS (NON-HYDRANT)
11/18, CHG 1: 11/20

PART 1 GENERAL

1.1 SUMMARY

This section defines the requirements for system components as related to a non-hydrant fuel distribution system. Provide the entire fuel distribution system as a complete and fully operational system. Size, select, construct, and install equipment and system components to operate together as a complete system. Substitutions of functions specified herein will not be acceptable. Coordinate the work of the system manufacturer's service personnel during construction, testing, calibration, and acceptance of the system. System components and piping specified herein must be designed to handle a working pressure of [275 psig for stainless steel systems][285 psig for carbon steel systems] at 100 deg F. Components specified herein must be compatible with the fuel to be handled. Components to be suitable for outside, unsheltered location, and to function normally in ambient temperatures between [_____] degrees F and [_____] degrees F.[If gasoline is being handled, refer to 40 CFR Part 60 Subpart Kb and XX, 40 CFR Part 63 Subpart R, BBBBBB, and CCCCCC for design, installation, and testing requirements.]

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 540	(1999; R 2004) Electrical Installations in Petroleum Processing Plants
API RP 1004	(2003) Bottom Loading and Vapor Recovery for MC-306 and DOT-406 Tank Motor Vehicles
API RP 1615	(2011) Installation of Underground Petroleum Storage Systems
API RP 2003	(2015; 8th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API STD 610	(2010; Errata 2011) Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASME B73.1	(2020) Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM C827/C827M	(2016) Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
ASTM D1655	(2018a) Standard Specification for Aviation Turbine Fuels

ENERGY INSTITUTE (EI)

EI 1529	(2014; 7th Ed) Aviation Fueling Hose and Hose Assemblies

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE 1100	(2005) Emerald Book IEEE Recommended Practice for Powering and Grounding Electronic Equipment

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2021; TIA 20-1; TIA 20-2) Flammable and Combustible Liquids Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 77	(2014) Recommended Practice on Static Electricity
NFPA 407	(2022) Standard for Aircraft Fuel Servicing
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS3275	(2009; Rev C) Sheet, Acrylonitrile Butadiene (NBR) Rubber and Non-Asbestos Fiber Fuel and Oil Resistant

SAE AS5877	(2016; Rev B) Detailed Specification for Aircraft Pressure Refueling Nozzle

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-25896	(1983; Rev E; Notice 1 1989; Notice 3 2003) Adapter, Pressure Fuel Servicing, Nominal 2.5 inch diameter
MIL-DTL-5624	(2016; Rev W; Notice 1 2020) Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-DTL-83413	(2012; Rev C; AMD 1 2017; AMD 2 2019) Connectors and Assemblies, Electrical, Aircraft Grounding, General Specification for
MIL-DTL-83413/4	(2018; Rev E; AMD 1 2018) Connectors and Assemblies, Electrical, Aircraft Grounding: Plugs, for Types I and II Grounding Assemblies
MIL-DTL-83413/7	(2018; Rev F; AMD 1 2018) Connectors and Assemblies, Electrical, Aircraft Grounding: Clamp Connector for Types I and III Grounding Assemblies, Clip, Electrical
MIL-P-52327C	(1990) Military Specification Pumps, Centrifugal, Electric-Motor-driven, Positive Prime, Petroleum Products, Airfield Defueling and Receiving
MIL-PRF-4556	(1998; Rev F; Am 1 1999; CANC Notice 1 2011) Coating Kit, Epoxy, for Interior of Steel Fuel Tanks
MIL-STD-130	(2007; Rev N; Change 1 2012) Identification Marking of U.S. Military Property
MIL-STD-161	(2005; Rev G; Notice 1 2010) Identification Methods for Bulk Petroleum Products Systems Including Hydrocarbon Missile Fuels

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50696	(2016; Rev D) Reels, Static Discharge, Grounding, 50 and 75 Foot Cable Lengths
CID A-A-59326	(Rev D) General Specification For Coupling Halves, Quick-Disconnect, Cam-Locking Type

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)

UNDERWRITERS LABORATORIES (UL)

UL 87	(2016) UL Standard for Safety Power-Operated Dispensing Devices for Petroleum Products
UL 87A	(2015; Reprint Jan 2020) UL Standard for Safety Power-Operated Dispensing Devices for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations up to 85 Percent (E0 - E85)
UL 330	(2017; Reprint Feb 2019) UL Standard for Safety Hose and Hose Assemblies for Dispensing Flammable Liquids
UL 842	(2015; Reprint Oct 2017) UL Standard for Safety Valves for Flammable Fluids

1.3 ADMINISTRATIVE REQUIREMENTS

Submit detail drawings consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operation of the system components and systems. Provide the drawings as one package with the design analysis. Shop fabrication drawings must include type of material, configuration, thickness, and necessary details of construction of the steel tank and vault. Shop drawings must also show the steel grating and supports. Submit Manufacturer's Catalog Data and Certificates of Compliance. Operation and maintenance information must be submitted for the system components items or systems listed in PART 2. Automatic pump controls must include step-by-step procedures required for system startup, operation, and shutdown.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Grounding and Bonding; G[, [_____]]

[Tightness Monitoring System; G[, [_____]]

][Truck Fillstand Overfill Protection and Ground Verification Unit; G [, [_____]]

][Venturi Tubes; G[, [_____]]

] Meters; G[, [_____]]

[Jockey Pump; G[, [_____]]

] Packaged Truck Offload System; G[, [_____]]

High Point Vent and Low Point Drain Pits; G[, [_____]]

Water Draw-Off System; G[, [_____]]

Operating Tank Vent; G[, [_____]]

SD-03 Product Data

Pressure Gages; G[, [_____]]

Differential Pressure Gauge; G[, [_____]]

Automatic Pump Controls; G[, [_____]]

[Tightness Monitoring System; G[, [_____]]

][Truck Fillstand Overfill Protection and Ground Verification Unit; G [, [_____]]

] Flow Switches; G[, [_____]]

[Venturi Tubes; G[, [_____]]

][Differential Pressure Transmitter; G[, [_____]]

] Pressure Sensor; G[, [_____]]

Relaxation Tank; G[, [_____]]

Meters; G[, [_____]]

Submersible Pump; G[, [_____]]

ANSI Type Centrifugal Pump; G[, [_____]]

Sliding Vane Rotary Pump; G[, [_____]]

Self-Priming Centrifugal Pump; G[, [_____]]

[Jockey Pump; G[, [_____]]

] Packaged Truck Offload System; G[, [_____]]

Deaerator Tank; G[, [_____]]

Truck Fillstand Hose; G[, [_____]]

Truck Fillstand Swivel Joints; G[, [_____]]

Tank Truck Bottom Loading Arm; G[, [_____]]

Top Loading Arm; G[, [_____]]

Filter/Separator; G[, [_____]]

High Point Vent and Low Point Drain Pits; G[, [_____]]

FRP Containment Sump; G[, [_____]]

Liquid Level Gauge; G[, [_____]]

Operating Tank Level Indicator; G[, [_____]]

Operating Tank Level Switches; G[, [_____]]

Water Draw-Off System; G[, [_____]]

Operating Tank Vent; G[, [_____]]

Product Dispensing Unit; G[, [_____]]

SD-06 Test Reports

[Tightness Monitoring System; G[, [_____]]

] Coating Testing; G[, [_____]]

SD-07 Certificates

System Supplier; G[, [_____]]

[Tightness Monitoring System; G[, [_____]]

] SD-10 Operation and Maintenance Data

Automatic Pump Controls; G[, [_____]]

[Tightness Monitoring System; G[, [_____]]

][Truck Fillstand Overfill Protection and Ground Verification Unit; G [, [_____]]

] Relaxation Tank; G[, [_____]]

Meters; G[, [_____]]

Submersible Pump; G[, [_____]]

ANSI Type Centrifugal Pump; G[, [_____]]

Sliding Vane Rotary Pump; G[, [_____]]

Self-Priming Centrifugal Pump; G[, [_____]]

[Jockey Pump; G[, [_____]]

] Packaged Truck Offload System; G[, [_____]]

Deaerator Tank; G[, [_____]]

Filter/Separator; G[, [_____]]

Operating Tank Level Indicator; G[, [_____]]

Water Draw-off System; G[, [_____]]

Operating Tank Vent; G[, [_____]]

Product Dispensing Unit; G[, [_____]]

1.5 QUALITY ASSURANCE

Submit the following data for approval:

a. Certification stating that the System Supplier has provided and installed at least five Programmable Logic Control (PLC)-based pump control systems in the last five years, for automatic cycling of pumps based upon varying dispensing demands, utilizing multiple pumps. These systems must be for dispensing [jet fuel] [mogas] [avgas] [diesel] [bio-diesel] [E-85] [burner fuel oils] [_____].

b. Certification that six systems have been successfully operated over the last three years and are currently in service.

c. Project names, locations, system description, and items provided at these installations. Include user point-of-contact and current telephone numbers.

1.5.1 Material and Equipment Qualifications

Provide materials and system components that are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship. Materials and system components must have been in satisfactory commercial or industrial use for a minimum two years prior to bid opening. The two year period must include applications of the system components and materials under similar circumstances and of similar size. Materials and system components must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the two year period.[Products having less than a two year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours, exclusive of the manufacturer's factory tests, can be shown.]

1.5.2 Nameplates

Attach nameplates to all specified system components, thermometers, gauges, and valves defined herein. List on each nameplate the manufacturer's name, address, [contract number,] [acceptance date,] component type or style, model or serial number, catalog number, capacity or size, and the system that is controlled. Construct plates of [anodized aluminum] [stainless steel] [melamine plastic, 1/8-inch thick, UV resistant, black with white center core, matte finish surface and square corners] [_____]. Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive. Minimum size of nameplates must be 1 by 2-1/2 inches. Lettering must be the normal block style with a minimum 1/4-inch height. Accurately align all lettering on nameplates.[For plastic nameplates, engrave lettering into the white core.][Key the nameplates to a chart and schedule for each system. Frame charts and schedule under glass, and locate where directed near each system. Furnish two copies of each chart and schedule. Each nameplate description must identify its function.]

1.6 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect system components and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

PART 2 PRODUCTS

If gasoline is being handled, refer to 40 CFR Part 60 Subpart Kb and XX, 40 CFR Part 63 Subpart R, BBBBBB, and CCCCCC for design, installation, and testing requirements.

2.1 MATERIALS

Materials of construction must be stainless steel, aluminum or nonferrous material except positive displacement meter case may be steel with electroless nickel plated internals coated to 3 mil thickness, or interior epoxy coating. No ferrous or zinc-coated material bronze, brass or other copper bearing alloys must be used in contact with the fuel. Do not install cast iron bodied valves or system components. Do not use aluminum valves.

2.1.1 Types of Fuel

Components must be suitable for use with [F-24 turbine fuel (Jet-A with additives FSII, CI/LE, and SDA); specific gravity 0.81 at 60 degrees F; viscosity 1.62 CS at 60 degrees F; Reid vapor pressure less than 0.05 psi; ASTM D1655] [JP-4 turbine fuel; specific gravity 0.76 at 60 degrees F; viscosity 0.92 CS at 60 degrees F; Reid vapor pressure 2 to 3 psi, MIL-DTL-5624] [JP-5 turbine fuel; specific gravity 0.82 at 60 degrees F; viscosity 1.62 CS at 60 degrees F; Reid vapor pressure less than 0.05 psi, MIL-DTL-5624]. Components to be ANSI Class 150 (275 psig at 100 degrees F) unless noted otherwise. Components to be suitable for outside, unsheltered location, and to function normally in ambient temperatures between [_____] degrees Fand [_____] degrees F.

2.1.2 Composition of Materials

Materials in contact with the fuel must be noncorrosive. No zinc-coated metals, brass, bronze, iron, lead or lead alloys, copper or copper alloys, or other light metal alloys containing more than 4 percent copper must be used in contact with the fuel.

2.1.3 Gaskets

Gaskets must be in accordance with Section 33 52 40 FUEL SYSTEMS PIPING (NON-HYDRANT).

2.1.4 Bolts and Nuts

Bolts and nuts must be in accordance with Section 33 52 40 FUEL SYSTEMS PIPING (NON-HYDRANT).

2.1.5 Flanges

Flanges and flanged end system components must be in accordance with Section 33 52 40 FUEL SYSTEMS PIPING (NON-HYDRANT).

2.1.6 Nitrile Butadiene (Buna-N)

Provide Buna-N material that conforms to SAE AMS3275.

2.1.7 Acrylonitrile Butadiene Rubber (NBR)

Provide NBR material that conforms to SAE AMS3275.

2.2 SYSTEM COMPONENTS AND MATERIAL

2.2.1 General

All items of system components and material must be new and of the best quality used for the purpose in commercial practice and must be products of reputable manufacturers. Each major component of the system components must have the manufacturer's name, address and catalog number on a plate securely affixed in a conspicuous place. The nameplate of a distributing agent only will not be acceptable. The gears, couplings, projecting set screws, keys and other rotating parts located so that any person may come in close proximity thereto must be fully enclosed or properly guarded. System Components, assemblies and parts must be marked for identification in accordance with MIL-STD-130 and MIL-STD-161. Pump and filter vessel numbers must be as indicated on the drawings. In addition, filter vessels must include element numbers and the date of the next element change. Identification tags made of brass, stainless steel, or engraved anodized aluminum, indicating valve number and normally open (NO) or normally closed (NC) must be installed on valves. Tags must be 1-3/8 inch minimum diameter, and marking must be stamped or engraved. Indentations must be black, for reading clarity. Tags must be attached to valves with No 12 AWG, copper wire, stainless or aluminum hanging wires, or chrome-plated beaded chain designed for that purpose.

2.2.2 System Supplier

Since the pump control system, including but not limited to pump control panel, [venturi tubes], transmitters, flow switches, fueling system pumps, all field instrumentation, [tightness monitoring system,] and control valves with all hardware and software, is an integrated system it must be furnished by a single systems supplier regularly engaged in the supplying of these system components. System Supplier must be a company whose regular, normal, and primary business is representing manufacturers in the distribution and start-up of aviation fueling facilities, and have no affiliation with the Contractor other than as a seller to the Contractor. Supplier must provide all system components and appurtenances regardless of manufacture, be a factory authorized certified representative, and be responsible to the Contractor for satisfactory operation of the entire system, and must oversee the installation of the system components. Substitutions of functions specified will not be acceptable. The Contractor and the System Supplier must be present at the system commissioning, and must coordinate and schedule the work during construction, testing, calibration, and acceptance of the system. The System Supplier must be on-site with their mechanical and control personnel to supervise and assist the contractor during pre-commissioning check-out of the mechanical systems and control systems, initial fuel receipt, initial filing, hydrostatic testing, pigging, flushing, cleaning, system component tests, performance testing and all training for the owner's representatives. The System Supplier must be responsible to the Contractor for scheduling all Contractor, Sub-contractor, and manufacturer's service personnel during system start-up and final commissioning.

2.3 ELECTRICAL

Motors, manual or automatic motor control system components except where installed in motor control centers, and protective or signal devices required for the operation specified herein must be provided under this section in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Any wiring required for the operation specified herein, but not shown on the electrical plans, must be provided under this section in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3.1 Grounding and Bonding

Ground and bond in accordance with NFPA 70, NFPA 77, NFPA 407, NFPA 780, API RP 540, API RP 2003, IEEE 142, and IEEE 1100. Provide jumpers to overcome the insulating effects of gaskets, paints, or nonmetallic components.

2.4 PRESSURE GAGES

Pressure gages must conform to ASME B40.100 with metal cases and 4-inch diameter white dials. Gages must be bottom connected, without back flanges. A pulsation dampener, adjustable to the degree of dampening required, must be provided for each gage. Range of gages must be as indicated. A ball valve must be provided for each pressure gage. Gages must have all parts immersed in [silicone] [glycerin] oil. Gages must be labeled with the calibration date.

2.4.1 Quick Disconnect

If indicated on drawings provide quick disconnect on pressure gauge. Quick disconnects for pressure gauges must be double shut-off, dry-break design, 316 stainless steel construction, with Fluorocarbon (Viton) seals, minimum working pressure of 1000 psig at 100 degrees F, with 1/2-inch female NPT threaded connections for both coupler and adapter, manufactured in accordance with ISO 7241, Series B. The quick disconnect assembly must consist of a coupler, half to be connected to the pressure snubber under the pressure gauge, and a nipple/adapter half to be connected above the pressure gauge isolation ball valve. The nipple/adapter is to be provided with an aluminum dust cap to protect the fitting when the gauge is removed.

2.5 DIFFERENTIAL PRESSURE GAUGE

The gauge must consist of a spring-supported, corrosion resistant piston moving inside a glass cylinder, with high pressure applied on top of the piston and low pressure applied below it. Under a differential pressure of 30 psi, leakage past the piston must not exceed 120 drops per minute. The cylinder and flanges must be stainless steel with Viton O-ring seals. The high pressure inlet of the gauge must have a 10-micron pleated paper filter and the low pressure connection must have a fine mesh stainless steel strainer. The gauge must have an operating pressure of 300 psi. Differential pressure range of the gauge through approximately 3-inches of piston movement must be 0-30 psi with an accuracy of plus 0.5 psi, calibrated linearly with one PSI scale graduations. High and low pressure connections must be 1/4-inch NPT female with a stainless steel bar stock valve at each connection. Construction of the gauge must be such that a 3-valve manifold is not necessary. If only one bar stock valve is closed, the gauge must not be damaged by up to 300 psi differential pressure in either direction. A pressure gauge must be attached to the differential pressure gauge to indicate the high pressure and have a range of 300 psi.

2.6 AUTOMATIC PUMP CONTROLS

The control system components specified in this paragraph must be obtained from a single supplier of such products (see the paragraph SYSTEM SUPPLIER in this section for the requirements). The supplier must be responsible for furnishing components that are compatible and that operate as a system to perform the required pump control functions. Control tubing between controls/instruments and fuel lines must be installed to eliminate air entrapment. Control tubing must be as specified in Section 33 52 40 FUEL SYSTEMS PIPING (NON-HYDRANT). Each system component specified hereafter must have manufacturer's authorized service personnel present to assist in PERFORMANCE TESTING as specified in Section 33 08 55 FUEL DISTRIBUTION SYSTEM START-UP (NON-HYDRANT). Items specified under this paragraph must be submitted for approval concurrently with items specified in Section 33 09 52 FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM (NON-HYDRANT).

Electrical supply and electrical control system components must be suitable for the location and area classification in which they are installed. All mounting hardware must be corrosion resistant.

2.6.1 Pump Control System

Provide a system that is furnished by a Single System supplier. System must include all required hardware and software in an integrated system. System must include the operator's interface computer and all required transmitters. System must monitor and control the following as a minimum:

a. Control valves

b. Refueler truck loading system

c. Over the road tank truck loading system

d. Railcar loading system

e. Over the road tank truck offloading system

f. Railcar offloading system

g. Tank truck overfill protection and ground verification unit

h. Vehicle dispensing system

i. Marine loading system

j. Marine offloading system

k. Transfer pipeline pumping system

2.6.2 Pump Control Panel

See Section 33 09 52 FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM (NON-HYDRANT).

2.6.3 Control Stations

Electrical supply and electrical control system components must be suitable for the location and area classification in which they are installed. All mounting hardware must be corrosion resistant.

2.6.3.1 Pump Control Start/Stop Station

Station must consist of an enclosure, start/stop pushbuttons and green indicator lights as required. Enclosure must be corrosion resistant. In hazardous areas, enclosure must be electrogalvanized iron alloy with factory coating or copper-free aluminum. In non-hazardous areas, enclosures must be galvanized steel, stainless steel, electrogalvanized iron alloy with a factory coating or copper-free aluminum. Pushbutton contacts must have a minimum rating of 10 A, 125/250 VAC. Contact configuration must be as required or indicated. Indicator lights must be LED.

2.6.3.2 Emergency Fuel Shut-Off (EFSO) Station

Enclosure must be corrosion resistant. In hazardous areas, enclosure must be electrogalvanized iron alloy with factory coating or copper-free aluminum. In non-hazardous areas, enclosures must be galvanized steel, stainless steel, electrogalvanized iron alloy with a factory coating or copper-free aluminum. All enclosures must be provided with a hinged glass or polycarbonate front and an open bottom. Paint the enclosure red. Mounting hardware must be corrosion resistant. Mount an emergency pushbutton inside the station housing. Pushbutton must be accessible through the hinged front. Pushbutton must be a momentary contact single unit with a jumbo mushroom operator, 1-NC and 1-NO contact. Mount a caution sign beside the emergency shutdown station, with red 2-inch letters stating "EMERGENCY SHUTDOWN". The sign must have white background and be of noncorrosive construction.

[2.6.4 Tightness Monitoring System

The system must be a permanent, fully automated, pressure step (no volume measurement) leak detection system, and will be used for tightness testing piping systems. System must have a guaranteed accuracy to detect a leak of less than 0.0004 gal/h per cubic foot at 150 PSI. The system must be US EPA Third Party Certified to the above sensitivity with a Probability of Detection greater than or equal to 95 percent and a Probability of False Alarm of less than or equal to 5 percent. System will have performed satisfactorily on at least five projects involving quantities and complexities at least equal to those required under this Contract. System components must be compatible with system components furnished and installed under this Section and Section 33 09 52 FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM (NON-HYDRANT), where the individual system components are common to both the Tightness Monitoring System functional operation, and the Fuel Control System functional operation. Test results must be unaffected by the temperature change of the fuel, and have a maximum test period of one hour. A local controller must implement and analyze data, store data and be capable of printing results, and be located in the the [pumphouse building] [conditioned enclosure] [_____]. Printer must be provided. Controller must utilize 120V, single phase power. Any additional utilities or system components needed to be added to the fuel system in addition to what is shown on the drawings to allow the Tightness Monitoring System to meet the requirements, will be the requirement of the Tightness Monitoring System Supplier. Provide calculations, design, and proof of compliance. Upon completion of 72-hours of continuous system operation and before final acceptance of work, test the Tightness Monitoring System in service to demonstrate compliance with contract requirements. Performance verification must be coordinated with overall fuel system start-up, and commissioning of fueling facilities. Perform performance verification in such a way as to obtain complete tightness information within the required accuracy stated herein and provided Tightness Certification on each pipe section tested.

][2.6.5 Truck Fillstand Overfill Protection and Ground Verification Unit

System must include connection plug, control cable, and monitoring and control module. System must be the self-checking type that automatically and continually monitors the liquid-level within a tank truck's storage compartment during fueling.[Connection plug must conform to [______].][The system must be compatible with the Scully Duocept w/Truck Identification Module (T.I.M.) P/N 09061 to monitor truck liquid level, provide ground verification and provide a method to electronically prevent product commingling.] System must be rated for an explosion-proof environment in accordance with NFPA 70 for Class I, Division I, Group D locations. Module must include status lights and a switch contact to allow interlock functions. Control cable must be the spiral, self-retracting type. Cable must be a minimum 30 feet in length. The fillstand tank level sensor must signal the fillstand control valves to shutdown and must serve as the primary fill stand overfill system.

]2.6.6 Flow Switches

Switches must be actuating vane type flow switch with single adjustable set-point. Switches must mount on ASME B16.5 Class 150 raised face flange. Flange material must match the piping material at their connection to the system. Provide snap action switch mechanism U.L. listed for Class I, Division 1, Group D hazardous locations. Switches to be double pole double throw (DPDT). Switch power must be 120 volts, single phase, 60 hertz, 10 amps minimum. Units installed on 2-inch piping and smaller may be threaded.

[2.6.7 Venturi Tubes

a. The venturi tubes must be provided in conjunction with Section 33 09 52 FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM (NON-HYDRANT).

b. Start-up, adjustments and calibration, and instruction of personnel in the operation and maintenance of the venturi tubes must be considered as a required portion of the controls package.

c. The venturi tubes must be low loss differential pressure producers consisting of a short housing piece and a fully machined, contoured throat section providing a restriction at the center, with both inlet approach and exit having geometrically symmetrical curves. They must be velocity head, impact, differential producing devices designed to measure differential pressure of [jet fuel] [mogas] [avgas] [diesel] [bio-diesel] [E-85] [burner fuel oils][_____]. They must be constructed of [304L stainless steel][carbon steel] with ANSI Class 150 flanges on each end and be suitable for operation of [275 psig] [285 psig] at 100 degrees F. They must be of sufficient thickness to with-stand the same stresses as the upstream and downstream piping. Each venturi tube must have a minimum of four 1/2-inch connections. An individual head-capacity curve must be furnished for each venturi tube.

d. Each venturi tube must be specifically custom manufactured for the specific flow conditions. Off the shelf designs are not acceptable. Date of manufacture must be stamped on the tube.

e. Operating conditions for the venturi tubes must be as follows:

(1) Issue Venturi Tube. Minimum inlet-to-throat differential pressure at [2,400] [_____] gpm: 200 in H2O.

(2) Return Venturi Tube. Minimum inlet-to-throat differential pressure at [600] [_____] gpm: 200 in H2O.

(3) Venturi tubes discharge coefficient "C" to be greater than or equal to 0.97 over pipe Reynolds number range between 200,000 and 1,000,000 and must be independent of Beta over a Beta range of 0.4 to 0.75. Pressure loss must be less than 24 percent of differential pressure generated by the venturi tube. Repeatability of the discharge coefficient "C" must be 2 percent for Reynolds number range of 10,000 to 1,000,000.

(4) Provide two portable GPM Meters, one for each size of venturi. The meters must be complete with valves, hoses and connecting disconnects, and carrying case. The meters must have stainless steel bellows, mounting bracket, 500 psi swp, 6-inch dial with 270 degrees arc. Dial must read GPM Jet Fuel. Range of scale must match the flow transmitter for issue and return. The venturi manufacturer must provide the portable meters with the venturi in order to be compatible. The venturi tubes must also be provided with a suitable table to convert inches differential pressure to gallons per minute.

][2.6.8 Differential Pressure Transmitter

Differential pressure transmitter must consist of a capacitance sensor operating on a differential in pressure of fuel. The output must be a 4 - 20mA dc, square root signal between a minimum of 4 - 100 percent of the input. It may be linear between 0 - 4 percent. It simultaneously will produce a digital HART (Highway Addressable Remote Transducer) output signal. Loop power must be provided from remote power supply located in the pump control panel (PCP).

a. Transmitter body must be stainless steel with stainless steel diaphragm capsule process connecting to a 1/2-inch NPT. Drain and vent valves to be stainless steel. Accuracy must be plus/minus 0.20 percent of calibrated span including combined effects of linearity, hysteresis and repeatability.

[b. One differential pressure dial must be supplied with each pair of transmitters. Differential pressure dial must consist of a bellows type pressure sensing element, operating on a differential in pressure of fuel, and a mechanical indicator, driven by the bellows unit. The bellows must be dual opposed, liquid filled, rupture-proof type with bellows movement converted to rotation and transmitted by a torque tube. Displacement of bellows must be 1.5 cubic inches for full scale travel. Bellows housing must be stainless steel and must have a rated working pressure of not less than 500 psi. Liquid used to fill the bellows must be suitable for the expected minimum ambient temperature. The indicating dial must be at least 6-inches in diameter with a weatherproof glass cover. The case must be finished with a weather resistant epoxy resin enamel. The indicating pointer must traverse a 270-degree arc. The scales must be graduated over the selected pressure ranges so that the flow rate can be accurately read in gallons per minute. Indicator accuracy must be 0.5 percent of full scale. Differential pressure indicating dial must be provided with built-in

pulsation damper and suitable over-range protection.
]
[c. Display at the transmitter must be LCD, one per each differential pressure transmitter. The digital scale must be a 4-digit LCD, capable of being read in low light/no light conditions. Indicator scale must be in gallons per minute.
]
d. Each venturi tube must have one transmitter and one indicating dial per function and must be installed as indicated on the drawings. Differential pressure ranges must be selected as necessary to operate in conjunction with associated venturi tube:

(1) Issue Venturi Tube - 0 to [_____] GPM (full range)

(2) [Return][Bypass] Venturi Tube - 0 to [_____] GPM (full range)

[e. Differential pressure transmitters must be UL, FM, or CSA listed for Class 1, Division 1, Group D hazardous environment as defined by NFPA 70, with maximum temperature rating T2D (419 degrees F). Each transmitter and indicating dial must be supplied with a factory assembled five valve stainless steel manifold. Vent valves must be furnished on upper ports of each transmitter and indicating dial. Differential pressure transmitters and the indicating dial must be suitable for mounting on a 2-inch pipe stand. Complete installation must be in accordance with manufacturer's recommendations.

]]2.6.9 Pressure Sensor

Sensor must be UL, FM, or CSA listed for Class 1, Division 1, Group D hazardous environment as defined by NFPA 70, with maximum temperature rating T2D (419 degrees F). Excitation voltage must be 12-28 VDC. Output signal must be 4-20 mA. Unit must have 0.25 percent accuracy and have built-in high pressure snubbers, minimum pressure range must be 0-300 PSI. Wetted material must be stainless steel.

Provide pressure sensors at pump suction header, pump discharge header, [bypass pressure control valve inlet,][bypass pressure control valve outlet,][backpressure control valve inlet,][backpressure control valve outlet,][truck fillstand manifold,][and,][_____].

2.7 RELAXATION TANK

Tank must conform to API RP 2003 and ASME BPVC SEC VIII D1. Tank housing must be constructed of 3003 or 6061 aluminum alloy. Provide each tank with an ASME pressure vessel seal. Provide tank with internal baffling to prevent flow short-circuiting. Provide tank with an air release tap, a pressure relief tap and a drain tap. Provide flanged end connections on all piping connections (inlet piping, outlet piping, pressure relief piping, vent piping, and drain piping).

2.8 METERS

2.8.1 Positive Displacement Meters

Meter must be a one-way flow, temperature compensating, positive displacement type meter designed for a continuous flow of [600 GPM] [300 GPM] [_____] at the truck fillstand. Meter must have ANSI Class 150 flanges and body working pressure of not less than [275 psig] [285 psig] and must be suitable for hydrostatic testing of [275 psig] [285 psig].

Meter must be factory calibrated for [jet fuel] [mogas] [avgas] [diesel] [bio-diesel] [E-85] [burner fuel oils] [_____] and capable of being calibrated in the field. The register must have a non-setback total indicator and a setback type run indicator so that individual runs can be registered without affecting the total of all runs as shown on the indicator. The total indicator must have a minimum of eight figures and the setback run indicator must have a minimum of five figures. The register must read in gallons and the smallest unit of indicated delivery must be one gallon. Accuracy must be within plus/minus 0.3 percent between ten percent and maximum rated flow. Meters must be provided with a suitable drain at the bottom, equipped with a ball valve. Pressure loss through the meter must not exceed 3 psi at [600 GPM] [300 GPM] [_____] flow rate.[Meter must have mechanical head.][Meter must have electronic head with means to remotely transmit the quantities passing through it by electronic pulse transmitters mounted on each meter.][Meter must have card-operated or key-operated data acquisition system to identify the receiver of the fuel and to allow access to the fuel.] Materials of construction must be stainless steel, aluminum, or carbon steel with electroless nickel plated or interior epoxy coated internals. The epoxy coating must be in accordance with MIL-PRF-4556.

[2.8.2 Turbine Meter

Volumetric Turbine Flow Meter must be a turbine type meter designed for a continuous flow of [1200] [_____] GPM, constructed of 316 stainless steel. The turbine meter must be supplied with Class 150 stainless steel ASME flanges, be capable of [275] [285] psig system pressure, and must be suitable for hydrostatic testing of [275] [285] psig. Meter must be factory calibrated for [F-24] [JP-4] [JP-5] [JP-7] [JP-8] [jet fuel] [mogas] [avgas] [diesel] [bio-diesel] [E-85] [burner fuel oils] [_____]. The measuring element of the turbine will consist of a straight blade, un-rimmed central rotor, rotating about a central rotor shaft that is supported bilaterally within the inside diameter of the meter body by cylindrical shaped spring clips that maintain the shaft and turbine rotor on the center line of the meter body independent of system pressures and temperatures. The cylindrical shaft clips also will counteract swirl and present a uniform fully turbulent flow profile and uniform boundary layer to the cones and turbine rotor. The turbine meter will have an accuracy of plus/minus 0.5 percent over a 10:1 range and a linearity of up to plus/minus 0.25 percent may be attained with premium calibration. Repeatability of the turbine meter will be 0.1 percent of reading over the entire range of the size of the turbine selected. The turbine meter must be approved by US NIST for solvent, gasoline, diesel fuel, fuel oil, and ethanol for use on custody transfer applications.[Provide turbine meter with flow straightener.]

The turbine meter will be supplied complete with an integrally mounted Multi-Function Microprocessor Based Rate Indicator / Totalizer with Field Programmability and Backlit Display in an Aluminum Enclosure. The enclosure must be rated for explosion proof environments. Input power must be self- contained battery, 10-14 VDC or 20-28 VDC. Outputs must include 4-20mA output and pulse output. A reset magnet, aluminum union, and 2-wire Molex signal cable will also be included with the Indicator/Totalizer. The Indicator/Totalizer must have temperature compensation with a four wire RTD input as well as the ability for RS232 data logging.

][2.9 TANK RECEIPT SLOWFILL FLOWRATE INDICATOR

Meter must consist of corner tapped orifice flanges, orifice flange plate, differential pressure gauge, and associated flow chart. The normal flow range is 0 to 600 gpm. Orifice flanges must be ANSI Class 150 and must be constructed of Type 304 or 304L stainless steel. Orifice Beta value must be 0.7, with a maximum pressure loss of no more than 3 psi at 600 gpm. Differential pressure gauge must have a display of 0-100 feet water column. A hand chart must be provided which shows the flow (gpm) for the pressure drop indicated on the differential pressure gauge. A note must be added: Tank must not be filled faster than [_____] gpm (3 fps) whenever the fuel is not in contact with the floating pan (tank fuel receipt outlet is covered by 3 feet of fuel when no floating pan is present).

]2.10 MISCELLANEOUS USE PUMPS

Pumps must be driven by an explosion-proof motor for Class I, Division 1, Group D hazardous locations as defined in NFPA 70. Pump assemblies must be statically and dynamically balanced for all flow rates from no flow to 120 percent of design flow. Pump motors must be non-overloading throughout their entire pump curve.

2.10.1 Submersible Pump

Pump must be the [single-][multi-]stage, vertical type. Pump and motor combination must operate totally submerged in the product of the storage tank. Pump must extend within 6-inches of the storage tank bottom. Pump fuel inlets must be horizontal. Pump mounting must completely support both the weight and vibration of the pump. Pump must include a steel lifting lug capable of supporting the weight of the entire pump and motor assembly. Pump must include a vertical solid shaft motor, base mounting flange, horizontal pump discharge, low net positive suction head (NPSH) first stage impellers, and dynamic and thrust balancing of impellers. Pump must be accessible for servicing without disturbing connecting piping. Pump baseplate, casing, and bearing housing must be of cast iron construction. Pump must be provided with a stainless steel one piece pump shaft. Internal pump components in direct contact with the fuel to be handled must be of compatible construction. Pump bearings must be selected to give a minimum L-10 rating life of 25,000 hours in continuous operation. Provide pump with [threaded][flanged] end piping connections.

2.10.2 ANSI Type Centrifugal Pump

a. Overloading, horizontal, centrifugal type. Pump must have a radially split casing with an open impeller and Class 300 flanged connections. The pump suction and discharge flange arrangement must conform to ASME B73.1.

b. Casing discharge must be vertical centerline discharge. Medium and large frame pump casings must incorporate centerline support feet as required by API STD 610. Small frame pumps must not have casing feet. The casing and back cover wall thickness will include 1/8-inch corrosion allowance. The suction and discharge neck must be drilled and tapped with 1/4-inch NPT connections, for pressure gauges [and][or] auxiliary piping. A rotation arrow will be cast on the surface of the casing to indicate the proper direction of rotation.

c. Repelling vanes must be cast on the back side of the impeller. The impeller hubs must incorporate a threaded fit to the pump shaft sealed by a Teflon O ring in the hub. The impeller must be balanced to ISO specification G.6.3, with option for G2.5, unless otherwise specified. Balancing must, unless detrimental to the component or its performance, be attained by the removal of material.

d. The back cover must be fastened to the pump casing with a confined type gasket inert to the fluid being pumped. Seals must be cartridge type end face mechanical seals. The method of lubrication must be oil bath. The thrust bearings must be locked into the cartridge by a bolt-on retainer cover. Snap ring bearing retainers are not acceptable. The radial bearing must be permitted to slide within the inside diameter of the bearing frame to prevent axial load and permit radial load only. Double row filled slot bearings are not acceptable. Bearings must be designed for a minimum L-10 life of 60,000 hours. Angular contact thrust bearings, as required by API STD 610, are required. The pumps must at minimum be fitted with the following bearings:

(1) Small Frame Pumps (ANSI AA through A50):

(a) The thrust bearing: a 5308, AHC3 clearance, double row, deep groove bearing. A pair of 7308 BEGAY, back to back angular contact bearings must be provided as an option when required.

(b) The radial bearing: a 6308, C3 clearance, single row, deep groove.

(2) Medium Frame Pumps (ANSI A60 through A80):

(a) The thrust bearing: a pair of 7310 BEGAY clearance, back to back angular contact bearings.

(b) The radial bearing: a 6310 C3 clearance, single row, deep groove.

(3) Large Frame Pumps (ANSI A90 through A120:

(a) The thrust bearing: a pair of 7314 BEGAY clearance, back to back angular contact bearings.

(b) The radial bearing: a 6314 C3 clearance single row, deep groove.

e. The pump shaft must be of solid construction. Shaft sleeves are not acceptable. In order to establish satisfactory mechanical seal life, the total shaft deflection at the primary seal faces, under the most severe dynamic conditions, must be limited to 0.002-inch, as required by API STD 610. To achieve this, the stiffness ratios (L3/D4), where L= length of shaft from impeller centerline to nearest bearing in inches and D= shaft diameter under the seal in inches, must not exceed the following values:

Shaft Size at Seal	L3/D4
Shafts 1.5 inch	46
Shafts greater than 1.5 inch, 2.0 inch	20
Shafts greater than 2 inch	19

f. The bearing frame must be cast iron, with radial fins for maximum cooling. The oil sump must contain a minimum of 8 ounces of oil for small frame pumps, 24 ounces of oil for mid-frames and 32 ounces of oil for large. The oil level within the bearing frame must be monitored by an oil sight glass. Two magnetic pipe plugs must be located near the bottom of the bearing frame. The oil fill fitting at the top must be of nylon with an easily removable cap for adding oil. Trico or bottle type constant level oilers are not acceptable. Each end of the bearing frame assembly must incorporate non-contacting labyrinth oil seals. This type of seal is required by API STD 610 to eliminate shaft damage due to fretting and to eliminate the heat generated by the use of contact type lip seals. Other seal systems will be considered only if they are non-fretting. Shaft contacting type lip seals will not be accepted.

g. The thrust bearing end of the bearing frame must be capable of precision impeller adjustments without the need to add or remove shims. The minimum delineation must be 0.003-inch and permit impeller clearance settings or readjustments without the need to remove the bearing frame from the volute section and without requiring shims, dial indicators, feeler gauges or disassembly.

h. The pump must be of the back pull-out design to permit the removal of the entire bearing frame assembly, including shaft, mechanical seal, and impeller, without disturbing the pump discharge and suction piping and without disturbing the motor (except for pumps equipped with C-Frame motor adaptors). Small frame and medium frame pumps must have a bearing frame foot that will support the power end in an upright position when removed from the wet end for service. A spacer type coupling must be furnished on non-motor adapter pumps to allow removal of the power end without disturbing the motor.

i. The pump must have the capability of incorporating a C-Frame motor adapter, which permits mounting of motors up to NEMA frame size 256TC for small frame, 405TC (447TSC) for medium frame, and 449T(S)C for large frame, without the need for parallel and angular alignment measurements and adjustments. The motor adapter may be equipped with adjustable feet in order to avoid frame soft foot and eliminate the need to use shims under the adapter assembly.

j. The pump must be constructed of the following materials:

(1) The pump casing and back cover/seal chamber must be constructed of ASTM A743 CF8M.

(2) The impeller must be open type, cast in ASTM A351 CD4MCU.

(3) The pump shaft must be constructed of solid 316SS (ASTM A276 T316) or 17-4PH (ASTM A 564 T630) as required by the application. Bimetallic shafts are acceptable.

2.10.3 Sliding Vane Rotary Pump

Pump must be a sliding vane type rotary pump. The pump construction must permit the removal of the rotor and sliding vanes without disconnecting the pump. Pump capacity must be [50][_____] gal per minute with a differential head of [57][_____] feet. The pump and motor must be mounted on a steel subbase. The motor must have sufficient power for the service required, be of a type approved by the manufacturer of the pump, be suitable for available electric service, be totally enclosed, fan cooled, TEFC, and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Pump must be provided with stainless suction screen.

2.10.4 Self-priming Centrifugal Pump

a. The pump must be a single-stage, horizontal, centrifugal type consisting of a centrifugal impeller combined with a vane-type rotary, positive evacuating, volumetric-displacement priming unit, mounted on a common shaft. Pump must meet MIL-P-52327C.

b. The pump must be such that all rotating parts may be removed without disconnection of the suction or discharge piping.

c. The pump must operate dry for not less than 1-hour without damage or permanent deformation of moving parts after the pump has been operated by the petroleum products.

d. The priming unit must be a vane-type rotary, positive, volumetric-displacement unit mounted on the same shaft as the centrifugal impeller. The priming unit must evacuate air from the suction piping and thereby initially priming the centrifugal impeller and restoring lost prime during the operation of the pump. A stainless steel self-cleaning strainer must be provided in the priming-unit intake line.

e. The motor must have sufficient power for the service required, be of a type approved by the manufacturer of the pump, be suitable for available electric service, be totally enclosed, fan cooled, TEFC, and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

f. Capacity must be [300][_____] gpm against a total head of [150][_____] feet when driven at 3600 rpm. Pump head capacity must be continually rising and must be free of dips and valleys from design point to shut-off head. Pump shut-off head must have a 10 to 20 percent head rise to shut off. Pump must be capable of at least a 10 percent head increase at rated conditions by installing a new impeller. Pumps must not overheat or be damaged in any way while operating continuously at a minimum flow condition of 50 percent of rated flow continuously at a maximum flow condition of 125 percent required capacity. The net positive suction head required at the center of the impeller must not exceed 6 feet.

g. Pump must consist of a centrifugal impeller combined with an integral variable-capacity vane type priming unit located within the main centrifugal housing. The vane type positive priming unit must be capable of initially priming the pump and of restoring prime during operation against back pressures to 8 psi. The air release must enable the pump to prime at any discharge head pressure from zero feet to maximum discharge head and must release drip-free to the atmosphere and drain any liquid back into the centrifugal pump.

h. The vane pump must be positively driven by the main pump shaft. No gears or pumps must be required to operate the primary pump. All parts must be factory inspected so that parts are interchangeable. Pumps and motors must be furnished as complete units as herein specified. Pump assembly must be statically and dynamically balanced for all flow rates from minimum flow to 120 percent of design flow.

i. Pump must include provisions for attaching a vacuum gauge on the suction side and a pressure gauge on the discharge side.

j. The pump must be fitted with a mechanical-type pump shaft seal for closure between the stationary pump case and the pump shaft. The seal must be capable of effectively sealing a pressure equal to 1-1/2 times the pump shut off head. The mechanical-type shaft deal must be a standard product of proven material and design. The sealing surface must be self-aligning and must be readily removable for repair or replacement without removing the electric motor from the base. The sealing surfaces must be constructed of carbon/ni-resist, and the elastomers must be viton. The rotating member must be pin driven by the pump shaft, or must be firmly retained on the pump shaft by a snap ring or other suitable means. Materials used as sealing members or elastomers must be impervious to the deleterious action of the specified product. All parts of the seal must be resistant to corrosion and oxidation.

k. The pump shaft must be fabricated from 410 stainless steel. The shaft must be turned, ground and polished, and hardened to resist wear where the shaft passes through the seal and bearings. The shaft must be supported in the shaft housing by means of heavy duty, anti-friction, sealed type ball bearings.

l. The pump shaft must be coupled to the motor shaft by means of a flexible coupling having sufficient torsional strength to accommodate the rated motor horsepower. The coupling must be capable of handling angular and non-parallel alignment.

m. The pump case must be ductile iron. Flange ratings must be class 105 kg 125-pound per ANSI Standard, and flanges must be faced and drilled.

n. The impeller must be of the closed type, and must be statically and dynamically balanced. The impeller must be constructed of aluminum 356-T6.

[2.10.5 Jockey Pump

The pump must have the capacity of not less than 5 gpm against a total head of 240 feet when driven at 3600 rpm and be an ANSI type centrifugal pump.

]2.11 PACKAGED TRUCK OFFLOAD SYSTEM

The truck offload system must be a factory fabricated and skid mounted unit.

2.11.1 Offload Pump (OP)

Refer to Section 33 52 43.23 AVIATION FUEL PUMPS.

2.11.2 Air Eliminator Tank

2.11.2.1 Tank Housing

Each Tank housing must be fabricated from carbon steel and must be internally coated with an epoxy coating in accordance with MIL-PRF-4556. Coat the exterior with alkyd resin primer (universal metal primer). Each unit must be constructed and labeled in accordance with ASME BPVC SEC VIII D1. The housing must be designed for a working pressure of 90 psig. The inlet and outlet connections must be provided with raised face flanges faced and drilled in compliance with ASME B16.5, Class 150. The configuration of the air eliminator tanks must be as shown on the drawings.

2.11.2.2 Sight Gauge

Provide a 5-inch armored, clear borosilicate (Pyrex) glass liquid level gauge for observing fuel level in the tank. The gauge must be equipped with stainless steel ball checks in both the upper and lower fittings, an upper and lower shutoff valve, and a bottom blowoff cock. The gauge will contain a colored density sensitive ball. Glass must be protected by a minimum of four guard rods.

2.11.2.3 High Level Shutoff

The vent connection must have a stainless steel high level shutoff mechanism to act as an overfill prevention device to keep fuel from going out the vent.

2.11.2.4 Level Sensors

The level sensors must be ultrasonic tip sensitive level control switches, NEMA 7/9, weatherproof, explosion proof for Class I, Div I, Group D, temperature T2D (419 degrees F), 120-volt input power, SPST relay output, one-inch flanged mounting.

2.11.2.5 Vent

Tank vent outlet must be equipped with pressure-vacuum breather vent, aluminum construction with weather hood and with fluoroelastomer pallet seat inserts, high density screens, stainless steel internals, with pressure relief setting at 0.5 oz per square inch, and vacuum relief set at 32 oz per square inch. Pressure venting capacity must be 5400 cubic feet per hour, vacuum capacity must be 5000 cubic feet per hour.

2.11.3 Non-Surge Check/Air Block Valve

Refer to Section 33 52 43.14 AVIATION FUEL CONTROL VALVES.

2.11.4 Offload Fuel Hose

The offload fuel hose must be 4-inch, lightweight, flexible, minimum 8-inch bend radius, non-pressurized offloading hose constructed of nitrile rubber, rigid PVC helix, synthetic braiding, smooth bore, corrugated outer diameter, non-collapsible, threaded, male NPT, both ends, and have UV protection.

2.11.5 Offload Sight Flow Indicator

The Truck Offload sight flow indicator must be 4-inch wafer pattern sight glass, plane indicator aluminum construction.

[2.11.6 Flood Lights

Mount three floodlights on the off load skid, approximately 12 foot high, two on one pole, one on another pole to provide 10 fc of illuminance at the offload connection point and 1 fc of general illumination in the offload area. Fixtures must operate on 277 volts, single phase, 60 Hz. Luminaires must be rated for installation in wet locations and have narrow vertical and wide horizontal beam spread. Luminaires must be bronze in color and accept 2-inch knuckle mounting. Provide a manual switch for control. See Section 26 56 00 EXTERIOR LIGHTING for applicable requirements.

]2.11.7 Flowmeter

Meter must be positive displacement type as indicated in paragraph METERS, designed for a continuous flow of [600][300] GPM.

[2.11.8 Grounding

The skid must be equipped with a self winding grounding cable reel. The cable must be at least 50 feet long. The cable reel, the grounding cable and the connection clamp must be in accordance with CID A-A-50696.

][2.11.9 Grounding Verification Unit

System must include grounding [clamp][plug], grounding cable, and monitoring and control module. System must automatically and continually monitor and verify a low-resistance static dissipation path (less than [10 Ohms][_____]) between connecting tanker and the designated ground point.[Grounding clamp must conform to MIL-DTL-83413 and MIL-DTL-83413/7.][Grounding plug must [conform to MIL-DTL-83413 and MIL-DTL-83413/4] [______].] Grounding cable must be corrosion resistant steel strands sheathed in a Hytrel jacket. Cable must be the spiral, self-retracting type. Cable must be a minimum 30 feet in length. Monitoring and control module must be rated for an explosion-proof environment in accordance with NFPA 70 for Class I, Division I, Group D locations. Module must include status lights (red for no ground verification and green for positive ground verification) and a lockable bypass switch. Module must include a switch contact to allow interlock functions.

]2.11.10 Other Offload System Components

For other system components shown on the drawings as part of the offload system, refer to this Section and refer to this Section.

2.12 DEAERATOR TANK

Deaerator tank must be constructed of carbon steel, designed, constructed and labeled in accordance with ASME Code, Section VIII, Division I, and must be interior epoxy coated in accordance with MIL-PRF-4556. No ferrous or zinc-coated material bronze, brass or other copper bearing alloys must be used in contact with the fuel. It must be rated for a working pressure of [275 psig] [285 psig]. Unit must be sized for a flow rate of [_____] gpm and incorporate 4-inch Class 150 flanges per ASME B16.5. Unit must incorporate an internal baffle/diffuser plate to inhibit the passage of air through its outlet flange. The unit is intended to prevent the passage of air through the downstream flow meter, and requires the use of a downstream air/block valve. Unit to be complete with the following accessories:

a. A 1/2-inch stainless steel sight gauge for level indication.

b. A 2-inch FNPT, two-stage, automatic air vent with outlet check.

c. A 2-inch FNPT, stainless steel, 100 mesh, strainer for under Automatic Air Vent (AAV).

d. A one-inch by one-inch flanged relief valve, ASME Code, set at working pressure.

e. A 2-inch MNPT, Explosion-proof, Class I, Div. I, Group D, side mount, float type level switch, SPDT, mounted a minimum of 25-inches above the tank's outlet flange, to be wired to the air/block valve.

f. A 1/2-inch flanged drain valve.

2.12.1 Deaerator Tank Air Block Valve (DTBV)

Refer to Section 33 52 43.14 AVIATION FUEL CONTROL VALVES.

2.12.1.1 Size

As indicated.

2.12.1.2 Flow

As indicated.

2.12.1.3 Operation

Deaerator block valve must be hydraulically operated. Upon a rise in air level in the deaerator tank as indicated by the level switch, the main valve must close tightly. The main valve must remain closed until a rise in tank fluid level above the level switch occurs.

2.12.1.4 Check Valve Feature

Valve must close rapidly when outlet pressure exceeds inlet pressure.

2.12.1.5 Flow Control

Valve to limit flow to [_____] gpm. Sensing must be by orifice. Valve to modulate to limit flow without hunting. Rate of flow to be manually adjustable and utilize a downstream orifice plate holder.

2.12.1.6 Strainer

A 40-mesh stainless steel wire, self-cleaning strainer must be provided in the pilot valve supply piping.

2.12.1.7 Minimum Differential Pressure Feature

The valve must be equipped with a minimum differential pressure pilot to maintain a differential pressure across the valve. Pressure must be adjustable with a range of 5 to 25 psi.

2.12.1.8 Opening Feature

The valve must be equipped with an adjustable differential pressure pilot and a quick cover exhaust system to allow the valve to open in 3-4 seconds when pressure is greater than [_____][30] psig.

2.12.1.9 Solenoid Control

The valve must be provided with solenoid control. The solenoid must close the DTBV upon low level alarm activation. The solenoid must be energized to close.

2.13 REFUELER TRUCK FILLSTAND (PANTOGRAPH TYPE)

For pantograph style fillstands, provide refueler and tactical refueler truck fillstand pantographs as specified in Section 33 52 43.12 AVIATION FUEL PANTOGRAPHS.

2.14 REFUELER TRUCK FILLSTAND (HOSE TYPE)

2.14.1 Truck Fillstand Hose

Provide hose that conforms to EI 1529, Grade 2, Type C, semi-hardwall. Provide each hose end with a coupler that conforms to paragraph [DRY-BREAK COUPLER][QUICK DISCONNECT COUPLER].

2.14.2 Truck Fillstand Swivel Joints

Flanged swivel joints must be stainless steel, single plane, capable of rotating 360 degrees. Welded swivel joints and welding of swivel joints to the pipe [and][or] elbow is not permitted. Swivel joints must be of the non-lubricated, maintenance free type with sealed bearings and no lubricating fitting. Swivel joint must be flanged at the end connecting to the piping system and threaded (female NPT) at the end connecting to the fuel hose. No leakage must be permitted under positive or negative pressure conditions. No leakage must be permitted under high or low temperature conditions. Welding of swivel joint to six-bolt flange connector is permitted. The swivel joints must be warranted for three years against leakage. There must be electrical continuity from one flange to the other without the use of ground straps. The electrical continuity from one flange to another (without the use of ground straps) must be less than 1000 ohms. Each swivel joint must have two ball bearing raceways, primary and secondary seals with leak detection port, and dust seal.

2.15 TANK TRUCK BOTTOM LOADING ARM

Loading arm must be the factory fabricated, factory assembled, bottom loading type. Loading arm must include swivel joints, boom assemblies, and riser standpipe. Loading arm's pipe and fittings must be Schedule 10S, Grade TP304L, stainless steel in accordance with ASTM A312/A312M.[Provide adjacent loading arm assemblies with the ability to crossover one another during operation.]

2.15.1 Dispensing End

The weight of the loading arm's dispensing end (includes piping, valves, nozzles, miscellaneous components, and fuel weight) must be counteracted by a counterbalance system. The counterbalance system must be the [hydraulically actuated cylinder][or][spring counterweight] type. The counterbalance system must allow one operator to manually maneuver and control the dispensing end at all times. The counterbalance system must ensure that minimum force is transferred from the dispensing end to a fueling connection. Nozzle in the dispensing end must be in accordance with paragraph PRESSURE FUELING NOZZLE.

2.15.1.1 Hose Loader Type

Dispensing end must be the fixed reach, hose loader type. Hose used in the loading arm assembly must be in accordance with the paragraph in this Section TRUCK FILLSTAND HOSE.

2.15.1.2 A-Frame Type

Dispensing end must be the rigidly piped, variable reach, A-frame type.

2.15.2 Truck Loading Arm Swivel Joints

Swivel joints must be the flanged, non-lubricated type with sealed bearings. Swivel joints must come from the manufacturer with required flanged bodies and flanged elbows. Welded swivel joints and welding of swivel joints to the pipe [and][or] elbow will not be permitted. Welding of swivel joints to flange joints will not be permitted. Swivel joints must be warranted for two years against leakage due to both positive and negative pressure conditions. Swivel joints must be capable of 360-degree rotation.

2.16 TOP LOADING ARM

Top loading arm [2-inch-100] [3-inch-200] [4-inch-300]gpm must have sufficient horizontal reach and pivot points to assure the vehicle does not have to be re-spotted. Drop pipe length must be able to reach fill tank bottom and be at a safe elevation for refueler operation. Loading arm must have four planes of movement: up-down (to allow drop pipe to enter tank), side to side (to allow arm to rotate out to tank and back out of position), drop-tube (to assure drop-tube remains vertical), scissor arm pivot (which allows 360 degree rotation of secondary arm allowing the drop-tube to reach further out thus allows a larger spotting distance). Materials of construction must be stainless steel. Arm must be counterweight or spring assisted for effortless operation of loading arm. Swivel joints must be of the non-lubricated, maintenance free type with sealed bearings and no lubricating fittings. Assembly must be a regular product for the purpose of top loading fuel from a manufacturer who has successfully provided the product for at least the past five years.

2.17 NOZZLES AND ADAPTERS

2.17.1 Pressure Fueling Nozzle

Nozzles must conform to SAE AS5877, Type [D-1] [D-2] [D-3]. Nozzles and nozzle components must be compatible with the fuel to be handled. Nozzles must be provided with an internal 60 mesh stainless steel strainer and a fuel sample connection tapping. Nozzle design must be for single point fueling of aircraft. Nozzles must be provided with a compatible dry break quick disconnect swivel. Coupler must allow for quick disconnect and reconnect of fueling nozzles with corresponding adapters. Coupler and adapter must provide a positive, leak proof connection under constant or surge flow. Coupler must be designed to prevent blowout of internal poppet.

2.17.2 Nozzle Adapter (SPR)

Adapter must be a nominal 2-1/2-inches with self-closing valve in accordance with MIL-A-25896. Adapter must have a 4-inch flange mounting and vacuum tight, locking dust cap using the SPR lugs.

2.17.3 Tight-Fit Fill Adapter

Adapter must be the [top seal] [side seal] type. Adapter must provide a tight-fit connection to prevent vapor emissions during fuel transfer. Adapter must be bronze and be fitted with a Buna-N or Viton gasket.

Provide a locking cap with each adapter. Cap must mate with the adapter and have a latching mechanism that provides a watertight seal. Cap must provide some type of locking provision and be easily attachable and removable. Cap must be attached to the tight-fit vapor recovery adapter by a minimum 12-inch section of brass cable or fuel resistant rope.

2.17.4 Tight-Fit Vapor Recovery Adapter

Adapter must be the [top seal] [side seal] type that includes an internal self-closing valve or poppet. Adapter must provide a tight-fit connection to prevent vapor emissions during fuel transfer. Adapter must be bronze and be fitted with a Buna-N or Viton gasket. The adapter's internal valve or poppet must be driptight throughout the entire specified temperature range. The adapter's internal valve or poppet must prevent vapor emissions when the locking cap is removed yet must open immediately when the adapter is connected to an appropriate coupler. The adapter's internal valve or poppet must operate at a lower pressure/vacuum than the system's pressure/vacuum relief vent in order for vapors to flow as designed instead of exiting to the atmosphere through the vent piping. Provide a locking cap with each adapter. Cap must mate with the adapter and have a latching mechanism that provides a watertight seal. Cap must provide some type of locking provision and be easily attachable and removable. Cap must be attached to the tight-fit vapor recovery adapter by a minimum 12-inch section of brass cable or fuel resistant rope.

2.17.5 Dry Break Coupler

API RP 1004 coupler must be compatible with the connecting adaptor. Coupler must provide a positive, leakproof connection when under constant or surge fuel flow. Coupler must prevent vapor emissions during fuel flow. Seals within the coupler must be Buna-N or Viton. Coupler must have an internal, manually operated shutoff valve. The valve must have an external operating handle with the valve's position (open or closed) clearly labeled. The internal valve must not be capable of being manually opened unless the coupler is properly connected to its connecting adapter. After connecting coupler and adapter, opening of the coupler valve must in turn open the poppet of the adjoining adapter to allow fuel flow.

2.17.6 Quick Disconnect Coupler

Coupler must be the quick disconnect, cam type that conforms to CID A-A-59326.[Provide coupler with a stainless steel dust plug and a stainless steel hanging eye for truck offloading systems.]

2.18 FILTER/SEPARATOR

Provide filter/separator as specified in Section 33 52 43.28 FILTER SEPARATOR, AVIATION FUELING SYSTEM.

2.19 HIGH POINT VENT AND LOW POINT DRAIN PITS

2.19.1 Pit Assembly

Each pit must incorporate the following items built into a self-contained assembly.

2.19.2 Pit

The basic pit must consist of 0.25-inch wall fiberglass liner with a main body approximately 23-inches in diameter and a minimum of 37-inches deep. The pit must contain two integral concrete anchors. The fiberglass top flange must require no exposed corrosive material, weldments, or strongbacks within the pit to support the cast aluminum ring and cover assembly. The pits must be the standard products of a firm regularly engaged in the manufacture of such product and must essentially duplicate items that have been in satisfactory use for at least three years prior to bid opening. Proof of experience will be submitted.

2.19.3 Pit Cover, General Requirements

The pit cover must include a removable outer ring frame and an interior 18-inch diameter (clear opening) hinged lid that opens 160 degrees.[The pit must have a tamperproof cover. The removable outer ring must have anchors to provide for means to secure the manhole and its moveable cover and lid to the "concrete" fiberglass containment. The inner hinged lid must have a means of being locked.] Each cover lid must move smoothly through its entire range of motion and must require a maximum opening force of 35 pound-force to be applied at a single lifting handle. Each handle must provide a comfortable, secure grip for an average adult male's full gloved hand. Tools must not be required to engage the lifting handle. Projections of the lid's hinges or handles above the plane of the lid, whether temporary or permanent, must not be allowed. The pit service must be integrally cast in raised letters on the top surface of each lid. The lettering must be a minimum of one-inch high and 0.0625-inch deep. The weight bearing flanges of the fiberglass pit liner and the aluminum cover frame (and lid) must be machined to assure uniform weight distribution.

2.19.4 Pit Cover Materials, Design, and Testing

The cover frames and lids must be designed and manufactured by a qualified company having a minimum of five years successful experience in the production of similar airport apron slab fixtures. All cover lids and frames must be designed using an appropriate cast aluminum alloy or rolled aluminum plate to support an aircraft wheel load simulated by a roving 200,000-pound test-load applied perpendicular to a 200-square-inch contact area(10 by 20 inches) of the cover's top surface. The aluminum alloy material selected for design must be ductile, corrosion-resistant, impact-resistant, and suitable for the intended use. All covers must be non-skid surface construction and free of injurious defects. Welding for the purpose of structural repair of casting defects must not be allowed. Minor cosmetic welding is acceptable. The cover must be capable of supporting the test-load without failure regardless of the location or orientation of the load. Localized yielding or cracking or excessive deformations must be considered as failure. Actual load-tests must be performed on a minimum of 10 percent of all the covers supplied. Load-tested units must be randomly selected. Load-test conditions must model field-installed conditions as nearly as practicable. The 200 Kip test-load must be applied to the cover for a minimum duration of 5-minutes. Absolute maximum deflection of the cover lid under the test-load must not exceed 1/180th of the interior diameter of the fiberglass pit body. Maximum deflection of the cover lids, remaining after removal of the test load must be plus 0.010-inches to assure that no permanent set has taken place. Upon removal of the test-load, the cover lid and frame must be carefully examined for cracks or localized areas of permanent deformation. All results must be submitted for review and approval. A single failure to meet any of the stated criteria must be considered sufficient grounds for the testing of 50 percent of the units.

2.19.5 Pipe Riser Seal

The riser pipe penetration through the pit floor must be sealed by means of a Buna-N boot. The boot must be secured to a metal collar welded to the pipe riser and to a flange at the floor opening by stainless steel clamps. Collar must be fabricated from the same material as the pipe.

2.20 FRP CONTAINMENT SUMP

Sump must be constructed of fiberglass reinforced plastic (FRP) that is chemically compatible with the fuels to be handled. Do not connect sump in any way to the manway cover or concrete above. Cap the top of each containment sump with a [friction fit] [watertight] access cover. Construct cover of the same material as the sump. Cover must have a minimum diameter of 22-inches. Cover must be easily removable through the manway above.

a. Rainfall drainage must not drain into a sump. Sump must be capable of withstanding underground burial loads to be encountered. Container must have a minimum 5 gal fuel storage capacity. Container must not contain any type of drain.

b. The sides of a containment sump must allow the penetration of carrier pipes, exterior containment pipes, conduits, and vapor pipes as required. Boot or seal penetrations in the containment sump sides to ensure that liquid will not escape from the sump in the event that the liquid level within the sump rises above the pipe penetration. Provide boots and seals that are chemically compatible with the fuel to be handled and that are water resistant to the influx of ground water. Boots and seals must be designed and installed to accommodate the anticipated amount of thermal expansion and contraction in the piping system.

2.21 LIQUID LEVEL GAUGE

Gauge must be the factory fabricated, sight glass assembly type designed to allow visual observation of liquid levels within a vessel. Assembly must include a 1/2-inch [glass] [fully shielded glass] tube, a ball check in both the upper and lower fittings, a shutoff valve in both the upper and lower fittings, guard rods, and a blowoff cock in the lower fitting. Gauge's body must be constructed of stainless steel.[The gauge must contain a colored density sensitive ball.]

2.22 OPERATING TANK LEVEL INDICATOR

The level indicating system must perform tank gauging and have local tank readout. The level indicating system must use a servo to measure all the various locations required for the primary measurement. The level indicating system must be able to measure and compute fuel level, fuel density, fuel actual volume, fuel and water corrected volume, and fuel ambient temperature. The reference point for all level measurements must be from the tank's datum plate. The servo system must attach to the tank's [8] [10] [12] inch riser/[10-inch] stilling well to minimize the effects of turbulence on the measurements and still allow the government access to take quality control samples. The level indicating system must be able to measure in underground, aboveground and cut and cover tanks with all floor and roof types. The level indicating system must be able to measure multiple tanks with a single field interface unit. The level indicating system must be able to determine whether the tank is issuing or receiving fuel while in the transfer mode. The level indicating system must require no periodic calibration after installation is complete. The level indicating system must be approved for installation in a hazardous area and certified intrinsically safe by an approved agency and provide lightning protection. The level indicating system must be able to interface with government owned information systems. The level indicating system must provide five sets of alarm outputs; high intermediate high, low, intermediate low and static tank movement alarm.

Level accuracy plus/minus 0.05-inches

Corrected volume accuracy plus/minus 0.1 percent

Density accuracy plus/minus 1 percent

Temperature accuracy plus/minus 1 degrees F

Detect water in the tank sump to a level equal to or slightly above the water draw-off pipe

[It will be an ENRAF Servo Gauge Model 854 Automatic Tank Gauging System or approved equal. Equality being determined by compatibility with the Base FAS System. The system must include an ENDRESS+HAUSER RTU 8130 and a local display similar or equal to a CP/2500. The RTU must transmit data to the Base FAS System located in the RCC via telephone lines as shown on the drawings. Base personnel must coordinate reprogramming of the FAS System to accept this new data.

]2.23 OPERATING TANK LEVEL SWITCHES

The switches must be an external mount liquid level switch with a stainless steel float chamber and stainless steel, type 304 or 316, float and trim. Switch contacts must be two single pole double throw switches factory mutual approved or U.L. listed for use in Class I, Division 1, Group D hazardous location with a maximum temperature rating of T2D (419 degrees F). Units must have provisions to check level switch operations without increasing the fuel level in the tanks as shown on the contract drawings.

2.24 OPERATING TANK LEVEL SWITCHES

a. System must be designed and installed in such a way that the system must be continuously and automatically self-checking. Switches must be an external mount with a stainless steel fluid chamber. Electronic level sensors must be thermistors or optic type, and be intrinsically safe Class I, Division 1, Group D for hazardous environments, with recognized FM, CSA or UL approval. The sensor holder/junction box must be accessible from the stairway. Units must have provisions to check level switch operations without increasing the fuel level in the tanks as shown on the contract drawings.

b. Level alarms must be mechanically and electrically independent and be totally isolated from the gauging system. The level switches must receive power and send their signal to the Pump Control Panel. Circuitry and cables from the PCP to the electronic level sensors in the tank must be intrinsically safe.

[2.25 OPERATING TANK LEVEL SWITCHES

a. System must be designed and installed in such a way that the system must be continuously and automatically self-checking. Switches must be mounted on top of the tank, in the pump house, as indicated. Electronic level sensors must be thermistors or optic type, and be intrinsically safe Class I, Division 1, Group D for hazardous environments, with recognized FM, CSA or UL approval. The sensor holder/junction box must be accessible.

b. Level alarms must be mechanically and electrically independent and be totally isolated from the gauging system. The level switches must receive power and send their signal to the Pump Control Panel. Circuitry and cables from the PCP to the electronic level sensors in the tank must be intrinsically safe.

]2.26 WATER DRAW-OFF SYSTEM

A water draw-off system must be provided for each Operating Tank. Water draw-off system must gravity drain. Each system must include tank, product return pump and all necessary pipe, pressure relief system, valves, and fittings.

2.26.1 Tank

Water draw-off tank must be a 55-gal fabricated stainless steel tank with supporting legs as shown. Tank and support legs must be fabricated from Type 304 stainless steel.

2.26.2 Sight Glass

Sight glasses for tank must be standard tubular gages with density ball and shut-off valves on each end. Wetted parts other than sight glass must be stainless steel. If glass breakage should occur, a stainless steel ball in the valve must close preventing product loss. Glass must be protected by minimum of four guard rods.

2.26.3 Return Pump

Product return pump (PRP-1 and PRP-2) must have the capacity of not less than 5 gpm against a total head of [_____] feet when driven at 3600 rpm. The pump must have flange connections and must be constructed of stainless steel or aluminum so as to have no zinc, brass or other copper bearing alloys in contact with the fuel. The unit must be explosion-proof, Class I, Division 1, Group D with maximum temperature rating of "T2D" (419 degrees F). The motor must not be overloading at any point on the pump curve. Contractor has the option of selecting either centrifugal or positive displacement type pump with the restriction of the positive displacement type pump must include a pressure relief between the discharge and suction protecting the pump from overloading.

2.26.4 Anchoring

All units of the water draw-off system must be installed plumb and level and secured in place by anchor bolts.

2.27 GROUNDING CABLE AND CLAMP

Grounding system must conform to CID A-A-50696, Type [I] [II].

[2.28 OPERATING TANK VENT

Tank vent outlet must be equipped with pressure-vacuum breather vent, aluminum construction with weather hood and with fluoroelastomer (FKM, Viton) pallet seat inserts, high density screens, stainless steel internals, with pressure relief setting at 0.5 oz psi, and vacuum relief set at 0.5 oz psi. Pressure venting capacity must be 9700 cubic feet/hour, vacuum capacity must be 14500 cubic feet/hour.

]2.29 GROUND VEHICLE FUELING SYSTEM COMPONENTS

2.29.1 Product Dispensing Unit

Unit and unit hardware must be the factory fabricated type that conforms to [UL 87][UL 87A], except as modified herein.[Unit housing and housing top must be constructed of stainless steel or aluminum in accordance with [UL 87][UL 87A].][Materials for unit components that will be in direct contact with the fuel must be stainless steel or nickel plated aluminum.] Unit must be computer controlled, lighted, [single] [double] sided, with [one] [two] [three] [four] [_____] hose outlets [each] suitable for single product delivery flow rate of 12 gallons per minute from each nozzle. Unit must be the [remote control] [self-contained] type. Unit housing must include a locking mechanism for each nozzle to allow securing each nozzle to the housing during non-operational periods.

2.29.1.1 Self-Contained Pump

Provide internal gear-type rotary suction pumps with adjustable bypass valves and suction strainers.

2.29.1.2 Accounting Meter and Display

Provide unit with positive displacement type meter and the manufacturer's standard microprocessor that has the following functions:

a. Displays: Solid state liquid crystal displays (LCD'S)[, five-digit cash display to $999.99], with automatic shutdown, and four-digit volume display to 999.9 gallons.

b. Totalizer: Eight-digit (999,999.99) electronic totalization with identification for each product volume in gallons.

[c. Price setting: Price-jog keyswitch on each computer housing to enable remote price setting from management control system.

]2.29.1.3 Filters

Provide a replaceable filter element on each product line with a nominal filtration efficiency of 5 micron or smaller porosity filters for gasoline and ethanol products, and 25 micron or smaller porosity filters for diesel and biodiesel product with a flow rating equal to the rate of the dispensing unit.

2.29.1.4 Battery Backup

Provide battery backup with automatic charging circuits to hold data for a minimum of three months without recharging. Sales display must remain visible for 15 minutes after power failure.

2.29.1.5 Interlocks

Provide nozzle supports interlocked to pump motor control switch to start and stop the pump by nozzle removal and replacement. Provide each unit with interlock switch and valve arrangement that prevents flow of product until meter is reset after dispensing nozzle is returned to holder.

2.29.1.6 Hose

Provide dispensing hose [conforming to UL 330] [of the coaxial vapor recovery type certified by the California Air Resources Board (CARB)], gasoline and oil resistant, statically grounded, flexible in sub-zero temperatures.[Hose must be compatible with E85 fuel.] Provide a minimum of [10] [12] feet of hose for each product line on the dispenser. Provide each hose with spring loaded cable to return device attached near mid-length of hose.

2.29.1.7 Nozzles

Provide manually activated, automatic shutoff type nozzles [with][without] a latch-open device. Nozzles must have full hand insulator to prevent splash-back.[Nozzles must be CARB certified for Stage II vapor recovery, contain an integral vapor valve[and evacuator], and be of the [bellows] [bellowless] design.][Vapor recovery nozzles are not required for diesel dispensing systems.]

2.29.1.8 Breakaway Device

Provide each product hose with UL listed[and CARB certified] emergency breakaway device designed to retain liquid on both sides of breakaway point. Breakaway device must have pressure balancing chamber to override line pressure to prevent nuisance breaks caused by a restriction in delivery hose diameter.

2.29.1.9 Emergency Shutoff Valve

Provide valve that conforms to UL 842. Valve must provide complete shutoff of a fuel line in the event a dispenser is dislocated or overturned due to a sudden impact. Valve must include a secondary poppet to limit spillage from the dispenser after a knockdown or during installation.

2.29.1.10 Dispenser Sump

Provide a sump under each dispensing unit. Each sump must provide convenient service access to piping components enclosed in the sump. Sump must be constructed of fiberglass-reinforced plastic. Sump must be chemically compatible with the fuel to be handled by the dispensing unit and any connecting piping. Sump must prevent fuel from escaping to the soil and ground water from entering the sump. Sump must provide a liquidtight termination point for secondary containment piping that allows for the anticipated expansion and contraction of the piping system. Sump must withstand maximum burial loads. Sump must mount directly to the bottom of the dispensing unit with a centering ring or stabilizer bar to assure proper shearing action for the emergency shutoff valve.

2.29.1.11 Accessories

Equip each assembly with accessories such as built-in air eliminators, line check valves, and lockable housing.

2.29.2 Management Control System

Provide management control system that furnishes computerized control of station fuel dispensing system including operational, control, and management functions from a central control console with displays and separately mounted electronics and data cabinets. Provide functions to provide receipt and report printout types.

2.29.2.1 Operating Functions

System must operate up to [_____] fueling positions with up to [_____] different products. System must operate prepay on preset volume or dollar operation. System must display grade, dispenser number, volume, and sales amount in one sequence. Provide audible signals and flashing indicators to alert operator to customer needs and dispenser status. Provide functions to calculate change if tank is too full to accept prepaid amount.

2.29.2.2 Control and Management Functions

System must accumulate, store, and deliver full range of management information including pricing by grades and types of service. System must provide totals for up to four shifts by product volume, cash and credit sales, and declining balance inventory.

2.29.2.3 Control Console

System must provide the following:

a. Indicators: Call, ready, in-use, used, stopped, unpaid

b. Manager's keyswitch: Key protection for setting operating modes

c. Keyboard: Standard international 11-pad numerical

d. Clock: Real-time operating, showing year, month, day, hour, minute, second

e. Function keys: Pump stop, pump start, mode, unit price, refund, recall, cash/credit, volume, print/enter, clear, credit paid, cash paid, authorize

2.29.2.4 Display

System must provide the following with light emitting diodes (LED'S):

a. Operating: Grade, pump number, volume, cash

b. Mode or memory: Mode number, sub-mode, memory data

c. Display indicators: Water, low inventory, new data, mode, prepay/preset, volume, cash, credit, return, price

2.29.2.5 Power

System must operate at 115 volts, 60 hertz.

2.29.3 Receipt and Totals Printer

Provide printer with the following characteristics:

a. Minimum print speed: 1.25 lines per second

b. Line length: 40 column, 12 characters per inch

c. Paper: Roll, one- or two-ply, 3-3/8 inches wide

d. Spacing: 6 lines per vertical inch

e. Character types: Upper and lower case, 96-character alpha-numeric, normal and double-width

f. Printing mechanism life: 10 million cycles

g. Power: 115 volts, 60 Hz

2.29.3.1 Customer Receipt

Configure printer and system functions to print the following customer receipts.

a. Time, date, and day of week

b. Name and grade of fuel product

c. Pump number and unit price

d. Total sale by payment method (cash or credit)

e. Total sales volume in gallons or liters

f. Prepaid deposit

g. Discount amount where applicable

h. Transaction number

i. Three line customizable heading

j. Customer receipt available only after dispensing

2.29.3.2 Shift Change Totals

Configure printer and system functions to print the dollar and volume totals and totalizer readings for current, first, second, and third shift totals.

2.29.3.3 Unit Price Summary

Configure printer and system functions to print the dollar and volume totals and totalizer readings for current, first, second, and third shift totals.

2.29.3.4 Station Programming Data

Configure printer and system functions to print the list parameters that determine which station dispensing system will operate.

a. Prepay or post pay

b. Cash or credit pricing

c. Sales and volume ration limits

2.29.3.5 Diagnostic Messages

Include printer test, last mode entries, system power ON/OFF records, and other information for diagnosing problems by station personnel.

2.30 VALVE AND SYSTEM COMPONENTS EXTERIOR PROTECTIVE COATINGS

2.30.1 Factory Coating

Valves, system components, and components must be blasted clean according to SSPC SP 5/NACE No. 1, and must be primed and coated in accordance with Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURES.

2.30.2 Field Coating

Painting required for surfaces not otherwise specified must be field painted as specified in Section 09 97 13.27 HIGH PERFORMANCE COATING FOR STEEL STRUCTURES. Do not paint aboveground stainless steel and aluminum surfaces. Do not coat system components or components provided with a complete factory coating. Prior to any field painting, clean surfaces to remove dust, dirt, rust, oil, and grease.

PART 3 EXECUTION

3.1 GENERAL

3.1.1 Installation

Install equipment and components in position, true to line, level and plumb, and measured from established benchmarks or reference points. Follow manufacturer's recommended practices for system components installation. Provide required clearances between equipment components, system components, apparatus, and accessories requiring normal servicing or maintenance to be accessible.

3.1.2 Anchoring

Anchor system components in place. Check alignment of anchor bolts before installing system components and clean-out associated sleeves. Do not cut bolts because of misalignment. Notify Contracting Officer of errors and obtain the Contracting Officer's acceptance before proceeding with corrections. Cut anchor bolts of excess length to the appropriate length without damage to threads. Where anchor bolts or like devices have not been installed, provide appropriate self-drilling type anchors for construction condition.

3.1.3 Grouting

System components which are anchored to a pad is to be grouted in place. Before setting system components in place and before placing grout, clean surfaces to be in contact with grout, including fasteners and sleeves. Remove standing water, debris, oil, rust, and coatings which impair bond. Clean contaminated concrete by grinding. Clean metal surfaces of mill scale and rust by hand or power tool methods. Provide necessary formwork for placing and retaining grout. Grout to be non-metallic, non-shrink, fluid precision grout of a hydraulic cementitious system with graded and processed silica aggregate, Portland cement, shrinkage compensating agents, plasticizing and water reducing agents; free of aluminum powder agents, oxidizing agents and inorganic accelerators, including chlorides; proportioned, pre-mixed and packaged at factory with only the addition of water required at the project site. Grouting must be in accordance with ASTM C827/C827M. Perform all grouting in accordance with system components manufacturer's and grout manufacturer's published specifications and recommendations.

3.1.4 Leveling and Aligning

Level and align system components in accordance with respective manufacturer's published data. Do not use anchor bolt, jack-nuts or wedges to support, level or align system components. Install only flat shims for leveling system components. Place shims to fully support system components. Wedging is not permitted. Shims to be fabricated flat carbon steel units of surface configuration and area not less than system components bearing surface. Shims to provide for full system components support. Shim to have smooth surfaces and edges, free from burrs and slivers. Flame or electrode cut edges not acceptable.

3.1.5 Direct Drives

Alignment procedure follows:

3.1.5.1 Rotation Direction and Speed

Check and correct drive shaft rotation direction and speed.

3.1.5.2 End Play

Run drive shafts at operational speed. Determine whether axial end play exists. Run drive shaft at operational speed and mark drive shaft axial position when end play exists. Block drive shaft in operating position when aligning drive shaft with driven shaft.

3.1.5.3 Shaft Leveling and Radial Alignment

Pump alignment must be accomplished by the factory technician or a millwright trained in pump alignment, and with the use of dial gauges or laser alignment equipment.

3.1.5.4 Angular Alignment and End Clearance

Check angular alignment and end clearance by inserting a feeler gage at 4 points, 90 degrees apart around outer edges of coupling halves.

3.1.5.5 Final Recheck

Check adjustments with dial indicator after completing recheck. Align shafts within 0.001-inch tolerance, except as other-wise required by more stringent requirements of system components manufacturer.

3.1.6 Precautions

Special care must be taken to ensure that system components and materials are stored properly to prevent damage and maintain cleanliness, and that the completed system is free of rocks, sand, dirt, and foreign objects.

Take the following steps to insure these conditions.

a. System components brought to the site and not stored inside, must be stored on blocks or horses at least 18-inches above ground.

b. Visual inspection must be made of each piece of system components to ensure that it is clean prior to installation.

c. The open ends of system components must be closed when work with that piece of system components is not in progress.

3.2 INSTALLATION OF UNDERGROUND TANKS

Installation must be per tank manufacturer's recommendations, API RP 1615, NFPA 30, 40 CFR 280, state and local codes and as specified herein. If recommendations require tank to be filled, only fuel will be allowed in tanks. Water filling is not acceptable. Before being placed in service, tank must be tightness tested in accordance with NFPA 30.

3.2.1 Coating Testing

The coating must be examined for flaws and tested for thickness. Provide the facilities, personnel, and equipment for testing for flaws and thickness. Thickness must be measured electronically. Coating must be tested directly before placement of the tank with an electric flaw detector, equipped with a bell, buzzer, or other type of audible signal that operates when a flaw is detected. The detector for the type of coating used must have an operating voltage of 10,000 to 35,000 volts. Check of the holiday detector potential may be made by the Contracting Officer at any time to determine the suitability of the detector. Damaged areas must be repaired with materials identical to those used originally, and after drying, must be retested electrically. Submit test results.

3.2.2 Steel Tanks

a. Cover the concrete hold down slab with 6-inches of tank bedding backfill evenly graded and thoroughly compacted, prior to tank placement.

b. Each tank is to be unloaded and placed on the sand bed using cranes and the rigging procedures provided by the tank manufacturer. Use the tank lifting lugs for lifting the tank into place. The use of slings around the tank is not permitted, nor is the use of chock blocks of any sort. During handling, carefully inspect the tanks for coating damage and repair any damage whatsoever before proceeding. After placement, check each tank to ensure it is sloped as required. The elevation must be confirmed.

c. Before proceeding with backfill, install the hold down straps and tighten the turnbuckles securely and evenly throughout the length of the tanks. The bottom and sides of the tanks to be fully and evenly supported by hand shoveling and tamping. Use tank bedding backfill up to 12-inches above the top of tank. Hand-guided power equipment can be used to place fill in 6-inch layers, compacted to a minimum of 95 percent maximum density, after the bottom quadrant is filled. A minimum of four density tests per tank to be performed. Clean, noncorrosive, well tamped gravel to be used for backfill from a point 12-inches above the tanks to finished grade.

d. Do not fill the tank, even partially, before the bottom quadrant is backfilled. The level of fuel product not to exceed the level of compacted backfill at any time.

e. Coordinate tank installation with the installation of cathodic protection.

3.3 INSTALLATION OF FIBERGLASS PITS

Submit recommended installation procedures and setting tolerances from the pit manufacturer/supplier for the fiberglass pit and the aluminum cover. These procedures must indicate recommended methods of supporting the pit in its proper position in the open excavation prior to and during concrete placement operations. Also, required installation tolerances, especially for flatness/levelness of the fiberglass pit lip, must be provided. Follow these recommendations and apply other procedures as required to ensure the integrity of the pit liner and cover assemblies in their installed positions. All penetrations through the fiberglass pit liner must be tightly sealed by suitable means to preclude water infiltration, with consideration for potential relative movements between the penetrating objects and the pit liner. Reference the Contract drawings for additional installation requirements.

3.4 VEHICLE DISPENSING UNIT

Following installation, fill island riser holes with clean sand. Install emergency shut-off valves with breaking point level with island surface. Isolate dispensing units from piping during flushing and cleaning operations.

3.5 POSTED OPERATING INSTRUCTIONS

For each designated system or system components item, provide instructions for guidance of operating and maintenance personnel. Following approval of content, prepare these instructions in a form and scale that will be readily legible when displayed in appropriate locations, to be designated by the Contracting Officer and meet the following requirements:

3.5.1 Each System

For each system, include diagrams of system components, piping, wiring and control. Define control sequences.

3.5.2 Each Tank

For each tank provide a P.E. stamped certified tank calibration chart in 1/16-inch increments reading in gallons, except for tanks less than 5,000 gallons.

3.5.3 Each Item

For each system components item, include starting, adjustment, operation, lubrication, safety precautions and shut-down procedures. Identify procedures to be performed in event of system components failure. Provide other instructions recommended by the manufacturer.

3.5.4 Diagrams

Provide a professionally prepared isometric piping diagram of the fueling system apparatus. Diagram must be 36 by 54 inches and must be color coded to match PCP color diagrams. Diagram must show the entire facility and must include all system components and the operational sequences of all system components with equipment numbers displayed. Diagram must show all valves along with the valve numbers shown on the drawings and listed as normally open/closed. It must be wall mounted under glass.

3.5.5 Volume of Fuel

Provide a certified system inventory of fuel in the pipe, tank, pumphouse, etc. The piping will show length of pipe, size of pipe, gal/foot, and total gal. Verify during initial fill.

3.6 DEMONSTRATIONS

Conduct a training session for designated Government personnel in the operation and maintenance procedures related to the system components/systems specified herein. Include pertinent safety operational procedures in the session as well as physical demonstrations of the routine maintenance operations. Furnish instructors who are familiar with the installation/system components/systems, both operational and practical theories, and associated routine maintenance procedures. The training session must consist of a total of [_____] hours of normal working time and must start after the system is functionally completed, but prior to final system acceptance. Submit a letter, at least 14 working days prior to the proposed training date, scheduling a proposed date for conducting the on-site training.

-- End of Section --

SECTION 33 60 02

ABOVEGROUND HEAT DISTRIBUTION SYSTEM
04/08

PART 1 GENERAL

1.1 SUMMARY

This specification covers the furnishing of materials for and the installation of an insulated aboveground heat distribution system. The contract drawings show the arrangement of piping, supports and the routing of the heat distribution system. Other details, such as sizes of piping, location of expansion loops, location of valves and items of equipment, are also shown on the contract drawings. This specification covers the installation of the system 6 inches into the building which it serves.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS ANSI O5.1	(2017) Wood Poles -- Specifications & Dimensions

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B31.1	(2020) Power Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA P5	(2015) Standard for Waterborne Preservatives

AWPA U1	(2022) Use Category System: User Specification for Treated Wood

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A475	(2022) Standard Specification for Metallic-Coated Steel Wire Strand
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B650	(1995; R 2018) Standard Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
ASTM C195	(2007; R 2013) Standard Specification for Mineral Fiber Thermal Insulating Cement
ASTM C449	(2007; R 2013) Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C547	(2019) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2022) Standard Specification for Cellular Glass Thermal Insulation
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F1139	(1988; R 2019) Steam Traps and Drains

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2015) (10th Ed) EJMA Standards

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-45	(2020) Bypass and Drain Connections
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	(2014) Class 3000 Steel Pipe Unions Socket Welding and Threaded

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Materials and Equipment

SD-03 Product Data

Materials and Equipment; G[, [_____]]

Procedures and Welders

SD-04 Samples

Insulation Systems

SD-10 Operation and Maintenance Data

Distribution System; G[, [_____]]

1.4 QUALITY ASSURANCE

[Weld piping in accordance with qualified procedures using performance qualified welders and welding operators. Qualify procedures and welders in accordance with ASME BPVC SEC IX. Submit [_____] copies of qualified procedures and lists of names and identification symbols of qualified welders and welding operators, prior to welding operations. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify Contracting Officer 24 hours in advance of tests to be performed at the work site, if possible. The welder or welding operator shall apply the personally assigned symbol near each weld made as a permanent record. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] [Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING.]

1.5 DELIVERY, STORAGE, AND HANDLING

After delivery to the jobsite, protect materials and equipment from anything which could cause damage to the material or equipment. Seal pipe at each end to keep the interior clean and free of dirt and debris. Keep fittings together with their interior surfaces clean at all times. Keep all stored insulation dry and clean.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of manufacturers regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use at least 2 years prior to bid opening. Submit complete fabrication and assembly drawings for all parts of the work in sufficient detail to check conformity with the requirements of the contract documents. The proposed layout for the aboveground heat distribution system, including provisions for pipe expansion, pipe anchors and guides, and supports shall be shown in plan views and pipe profile elevations. Include data composed of catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope, details and calculations, with expansion stress calculations, required to demonstrate that the system has been coordinated and will properly function as a unit. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2 PIPING

2.2.1 General

Unless otherwise specified, steel pipe, fittings, valves, and piping accessories shall conform to the requirements of ASME B31.1, and shall be suitable for [the indicated pressure and temperature requirements] [_____]. Joints for ferrous piping shall be welded, except that joints 3/4 inches and smaller may be threaded. High temperature hot water system threaded joints shall be seal welded. Pipe shall be seamless or electric resistance welded conforming to ASTM A53/A53M or ASTM A106/A106M, Grade B. Steel pipe 1-1/2 inches in diameter and smaller shall be seamless conforming to ASTM A106/A106M, Grade B.

2.2.2 Supply Pipe

[Steam] [High temperature hot water] [High temperature hot water return]

[Steam and high temperature hot water] pipes shall be black steel Schedule 40 with plain end beveled. Nominal pipe sizes 1 inch and below shall be Schedule 80.

2.2.3 Condensate Return Pipes

Condensate return pipes shall be black steel, Schedule 80 with plain end beveled.

2.2.4 Drip, Vent, Relief, and Gauge Pipe

Drip, vent, relief, and gauge connecting pipe and threaded pipe shall be black steel, Schedule 80.

2.3 FITTINGS

2.3.1 Threaded Fittings

Threaded fittings shall conform to the requirements of ASME B16.11, Pressure Class 3000.

2.3.2 Unions

Unions shall conform to the requirements of MSS SP-83.

2.3.3 Welding Fittings

Welding fittings shall conform to the requirements of ASTM A105/A105M/ or ASTM A234/A234M. Welding fittings shall also conform to ASME B16.9 for buttweld fittings and ASME B16.11 for socket-weld fittings. Long radius buttwelding elbows conforming to ASME B16.9 shall be used whenever space permits.

2.3.4 Pipe Threads

Pipe threads shall conform to ASME B1.20.1. Pipe to be threaded shall be Schedule 80.

2.4 VALVES

2.4.1 General

Unless otherwise specified, ferrous and nonferrous valves shall meet the material, fabrication and operating requirements of ASME B31.1. Valves furnished shall be suitable for the temperature and pressure requirements of the system on which they are to be installed. Valves for [steam] [hot water] shall conform to ASME B31.1 Class [150] [and] [or] [300] as suitable for the application. [Valves for condensate services shall conform to ASME B31.1 Class 150.] Valves 6 inches and larger shall have a 1 inch minimum gate or globe [integral] bypass valve sized in conformance with MSS SP-45. Valves shall have the manufacturer's trademark.

2.4.2 Bronze Valves

2.4.2.1 Globe, Gate and Angle Valves

Globe, gate and angle valves shall conform to the requirements of MSS SP-80.

2.4.2.2 Check Valves

Check valves shall conform to the requirements of MSS SP-80.

2.4.3 Steel Valves

Steel globe, gate, angle and check valves shall conform to the requirements of ASME B16.34 and ASME B31.1 for the temperature and pressure requirements of the system.

2.4.4 Packing

Packing used with valves shall not contain asbestos. Valve stem packing shall be die-formed, ring type specifically designated as suitable for the temperature and pressure of the service and compatible with the fluid in the system. Packing rings shall be polytetrafluoroethylene with minimum 50 percent graphite filament top and bottom rings. Valves 1-1/2 inches and smaller shall have 4 or 5 packing rings, and valves 2 inches and larger shall have at least 6 packing rings. Spiral or continuous packing will not be acceptable. A metal insert shall be provided having proper clearance around the valve stem at the bottom of the stuffing box and acting as a base for the packing material. Packing glands shall be furnished with a liner of noncorrosive material and shall be of 1 piece construction with provisions for not less than 2 bolts for packing adjustment.

2.5 STEAM TRAPS

2.5.1 General

Class of trap bodies shall be suitable for a working pressure of not less than 1.5 times the steam supply pressure, but not less than 200 psi, and traps shall be capable of operation under a steam-supply pressure as indicated. Traps shall have capacities as shown when operating under the specified working conditions. Traps shall fail open.

2.5.2 Bucket Traps

Bucket traps shall be an inverted-bucket type with automatic air discharge conforming to the requirements of ASTM F1139.

2.5.3 Thermostatic Traps

Traps shall be thermostatic type, bimetallic element with automatic air discharge conforming to ASTM F1139.

2.6 STRAINERS

Basket or Y-type strainer body connections shall be the same size as the pipelines in which the strainers are installed. The strainer bodies for steam systems shall be heavy and durable, of cast steel, with bottoms drilled and plugged. The strainers shall be suitable for the temperature and pressure requirements of the system on which they are installed. The bodies shall have arrows clearly cast on the sides to indicate the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment basket. The body or bottom opening shall be equipped with nipple and gate valve for blowdown. The basket for steam systems shall be not less than 0.025 inch thick stainless steel, Monel or sheet brass, with small perforations of sufficient number to provide a net free area through the basket of at least 2.5 times that of the entering pipe. The flow shall be into the basket and out through the perforations.

For high temperature hot water systems, only cast steel bodies and stainless or Monel baskets shall be used.

2.7 ABOVEGROUND PIPE SUPPORTS

2.7.1 Concrete

Concrete used in the formation of poles or foundation for the supports shall conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.7.2 Steel

Steel used as support members or as part of the pipe support structure shall conform to the requirements of Section 05 12 00 STRUCTURAL STEEL. To the maximum extent possible, the pipe supports shall be hot-dipped galvanized after they have been fabricated.

2.7.3 Wood Poles and Lumber

Wood poles shall conform to the requirements of ATIS ANSI O5.1, Class 3, treated southern pine, machine trimmed to a smooth surface, free of crooks or sweeps exceeding 1 inch per 10 feet of pole length, and bored, gained and roofed before treatment. Wood poles shall be pressure treated with nonleaching water-borne preservative, ACA or CCA conforming to AWPA P5. Treatment shall be in accordance with AWPA U1. Poles shall be furnished with pole caps. Lumber shall be No. 1 dense stress grade southern pine, pressure treated with nonleaching water-borne preservative, ACA or CCA conforming to AWPA P5. Treatment shall be in accordance with AWPA U1.

2.7.4 Accessories

The following accessories shall be furnished as needed to support the poles and/or to maintain the alignment of the aboveground structure. Materials shall have a hot-dipped galvanized finish.

2.7.4.1 Guy Wires

Guy wires shall conform to the requirements of ASTM A475, extra high strength grade, extra galvanized, stranded with 7 or 19 wires in each strand. Thimbles shall be provided at each end of guy wires.

2.7.4.2 Anchor Rods

Anchor rods shall be 1-1/4 inch diameter threaded rod with oval eye.

2.7.4.3 Screw Anchors

Screw anchors shall be 10 inch diameter.

2.7.4.4 Turnbuckles

Turnbuckles shall be the open type, forged body, with jaw and jaw end pulls, 3/8 inch size and hot-dipped galvanized.

2.7.4.5 Clamps

Clamps shall be forged high carbon steel fitted with galvanized heat treated bolts of best commercial grade. Clamps shall be capable of developing full strength of the guy wire. Two clamps at each connection of the guy wire shall be provided.

2.8 INSULATION SYSTEMS

Display sample sections for insulation of pipe, elbow, tee, valve, support point, and terminating points. After approval of materials and prior to insulation of piping, prepare a display of insulated sections showing compliance with specifications, including fastening, sealing, jacketing, straps, waterproofing, supports, hangers, anchors, and saddles. Keep approved display sample sections on display at the jobsite during the construction period until no longer needed by Contracting Officer, then remove.

2.8.1 Insulation

Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING. Insulation for piping, fittings, and valves shall be molded mineral fiber insulation conforming to the requirements of ASTM C547, Class 2, asbestos free, molded calcium silicate conforming to the requirements of ASTM C533, Type I, asbestos free or cellular glass insulation conforming to ASTM C552. The thickness of insulation used on aboveground piping shall be as shown in Tables 1 and 2.

TABLE 1
Minimum Pipe Insulation Thickness (inches)

For steam up to 250 psig and high temperature hot water supply and return piping up to 450 degrees F

Nominal Pipe Diameter (inches)	Insulation Thermal Conductivity (k)		
	k less than 0.29	k from 0.29 to 0.40	k greater than 0.40
1.0	2.0	2.5	4.0
1.5	2.0	2.5	4.0
2.0	2.5	3.5	4.5
2.5	2.5	3.5	4.5
3.0	3.0	4.0	5.0
4.0	3.0	4.0	5.0
5.0	3.0	4.0	5.0
6.0	3.5	4.5	5.5
8.0	3.5	4.5	5.5
10.0	4.0	5.0	6.0
12.0	4.0	5.0	6.0
14.0	4.0	5.0	6.0

TABLE 1 Minimum Pipe Insulation Thickness (inches)			
For steam up to 250 psig and high temperature hot water supply and return piping up to 450 degrees F			
16.0	4.0	5.0	6.0
18.0	4.0	5.0	6.0
NOTE: Insulation thermal conductivity (k-value) is in units of Btu-inches/hour-square-feet-degrees F at 200 degrees F mean temperature.			

TABLE 2 Minimum Pipe Insulation Thickness (inches)			
For Low Pressure Steam (less than 16 psig), Condensate Return and Low Temperature Hot Water (less than 250 degrees F) supply and return piping.			
Nominal Pipe Diameter (inches)	Insulation Thermal Conductivity (k)		
	k less than 0.29	k from 0.29 to 0.40	k greater than 0.40
1.0	1.5	2.0	3.0
1.5	1.5	2.0	3.0
2.0	1.5	2.0	3.0
2.5	1.5	2.0	3.0
3.0	2.0	2.5	3.5
4.0	2.0	2.5	3.5
5.0	2.0	2.5	3.5
6.0	2.5	3.0	4.5
8.0	2.5	3.0	4.5
10.0	3.0	4.0	5.0
12.0	3.0	4.0	5.0
14.0	3.0	4.0	5.0
16.0	3.0	4.0	5.0
18.0	3.0	4.0	5.0

TABLE 2 Minimum Pipe Insulation Thickness (inches)
For Low Pressure Steam (less than 16 psig), Condensate Return and Low Temperature Hot Water (less than 250 degrees F) supply and return piping.
NOTE: Insulation thermal conductivity (k-value) is in units of Btu-inches/hour-square-feet-degrees F at 200 degrees F mean temperature.

2.8.2 Insulation Jackets

2.8.2.1 Nonmetallic Jackets

Nonmetallic jacketing shall consist of a 6 ounces per square yard fiberglass fabric impregnated with chlorosulfonated polyethylene (Hypalon) and a 1.5 mil polyvinyl fluoride film (Tedlar) bonded to it. Overall thickness of the composite shall be 0.010 inch and weigh approximately 10.5 ounces per square yard. Jackets may be either field or factory applied to the insulation. Nonmetallic jackets shall be used with molded mineral fiber insulation.

2.8.2.2 Aluminum Jackets

Aluminum jackets shall be smooth sheet and shall meet the requirements of ASTM B209, Alloys 3003, 3105 or 5005. Aluminum jackets shall be not less than 0.016 inch thick and shall be secured with aluminum or Type 304 annealed stainless steel securing bands. Securing bands shall be at least 1/2 inch wide for jackets with less than a 20 inch circumference and 3/4 inch wide for jacket circumferences 20 inches and greater. The jacket may, at the option of the Contractor, be provided with a factory fabricated "Pittsburg" or "Z" type longitudinal joint. When the "Z" joint is used, the circumferential joints shall be designed by the manufacturer to seal the joints and hold the jacket in place. The jacket shall be supplied with a factory installed moisture barrier. This moisture barrier shall consist of at least 40 pound kraft paper coated on 1 side with a 1 mil polyethylene film. The moisture barrier shall be adhered to the aluminum jacket over 100 percent of the aluminum jacket surface. Jacket may be either field or factory applied to the insulation. Aluminum jackets shall be used with calcium silicate insulation.

2.8.3 Finishing Materials

2.8.3.1 Wire

Wire used to secure the insulation prior to the installation of the jacket shall be [soft annealed Type 302, 304 or 316 stainless steel, 16 or 18 gauge] [soft annealed galvanized, 16 gauge].

2.8.3.2 Staples

Staples shall be the outward clinching type [made of monel] [conforming to the requirements of ASTM A167, Type 304 or 316].

2.8.3.3 Insulating and Finishing Cement

Mineral fiber hydraulic-setting thermal insulating and finishing cement shall conform to the requirements of ASTM C449.

2.8.3.4 Glass Tape

Glass tape shall meet the requirements of UL 723 and ASTM E84. There shall be no distortion of the tape when a sample 24 inches in length is spread across a flat horizontal surface and observed for evidence of distortion (such as tendency to curl rather than lie flat). The width tolerance is plus or minus 1/8 inch.

2.8.3.4.1 Plain Weave, Untreated

The ends shall be properly interlocked with the picks to ensure that there is no raveling of the tape edges. It shall have an average weight of 5.8 ounces per square yard, plus or minus 10 percent. An average thickness of 0.007 inches plus or minus 0.001 inches, warp ends/wales of 42 plus or minus 2 per inch or filling picks/courses of 32 plus or minus 2 per inch, a minimum breaking strength of 150 pounds per inch of width, and after heating to 900 degrees F for 2 hours, a minimum breaking strength of 40 pounds per inch of width.

2.8.3.4.2 Knitted, Untreated

The wales shall be properly interlocked with the courses to ensure that there is no raveling of the tape edges. It shall have an average weight of 4.5 ounces per square yard, plus or minus 10 percent. An average thickness of 0.007 inches plus or minus 0.001 inches, warp ends/wales of 16 plus or minus 2 per inch. A minimum breaking strength of 40 pounds per inch of width, and after heating to 900 degrees F for 2 hours, a minimum breaking strength of 21 pounds per inch of width.

2.8.3.4.3 Open-Weave Type

Tape shall be open-weave type and shall have an average weight of [_____] ounce per square yard and shall be used for embedding between coats of adhesive or coating materials.

2.8.3.5 Glass Cloth

Glass cloth shall be an untreated light weight satin weave. It shall be woven with an 8-harness satin weave and shall be fabricated from fibrous glass yarn. The yarn shall be made from low twist continuous filament glass fiber. The maximum average diameter of the glass fibers used for the yarns shall not exceed 0.000299 inch. The cloth shall meet the requirements of UL 723 and the following properties:

a. Average weight 8.9 ounces/square yard.

b. Fabric count-warp 57 yarns/inch ends.

c. Filling picks 54 yarns/inch.

d. Minimum breaking strength:

   (1) Warp 200 lb/inch.
   (2) Filling 180 lb/inch.

e. After heating to 900 degrees F for 2 hours:

   (1) Warp 60 lb/inch.

(2) Filling 60 lb/inch.

f. Nominal width of the cloth shall be [_____] feet with the following tolerances:

(1) Up to and including 40 inches, tolerance of plus or minus 1/2 inch.

(2) Over 40 inches and less than 60 inches, tolerance of plus or minus 3/4 inch.

(3) Over 60 inches, tolerance of plus or minus 1 inch.

g. The cloth shall be furnished in 50 yard, plus or minus 5 yard rolls. The minimum length in a spliced roll shall be 4 yards, and a spliced roll shall contain no more than 3 pieces for each 50 yard length. Open-weave type of [_____] ounce per square yard may be used for embedding between coats of adhesive or coating materials.

2.8.4 Adhesives

2.8.4.1 Mineral Fiber Insulation Cement

Cement shall be in accordance with ASTM C195.

2.8.4.2 Contact Adhesive

Contact adhesive may be dispersed in a non-halogenated organic solvent with a low flash point (flash point less than 25 degrees F) or, dispersed in a nonflammable organic solvent which shall not have a fire point below 200 degrees F. The adhesive shall not adversely affect, initially or in service, the insulation to which it is applied, nor shall it cause any corrosive effect on metal to which it is applied. Any solvent dispersing medium or volatile component of the adhesive shall have no objectionable odor and shall not contain any benzene or carbon tetrachloride. The dried adhesive shall not emit nauseous, irritating, or toxic volatile matter or aerosols when the adhesive is heated to any temperature up to 212 degrees F. The adhesive shall be nonflammable, fire resistant conforming to ASTM E84.

2.8.4.3 Lagging Adhesive

Lagging adhesives shall be nonflammable, fire-resistant in accordance with NFPA 90A, UL 723, and ASTM E84. Adhesives shall be either the Class 1 or Class 2 type. Class 1 adhesives shall be pigmented [white] [red] and shall be suitable for: bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; bonding cotton batiste cloth to faced and unfaced fibrous glass insulation board; sealing edges of and bounding fibrous glass tape to joints of fibrous glass board; or bonding lagging cloth to thermal insulation. Class 2 adhesive shall be pigmented white and shall be suitable for attaching fibrous glass insulation to metal surfaces. Lagging adhesives shall be applied in accordance with the manufacturer's recommendations.

2.9 PIPE SLEEVES

Sleeves in masonry and concrete walls, floors, and roofs shall be Schedule 40 galvanized steel pipe conforming to ASTM A53/A53M. Sleeves in nonmasonry and nonconcrete walls, floors, and ceilings shall be fabricated of 26 gauge galvanized steel.

[2.10 Bellows-Type Joints

Select bellows-type or slip-type to satisfy specific design conditions. Joints shall be flexible, guided expansion joints. Expansion element shall be of stainless steel. Bellows-type expansion joints shall be in accordance with the applicable requirements of EJMA Stds and ASME B31.1 with internal liners.

2.11 Expansion Joints

Expansion joints shall provide for either single or double slip of connected pipes, as required or indicated, and for not less than the traverse indicated. Joints shall be designed for hot water working pressure not less than [_____] psig and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. Joints shall be designed for packing injection under full line pressure. End connections shall be flanged or beveled for welding as indicated. Joints shall be provided with anchor base where required or indicated. Where adjoining pipe is carbon steel, the sliding slip shall be seamless steel plated with a minimum of 2 mils of hard chrome conforming to ASTM B650. Joint components shall be fabricated from material equivalent to that of the pipeline. Initial settings shall be made in accordance with manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by joint manufacturer, but in any case shall not be more than 5 feet from expansion joint except for lines 4 inches or smaller, guides shall be installed not more than 2 feet from the joint. Service outlets shall be provided where indicated.

2.12 Flexible Ball Joints

Flexible ball joints shall be constructed of alloys as appropriate for the service intended. Where so indicated, the ball joint shall be designed for packing injection under full line pressure to contain leakage. Joint ends shall be threaded (to 2 inches only), grooved, flanged or beveled for welding as indicated or required and shall be capable of absorbing a minimum of 15-degree angular flex and 360-degree rotation. Balls and sockets shall be of equivalent material as the adjoining pipeline. Exterior spherical surface of carbon steel balls shall be plated with 2 mils of hard chrome conforming to ASTM B650. Ball type joints shall be designed and constructed in accordance with ASME B31.1 and ASME BPVC SEC VIII D1, where applicable. Flanges where required shall conform to ASME B16.5. Gaskets and compression seals shall be compatible with the service intended.

]PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number on a plate secured to the item of equipment.

3.2.1 Support Structures

Pipes shall be supported by concrete, steel, or wood structures as indicated. Structures shall be set, plumbed and guyed as required. Guy wires shall be stressed until taut. Elevation of the structures shall be as indicated on the drawings. Painting of structural steel members shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.2 Piping and Valves

3.2.2.1 Piping

Install the heat distribution system in accordance with ASME B31.1, unless otherwise specified or indicated. Submit [6] [_____] copies of operation and [6] [_____] copies of maintenance manuals for the equipment furnished; one complete set prior to performance testing and the remainder furnished upon acceptance. Detail in the operation manuals the step-by-step procedures required for equipment startup, operation, and shutdown. Include in the operation manuals the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include in the maintenance manuals piping and equipment layout and simplified wiring and control diagrams of the equipment as installed. Manuals shall be approved prior to the field performance testing. Piping shall be installed straight and true to bear evenly on supports. Changes in direction shall be made by pipe fittings. Changes in horizontal steam piping sizes shall be made using eccentric reducing fittings to keep bottom of pipe at the same level. Horizontal steam piping, unless otherwise indicated, shall be pitched with a grade of not less than 1 inch in 20 feet in the direction of flow. All other piping, unless otherwise indicated, shall be pitched with a grade of not less than 1 inch in 40 feet toward the drain points. Pipe shall be accurately cut to measurements established at the construction site and shall be worked into place without springing or forcing, properly clearing all openings and equipment. Excessive cutting or other weakening of structural members to facilitate piping installation will not be permitted. Pipe ends shall have burrs removed by reaming and shall be installed to permit free expansion and contraction without damage to joints or hangers. Open ends of pipe lines and equipment shall be properly capped or plugged during installation to keep dirt or other foreign matter out of the system.

3.2.2.2 Valves

Valves shall be installed with stems horizontal or above. Valves shall be welded, except sizes smaller than 3/4 inch may have threaded end connections with a union on one side of the valve.

3.2.3 Joints

3.2.3.1 Welded Joints

Joints between sections of pipe and between pipe and fittings shall be welded, except where threaded fittings are allowed and used. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitations. Where branch outlet fittings are used, they shall be forged, flared for improved flow where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Threaded joints in high temperature water systems shall be seal welded.

3.2.3.2 Threaded Joints

Threaded joints shall be made tight with polytetrafluoroethylene tape applied to the male pipe threads only. Threaded joints in high temperature water systems shall be seal welded.

3.2.4 Branch Connections

Branch connections from supply and return mains shall be installed as indicated or as approved. Connections shall be carefully made to ensure unrestricted circulation, eliminate air pockets, and permit the complete drainage of the system.

3.2.5 Pipe Supports

Horizontal and vertical runs of pipe shall be securely supported. Suspended pipe shall be supported by adjustable pipe hangers having bolted hinged loops and turnbuckles or by other approved devices, conforming to MSS SP-58. Chain or flat steel strap hangers or single point supports will not be accepted. Pipe hangers, guides, brackets, supports and anchors shall be as detailed on the drawings. Spacing for the pipe supports shall be in accordance with MSS SP-58, Table 3, Column 1. For hangers located on the outside of the insulation, a preformed, minimum 18 inches long, full round, 14 gauge, galvanized steel saddle shall be positioned between the hanger and the insulation. The saddle shall be of sufficient size and thickness to limit the compressive load on the insulation to 33 psi.

3.2.6 Pipe Sleeves

Pipe sleeves shall be provided where piping passes through walls or floor slabs. Sleeves shall be secured in proper position and location during construction. Sleeves shall be of sufficient length to pass through the entire thickness of walls or floor slabs. Sleeves in floor slabs shall extend 3 inches above the finished floor. The annular space between the exterior of piping or pipe insulation and the interior of the sleeve shall be not less than 1/4 inch; and the space shall be firmly packed with insulation and both ends of the sleeve shall be caulked with plastic waterproof cement which will cure to a firm but pliable mass.

3.3 INSULATION

3.3.1 General

Install insulation in a manner that prevents damage by pipe expansion or contraction. Insulation installed over welds shall be grooved to assure a snug fit. Insulation shall be held in place with stainless steel straps or wire. All flanges, unions, valves, and fittings shall be insulated with premolded, prefabricated, or field fabricated segments of insulation of the same material and thickness as the adjoining pipe insulation.

3.3.2 Installation

Except as otherwise specified, material shall be installed in accordance with the recommendations of the manufacturer. Insulation materials shall not be applied until tests specified are completed, foreign material such as rust, scale, or dirt has been removed, and the surfaces are clean and dry. Insulation shall be kept clean and dry at all times.

3.3.3 Wet Insulation

3.3.3.1 Prior to Installation

Insulation which has become wet prior to installation shall be thoroughly dried before proceeding with the installation. After drying, a representative cross section of the insulation, as determined by the Contracting Officer, shall be taken and quickly placed in an airtight container for a moisture determination. The sample shall be weighed in the airtight container on an accurate balance or scale, after which the container shall be opened and placed in an oven at 215 degrees F until its weight becomes constant. The percentage of water by weight shall be determined from the initial and final weight of the container and the sample after appropriate corrections are made for the weight of the empty container. The average water content of the sample shall not exceed 5 percent by weight. If the average water content of the insulation exceeds 5 percent by weight, the insulation shall be replaced with dry insulation.

3.3.3.2 After Installation

Insulation which becomes wet during or after installation shall be thoroughly dried by applying heat through the carrier pipe and allowing the moisture to evaporate to the atmosphere. A sample of the insulation shall be checked for water content in accordance with the guidance in the preceding paragraph. The insulation shall be dried until it is found to contain an average water content of less than 5 percent by weight. If approved by the Contracting Officer, installed insulation may be removed and dried in accordance with the guidance in the preceding paragraph and after drying, reinstalled.

3.3.4 Covering of Insulation

Insulation for pipe, flanges, valves, and fittings shall be covered with a jacket as specified by one of the following methods.

3.3.4.1 Aluminum Jacket

The longitudinal and circumferential seams shall be lapped not less than 3 inches. The jackets shall be secured with bands installed at least every 12 inches. Jackets on horizontal lines shall be installed so that the longitudinal seams are on the bottom side of the pipe with the seam of each jacket slightly offset from the seam of the adjacent jackets. The seams of jackets installed on vertical lines shall be placed on the off-weather side of the pipe and shall be slightly offset as on horizontal lines. The jackets on vertical lines and lines pitched from the horizontal shall be installed from low point to high point so that the lower circumferential edge of each jacket overlaps the upper circumferential edge of the jacket below it. Joints shall be sealed with a moisture barrier. Special fitting jackets conforming to the above, with the exception of longitudinal lapping dimensions and location of seams, may be used for fittings, valves, and flanges. Jackets for fittings, valves, and flanges shall be properly overlapped and secured. The jacketing shall not be allowed to become electrically coupled to the piping.

3.3.4.2 Nonmetallic Jacket

The color of the jacket shall match the nearest existing piping insulation nonmetallic jacket. However, if no piping exists, the jacket shall be gray in color. The jacket shall overlap not less than 2 inches at longitudinal and circumferential joints, except that factory applied jacket systems shall be butted at the circumferential joint; and a 3 inch matching butt strip furnished by the manufacturer shall be applied. The butt strip shall be at least 2 inches longer than the insulation circumference and shall be secured by outward clinching staples (2 located at the beginning of the strip overlap and 2 at the end of the strip overlap). The edges of the butt strip shall be closed with 2 inches wide 1.5 mil polyvinyl fluoride (TEDLAR PVF) pressure sensitive tape made from a similar material and color as the jacket. Longitudinal joints shall be overlapped down to shed water and located at the bottom of the pipe. The overlap shall be stapled on 2 inch centers, working from the center toward the ends to eliminate any wrinkles. Matching PVF tape (2 inches wide for 12 inch and less diameter insulation, and 3 inches wide for insulation diameters greater than 12 inches) shall be applied to the clean and dry overlap, covering the seam and the staples. The matching PVF tape shall be used to weatherproof the clean and dry circumferential lap between sections. Tape shall be rubbed down with a plastic squeegee.

3.3.4.3 Flanges, Unions, Valves, Fittings and Accessories

Flanges, unions, valves, fittings and accessories shall be insulated with premolded, prefabricated, or field fabricated segments of insulation. Insulation shall be removable and reusable and shall have essentially the same thermal characteristics and thickness as the adjoining piping.

3.4 PIPE GUIDES AND SUPPORTS

Pipe supports and alignment guides shall be provided as indicated or necessary and shall permit pipe expansion and contraction without damage to the insulation. The supports, anchors, and guides shall be designed to permit complete drainage of the system, shall have rigid steel frames of adequate strength and corrosion resistance for the service, and shall be securely embedded in concrete or securely attached to the piping supports. Pipe supports shall be equipped with steel bars and cast-iron rollers.

[3.5 PIPE EXPANSION

Expansion shall be accommodated by loops and bends as indicated on the drawings and as specified. Pipe in the loops and bends shall accommodate expansion while maintaining required insulation clearance from other pipes; crushing or breaking of insulation shall be avoided. Expansion loops may be designed around obstacles such as structures, or trees to avoid construction conflicts. Slopes of pipe shall be maintained. Contractor will have the option to adjust the loop dimensions around obstacles based on final field measurements, if approved by the Contracting Officer. Submit pipe stress calculations for each revised expansion loop or bend based on the final actual measured lengths, or submit dimensions to the Contracting Officer for verification of loop and bend sizes before proceeding with that segment of work. Allowable pipe stresses shall be in accordance with ASME B31.1. Final expansion loop insulation method shall be submitted for approval to the Contracting Officer.

]3.6 TESTS

3.6.1 General

Conduct tests before, during, and after the installation of the system. Provide instruments, equipment, facilities, and labor required to properly conduct the tests. Test pressure gauges for a specific test shall be approved by the Contracting Officer and shall have dials indicating not less than 1.5 times nor more than 2 times the test pressure. Any deficiencies found shall be corrected and the system retested.

3.6.2 Cleaning of Piping

Prior to the hydrostatic and operating tests, the interior of the pipe shall be cleaned of all foreign material by thorough flushing with clean water. Supplementary pumps shall be provided to circulate the flushing liquid at a velocity between 7 and 10 feet per second for a minimum of 4 hours. Temporary strainers shall be installed as required. After flushing, the flushing liquid shall be drained out of the piping system and the piping system shall be filled with clean water.

3.6.3 Field Tests

3.6.3.1 Hydrostatic Tests of Service Piping

Service piping shall be tested hydrostatically before insulation is applied at the joints and shall be proved tight at a pressure 1-1/2 times the working pressure or at 200 psig, whichever is greater, except high temperature water lines shall not be tested at more than 500 psig. Hydrostatic test pressures shall be held for a minimum of 4 hours. If any failures occur, make such adjustments, repairs or replacements as the Contracting Officer may direct, and the tests shall be repeated until satisfactory installation and operation are achieved.

3.6.3.2 Equipment

Valves, traps, alarms, controls and other operable items of equipment that are a part of the aboveground heat distribution system shall be checked to show proper operation. These checks shall be performed in the presence of the Contracting Officer or his representative.

3.6.3.3 Operational Tests

Operational test shall be performed on the complete system or testable portions thereof. The test shall be conducted with full design flows and operating temperatures in all runs of piping as if in service, to demonstrate satisfactory function and operating effectiveness. The operational test shall have 2 cycles. Each cycle shall consist of a 6-hour period with water in the system at the maximum operating temperature and maximum flow rate; and a period of at least 6 hours with no flow rate. For dual temperature systems, the first cycle shall use the heating temperature and the second cycle the cooling temperature of the designed system. Supply all items necessary to perform the test including temporary pumps, piping connections, boilers, chillers and the gauges required to circulate the water at the desired temperatures and flow rates. Water shall be circulated through supply lines and returned through the return piping to demonstrate that the pressure drop is compatible with the flow rate and size of pipe; and to show that obstructions do not exist in the piping system. Any unusual indicated pressure drop shall be investigated and any obstructions removed. Leaks found shall be repaired. After obstructions have been removed and leaks repaired, the carrier piping tests shall be repeated.

-- End of Section --

SECTION 33 61 13

PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM
08/10, CHG 1: 02/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 300	(2003; R 2017) Standard Specification for Inorganic Zinc-Rich Primer

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A134/A134M	(2019) Standard Specification for Pipe, Steel, Electric-Fusion (Arc)-Welded (Sizes NPS 16 and Over)
ASTM A135/A135M	(2021) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A139/A139M	(2016) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting

	Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM C177	(2019) Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
ASTM C518	(2021) Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM D1895	(2017) Standard Test Methods for Apparent Density, Bulk Factor, and Pourability of Plastic Materials
ASTM D2310	(2006; R 2012) Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

1.2 DEFINITIONS

The following definitions shall apply to the work.

1.2.1 Heat Distribution System

A complete pre-engineered, underground [heat distribution] [and] [condensate return] system including all required components such as carrier pipes, [steam pipe,] [high temperature hot water supply pipe,] [condensate return pipe,] [high temperature hot water return pipe,] and fittings, anchors, pipe supports, insulation, protective casing, and cathodic protection, for the system supplied. The pre-engineered system does not include valve manholes and the piping and equipment inside the valve manholes; Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES shall be used for pertinent requirements. The pre-engineered system shall include all piping and components to a point at least 6 inches inside the building and valve manhole walls. The UHDS shall not use any part of the building or valve manhole structure as an anchor point.

1.2.2 Direct-Buried

A system which is buried, without the need for a field-fabricated protective enclosure such as a concrete trench or tunnel.

1.2.3 UHDS Types

1.2.3.1 Drainable-Dryable-Testable (DDT) Direct-Buried

A factory-fabricated system including an air and water-tight outer protective casing, air space and an insulated carrier pipe. Drains and vents are provided at the end plates of the system (in manholes or buildings). The drains are normally capped but the caps can be removed to drain water which may leak into the air space if there is a failure in the casing or the carrier pipe. The vents allow water vapor to escape and provide a tell-tale sign of leakage.

1.2.3.2 Water Spread Limiting (WSL) Direct-Buried

A factory fabricated system including an outer protective casing and an insulated carrier pipe. The system is fabricated in sections which are independent from each other; ground water or condensate which leaks from or into one section cannot travel into the next section. Field-assembly of the sections requires no welding as the sections push together and are sealed with a system of couplings and seals.

1.2.3.3 Water Spread Limiting Poured-In-Place Insulation (PIPI)

A field fabricated system consisting of steel carrier pipes and supports encased in the poured-in-place insulation (PIPI). The PIPI consists of chemically modified calcium carbonate powder. The particles cohesively bond with each other to form a closed-cell insulation that thermally insulates the pipes and provides corrosion protection.

1.3 SYSTEM DESCRIPTION

1.3.1 Scope

The work includes the design and fabrication; furnishing; installing, and testing of a direct buried underground [insulated heat-distribution system] [and] [insulated steam pipe,] [insulated high temperature hot water supply pipe,] [insulated steel condensate return pipe,] [insulated high temperature hot water return pipe] consisting of piping as indicated, cathodic protection system (where required by this specification), together with fittings and appurtenances necessary for a complete and operable system. Gland type end seals will not be permitted. DDT systems with fiberglass casings will not be allowed.

1.3.2 UHDS Design

Submit a Certificate of Satisfactory Operation certifying that at least 3 systems installed by the UHDS manufacturer within the previous 5 years are operating satisfactorily, not later than [_____] days after notice to proceed. The UHDS manufacturer shall be responsible for the complete design of the UHDS, the product to be supplied, fabrication, witnessing installation and testing of the system within the design parameters established by the contract drawings and specifications, and in compliance with the detailed design. The complete design of the UHDS shall be sealed by a Professional Engineer in the employ of the UHDS manufacturer.

1.3.3 Cathodic Protection

Cathodic protection shall be provided for systems with coated steel casings in accordance with paragraph Cathodic Protection Installation.

1.3.4 Operating Characteristics

The [[steam] [high temperature hot water] supply system shall have an operating temperature of [_____] degrees F and an operating pressure of [_____] psig.] [[condensate] [high temperature hot water] return system shall have an operating temperature of [_____] degrees F and an operating pressure of [_____] psig.]

1.3.5 Rated Characteristics

Furnish thermal expansion calculations for the supply and return piping using the following design characteristics and installation temperature. The system design conditions for [steam] [condensate] [high temperature hot water] supply and/or return shall be a temperature of 450 degrees F and a pressure of 665 psig. For calculation purposes, the installation temperature shall not be higher than the ambient temperature at the site: [_____] degrees F.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heat Distribution System; G[, [_____]].

SD-03 Product Data

Expansion Loops and Bends; G[, [_____]].

Cathodic Protection Installation; G[, [_____]].

Interruption of Existing Service; G[, [_____]].

Work Plan; G[, [_____]].

Quality Assurance Plan

UHDS Manufacturer's Representative Reports

Connecting to Existing Work; G[, [_____]].

SD-06 Test Reports

Thermal Performance Testing; G[, [_____]].

Operational Test; G[, [_____]].

Tests; G[, [_____]].

Test of WSL Systems for Steam Service; G[, [_____]]

Test of WSL Systems for Condensate Return Service; G[, [_____]]

SD-07 Certificates

Manufacturer; G[, [_____]].

Manufacturer's Representative; G[, [_____]].

UHDS Design; G[, [_____]]

Certificate of Compliance; G[, [_____]].

Testing Firm

Welding

SD-10 Operation and Maintenance Data

Heat Distribution System; G[, [_____]].

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer

The UHDS manufacturer is the company responsible for the design and manufacture of the pre-engineered system. The Contractor shall submit certification of past experience stating that the UHDS manufacturer regularly and currently manufactures direct-buried systems, and that the designs of the system and equipment to be provided for this project conform to specification requirements. This certification shall be an original signed by a principal officer of the UHDS manufacturer and shall be submitted at least [2 weeks] [_____] prior to the start of work; the certificate shall indicate the location, type of system, size of system, point of contact (POC) including phone number, for information verification. The UHDS manufacturer directs the installation of the system and has a representative on the jobsite. The manufacturer shall submit a Work Plan indicating when various items of work and tests are to be carried out and when its representative will be present at job site. The Contractor shall submit a proposed schedule of activities, not later than [_____] days after notice to proceed. The manufacturer shall submit a list of characteristics indicating what defects or damage will necessitate replacement. The manufacturer shall submit a Quality Assurance Plan not later than [_____] days after notice to proceed for fabrication, delivery, storage, installation and testing of the system. The manufacturer shall submit data sheets for all coatings and indicating thicknesses of insulation for carrier pipes.

1.5.2 Manufacturer's Representative

Submit a letter from the system manufacturer, at least [2 weeks] [_____] prior to the start of work, listing the experience and training of the manufacturer's representative, who shall be a person who regularly performs the duties specified, is certified in writing by the UHDS manufacturer to be technically qualified and experienced in the installation of the system, and shall be authorized by the manufacturer to make and sign the daily reports specified. The UHDS manufacturer's representative shall be under the direct employ and supervision of the UHDS manufacturer.

1.5.3 Corrosion Engineer

Corrosion engineer refers to a person who, by knowledge of the physical sciences and the principles of engineering and mathematics acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control. Such person may be a licensed professional corrosion engineer or certified as being qualified by the National Association of Corrosion Engineers (NACE), if such licensing or certification includes 3 years experience in corrosion control on underground metallic surfaces of the type under this contract. NACE certification shall be technologist, corrosion specialist, or cathodic protection specialist. The corrosion engineer shall make at least 3 visits to the project site. The first of these visits shall include obtaining soil resistivity data, acknowledging the type of pipeline coatings to be used and reporting to the Contractor the type of cathodic protection required. Once the submittals are approved and the materials delivered, the corrosion engineer shall revisit the site to ensure the Contractor understands installation practices and laying out the components. The third visit shall involve testing the installed cathodic protection systems and training applicable personnel on proper maintenance techniques. The corrosion engineer shall supervise, inspect, and test the installation and performance of the cathodic protection system.

1.5.4 Testing Firm

Submit a Certificate of Qualification from the independent testing firm or firms, not later than [_____] days after notice to proceed. The Testing Firm must be able to certify that: weld examination methods and procedures, and the interpretation of radiographic films will be performed in accordance with ASME B31.1; the firm intends to utilize the proper film exposure, techniques, and penetrameter to produce density and geometric sharpness in sufficient clarity to determine presence of defects; and that all radiographic films will be reviewed and interpreted, and reading reports signed, by not less than a Certified American Society for Nondestructive Testing Level III Radiographer.

1.5.5 Contract drawings

The contract drawings accompanying this specification provide information on:

a. The size of carrier pipes, approximate length, and site location of the system.

b. The routing and elevation of the piping along the route.

c. Location and design of manholes.

d. The obstacles that must be avoided along the path.

e. Location of piping anchors (anchors will be no closer than 3 feet or further than 5 feet from entrance to manholes or buildings) at manholes and/or buildings. The UHDS manufacturer shall incorporate anchors as needed for the system.

f. Operating pressure and temperature of system.

1.6 DELIVERY, STORAGE, AND HANDLING

Equipment and material placed on the job shall remain in the custody of the Contractor until final acceptance whether or not the Contractor has been reimbursed for the equipment and material by the Government. The Contractor is solely responsible for the protection of the equipment and material against damage from any source while stored or during installation. Protect materials against damage from UV light, and entry of water and mud, by installing watertight protection on open ends at all times. Immediately replace sections of the casing or carrier piping found to have been subjected to full or partial submergence in water (which would allow the insulation to become wet). Materials awaiting installation shall be covered to protect from UV degradation.

1.7 SITE CONDITIONS

Classification of the site conditions for the UHDS shall be based on ASTM D2487 and the following criteria: [_____].

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide for this project a designed system and equipment which is of current production and that essentially duplicate systems that have been in satisfactory use for at least 5 years prior to bid opening at 3 locations. Provide systems that have been operated under pressure, temperature and site characteristics which are equal to or more severe than the operating conditions in this specification and that have distributed the same medium. The system shall be supported by a service organization that can reach the site after a service call within [48] [_____] hours.

2.2 FACTORY FABRICATED, DIRECT-BURIED DDT SYSTEMS

2.2.1 DDT Steam and High Temperature Hot Water Carrier Pipes

Requirements shall be in accordance with paragraph HEAT DISTRIBUTION PIPING.

2.2.2 DDT Condensate Carrier Pipes

Carrier piping for condensate return systems shall be steel, schedule 80. Pipe requirements shall be in accordance with paragraph HEAT DISTRIBUTION PIPING. Condensate carrier pipes shall not be located in conduit casings which contain steam pipes or any other piping.

2.2.3 DDT Carrier Pipe Insulation

Carrier pipe insulation shall conform to minimum thicknesses and type listed in Tables 1 and 2 as required for temperature specified under paragraph Rated Characteristics.

2.2.4 Insulation Banding and Scrim

Stainless steel bands and clips, at least 1/2 inch wide, conforming to ASTM A167 (304 stainless steel), at a maximum spacing of 18 inches shall be used over the scrim to secure the insulation onto the carrier pipe; a minimum of 2 bands shall be used for each 4 foot section of insulation. Scrim shall be vinyl-coated fiberglass with 18 x 16 mesh (number of filaments per 1 inch) and made of 0.013 inch diameter vinyl-coated fibrous glass yarn.

2.2.5 Casing

Casing shall be smooth-wall steel, electric resistance spiral welded, conforming to ASTM A134/A134M, ASTM A135/A135M, or ASTM A139/A139M and the values tabulated below. Eccentric connectors shall be provided between casing sections as needed to provide drainage of casing section between manholes and between manholes and buildings.

Casing Diameter (inches)	Minimum Thickness (inch)
6 - 26	0.250
27 - 36	0.250
37 - 42	0.250
46	0.250

2.2.6 Casing End Plates, Vents, and Drains

End plates shall be made of ASTM A36/A36M steel, minimum thickness 1/2 inch for conduit pipe sizes above 12 inches and 0.375 inches for conduit pipe sizes 12 inches and less. A 1 inch ASTM A53/A53M, Sch 40, galvanized vent riser pipe shall be provided on end plate vent opening. Vent pipe shall extend to top of manhole and terminate 12 inches above grade with a 180 degree bend. A 1 inch drain shall be provided at the bottom and vent at the top. Brass plugs and half coupling, constructed with welded steel and welded to the end plate, shall be furnished; drains shall be plugged; vents shall not be plugged.

2.2.7 Air Space

Continuous 1 inch minimum air space shall be provided between carrier pipe insulation and casing.

2.2.8 Casing Coating

Coating shall be rated by manufacturer for continuous service for at least 25 years at temperatures of 230 degrees F. Coating shall be applied in accordance with the coating manufacturer's instructions, shall be factory inspected for holidays and repaired as necessary.

2.2.8.1 Fusion-Bonded Epoxy

Casing coating shall be fusion-bonded epoxy, minimum thickness 0.04 inches.

2.2.8.2 Urethane Elastomer

Coating shall be urethane elastomer, minimum thickness 0.04 inches.

2.2.9 Coating of End Plates and Conduit Extending into Manholes

End plates and conduit extending into manholes shall be coated with a zinc-rich coating conforming to AASHTO M 300 Type IA, except that volatile organic compounds shall not exceed 2.8 pounds/gallon. The zinc-rich coating shall be applied in accordance with the coating manufacturer's requirements including surface preparation. No additional top coat shall be applied.

2.2.10 Carrier Pipe Guides

Carrier pipe guides shall be spaced 10 feet on centers maximum, no more than 5 feet from pipe ends, with a minimum of 3 guides per elbow section. Guides shall be designed to allow thermal expansion without damage, to provide proper pipe guiding, and to allow horizontal movement in 2 directions as required at expansion loops and bends. Design of supports shall permit flow of water through the support. Pipe insulation shall extend through the pipe guides and be protected by steel sleeves. Design of guides shall negate metal-to-metal contact between the casing and the carrier pipe. Insulation or non-metallic material used to ensure no metal-to-metal contact shall not be compressed by the weight of the carrier pipe when full of water.

2.2.11 Anchor Plates

Anchor plate shall be ASTM A36/A36M steel, welded to carrier pipe and casing, 1/2 inch minimum thickness, with passages for air flow and water drainage thru the annular air space in the system. Exterior surface of the anchor plate shall be coated with the same coating material as the casing.

2.2.12 Field Connection of Casing Sections

Field connection of casing shall be made using a compatible steel section, welded to casing sections, coated on all surfaces with UHDS manufacturer's coating field repair compound, and covered with a 0.05 inch minimum thickness polyethylene shrink sleeve designed for a service temperature exceeding 176 degrees F.

2.2.13 Manufacturer's Identification

Embossed brass or stainless steel tag, hung by brass or stainless steel chain at each end of each conduit or insulated piping in the manholes and buildings, shall be provided. The tag shall identify UHDS manufacturer's name, date of installation, Government contract number, and manufacturer's project number.

2.3 FACTORY FABRICATED, DIRECT-BURIED WSL SYSTEM

2.3.1 WSL Steam and Carrier Pipes

Pipe material requirements shall be in accordance with paragraph HEAT DISTRIBUTION PIPING. The pipe shall be steel with the ends machined and metallized to provide a satisfactory sealing surface for the sealing rings. The metallizing shall be a high nickel alloy applied to an excess thickness and then machined to the required OD.

2.3.2 WSL Condensate Carrier Pipes

Carrier piping for condensate return systems shall be steel, schedule 80. Pipe requirements shall be in accordance with paragraph HEAT DISTRIBUTION

PIPING. Condensate piping shall not be located in casings which contain any other piping.

2.3.3 Casing for Steam and Condensate

The casing shall be reinforced thermosetting resin plastic (RTRP) piping manufactured by the filament winding process. The casing pipe shall be wound to meet ASTM D2310 classification RTRP and ASTM D2996. The resin shall be a polyester isothalic resin. The outer surface shall be coated with a pigmented, protected resin containing a paraffinated wax and ultraviolet inhibitors. Casing thickness shall be as follows:

Carrier Pipe Size (Inches)	Caasing Thickness (Inches)
2	0.185
3	0.185
4	0.185
6	0.250
8	0.250
10	0.250
12	0.250

2.3.4 Pipe Coupling, Steam

Coupling shall be of a multi-stage seal designed to accommodate the expansion and contraction of the system in the coupling. Couplings shall be of corrosion resistant materials capable of handling the design characteristics of the system listed in paragraph Rated Characteristics. The annular seals and carrier pipe ends shall be specifically designed to protect the seals and resist abrasion due to lateral loads in the system.

2.3.5 Pipe Coupling, Condensate

Coupling shall be a single stage seal design to accommodate the expansion and contraction of the adjacent pipes. Coupling shall be of corrosion resistant materials capable of handling the design characteristics of the system listed in paragraph Rated Characteristics. The annular seals and carrier pipe ends shall be specifically designed to protect the seals and resist abrasion due to lateral loads in the system.

2.3.6 WSL Carrier Pipe Insulation

Insulation shall conform to minimum thicknesses and type listed for WSL systems in Tables 1 and 2 as required for temperature in carrier pipe. Insulation shall consist of an inner layer of high temperature calcium silicate and an outer layer of polyurethane foam.

2.3.6.1 Calcium Silicate for Steam Systems

The calcium silicate insulation shall be a hydrous material satisfactory for temperatures to 1200 degrees F. Calcium silicate insulation shall conform to ASTM C533. The physical properties shall be as follows:

a. Density (dry): 13 pcf (minimum).

b. Compressive Strength to produce 5 percent compression: 250 psi (For 1.5 inch thick sample).

c. Maximum linear shrinkage after 24 hour soaking period at 1200 degrees F: 1.1 percent

d. Maximum Thermal Conductivity k: k = BTU-IN/HR-FT2-DEG.F). Where k varies with temperature as shown:

Mean Temp (degrees F)	k
100	0.38
200	0.41
300	0.44
400	0.48

2.3.6.2 Polyurethane Foam for Steam and Condensate Systems

Polyurethane foam shall conform to ASTM C591. The polyurethane foam shall completely fill the annular space between the calcium silicate insulation and the casing for the steam pipe and between the carrier pipe and the casing for condensate return system. Polyurethane foam insulation shall also meet the following requirements:

a. Type: Two component urethane.

b. Compressive Strength: 25 psi parallel to rise (minimum at 50 percent compression).

c. Shrinkage: None at 30 to 70 degrees F.

d. Free Rise Density: 2 pcf.

e. Maximum aged k (90 degrees F 90 percent RH for 72 hours): 0.14 (BTU-IN/HR FT2-DEG. F) at 75 degrees F, when tested in accordance with ASTM C518.

f. Minimum Closed Cell Content: 90 percent

2.3.6.3 Insulation Concentricity

Carrier pipe shall be concentric in relation to the casing pipe. The allowable maximum deviation from center line of the carrier pipe shall be plus or minus 1/4 inch at the casing center point and plus or minus 1/16 inch at the end seals.

2.3.6.4 Insulated Fittings

Fittings shall be pre-insulated by manufacturer using the same insulation thickness and casing as the straight sections.

2.3.6.5 Coupling Insulation for Steam Systems

The material which locks the bronze coupling in the casing shall be composed of refractory composite. The approximate minimum conductivity of this material shall be 1.6 (BTU/HR/F/IN DEG.F) at a mean temperature of 2300 degrees F.

2.3.6.6 Coupling Insulation for Condensate

The coupling shall be insulated with polyurethane foam as specified. The insulation thickness shall be equal to the carrier pipe insulation. The coupling shall be encased in the same casing as the pipe.

2.3.7 Manufacturer's Identification

Provide an embossed brass tag hung by a brass chain, or a stainless steel tag hung by a stainless steel chain, at each end of each casing or insulated piping in the manholes and buildings. The tags shall identify UHDS manufacturer's name and date of installation.

2.3.8 End Seals

Each preinsulated section of piping shall completely seal the insulation, providing a permanent water and vapor seal at each end. Preinsulated factory fabricated sections of piping modified in the field shall be provided with an end seal which is equivalent to the end seals furnished with the preinsulated section of piping. Tests shall be conducted by the UHDS manufacturer to demonstrate that casings, couplings and end seals are capable of resisting penetration of water into the casing and insulation under rated conditions. The tests shall be performed on each type of pre-fabricated system to be furnished, and the test results shall be verified by an independent testing laboratory. The steam and condensate return systems shall be tested and certified in accordance with paragraph Assembly Test of WSL Systems for Condensate Return Service.

2.3.8.1 End Seals for Steam Service

End seals shall be elastomer-ring type designed and dimensioned to fit in the annular space between the casing and the carrier pipe. Tape used for covering field repair joints shall be multi-polymer alloy film type and shall be compatible with synthetic elastomeric tape, suitable for cold application.

2.3.8.2 End Seals for Condensate Return Service

End seals provided shall be one of the following types:

a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Sufficient surface bonding area shall be provided between the casing and the carrier pipe.

b. Using specially designed molded caps made of polyethylene or rubber of standard manufactured thickness. A minimum 1-1/2 inch surface bonding area shall be provided between the cap and both the casing and carrier pipe.

c. Using elastomer-ring end seals designed and dimensioned to fit in the annular space between the casing and the carrier pipe.

d. Using a waterproof mastic seal vapor barrier over the exposed insulation ends.

e. Shrink sleeves.

2.3.9 Test of WSL Systems for Steam Service

The tests shall demonstrate that the WSL system will operate successfully for 25 years under typical operating conditions. The tests shall be conducted in both a dry and wet environment. The WSL system shall be as described in the manufacturer's brochure. The testing program described below shall be conducted at the expense of the WSL system manufacturer. Tests shall be witnessed and verified by an independent testing laboratory. The entire pre-insulated test section shall be hydrostatically tested, with water, to 375 psig (1.5 times the rated pressure) before and after temperature cycling. The tests shall be conducted in a dry environment for 60 cycles followed by a test in a wet environment for 60 cycles for a total of 120 cycles. The test in the wet environment demonstrates resistance to ground water infiltration. All tests shall be conducted on 1 test section and all testing shall be completed in 1 time period (approximately 6 weeks) and the 120 testing cycles shall be continuous except for weekend time periods.

2.3.9.1 Apparatus

A curved bottom test tank at least 12 feet long, 32 inches wide, 32 inches deep shall be used. The tank shall be fitted with a gasketed and bolted cover to pressurize the tank to 8.67 psig. The tank shall have a drain at the lowest point and a vent at the highest point. Manhole entrance sleeves (i.e. wall sleeves through the ends of the tank to simulate manhole entries in actual field conditions) shall be centrally located on each end of the tank. Auxiliary equipment shall include: Steam supply with sufficient capacity to satisfy testing requirements, makeup water tank and pump, and a means for continuously recording temperatures and pressures at needed locations. Thermocouples shall be used to record temperatures and pressure at the following points:

a. Carrier pipe at tank inlet (in thermowell).

b. Casing at mid-point in pipe length (on casing).

c. Casing at anchor point (above FRP overwrap on plate).

d. Casing at field joint (repair, on casing).

e. Casing at coupling mid-point (on casing).

f. End seal flange at coupling (on elastomer).

g. Outer edge of new end plate (at steel plate and FRP wrap).

h. Carrier pipe at specimen outlet end (in thermowell).

i. Interface of calcium-silicate and polyurethane insulations.

j. Interface of calcium-silicate and polyurethane insulations.

k. Carrier pipe internal pressure, at inlet to test specimen.

l. Pressure at test tank.

Surface thermocouples shall be epoxied to the surface of the casing. The calibration of the thermocouples shall be checked and recorded prior to installation and the recorder shall record within 0.1 degree Fresolution.

2.3.9.2 Test Section

A 4 inch steel carrier pipe test section consisting of 27 feet of pre-insulated pipe meeting specified materials and design requirements shall be provided. Approximately 12 feet of the test section shall be encased within the tank as described below. The test section within the tank shall consist of an expansion coupling, field repair joint, anchor plate, anchor block and end seals. The test section shall be installed (as directed) on at least 11 inches of firmly tamped sand. Sand shall surround the casing, and top surface of the sand shall not be any farther than 4 inches from the top of the tank. The test section shall be anchored to the tank wall at one end and the building floor at the other end on the portion of the pipe external to the tank. The expansion coupling shall be misaligned by 1.5 degrees in the horizontal plane. Sand (4 fluid oz) shall be introduced into the carrier pipe and disbursed throughout the test loop at startup.

2.3.9.3 Resistance to Water Damage and Joint Leakage

This test shall simulate the operation of the WSL system to assure the system will provide successful service life thru its expected life span. The system shall be tested in steam service by cycling for an extended period of time, as described below. System performance shall be deemed successful if there is no joint leakage, deformation of the casing, deterioration of the end seals, or any other deleterious effects.

a. The piping system shall be subjected to 60 cycles of steam introduced into the system while at ambient temperature 100 degrees F up to a temperature of 406 degrees F (as measured at the core pipe at the tank inlet and tank outlet) and back to ambient temperature. The system shall be held at 406 degrees F minimum for a minimum of 30 minutes, each cycle. This cycling shall continue for 60 cycles in dry sand followed by 60 cycles in a saturated environment. The reduction in temperature to 100 degrees F shall occur naturally with no artificial means of cooling used.

b. Results shall conform to paragraph Criteria for Satisfactory Results and Reporting.

2.3.9.4 Resistance to Mechanical or Structural Damage

This test shall simulate loads induced by truck traffic over pipe, which may occur under actual operating conditions. This test shall be conducted commencing with the 41st cycle of the Resistance to Water Damage and Joint Leakage test and continue through the 60th cycle. Other aspects of the Resistance to Water Damage and Joint Leakage test shall continue simultaneously with this test.

2.3.9.4.1 Apparatus

Same as for apparatus used in Resistance to Ground Water Infiltration test with the addition of a 2000 psf loading device. A hydraulic jack shall be used to apply the test pressure against a 18 by 18 inch plate bearing on the sand directly over the coupling in the tank.

2.3.9.4.2 Procedure

A steady and constant vertical load of 2000 psf shall be applied to the plate for 14 days during the test. The test section shall be installed as in the Resistance to Ground Water Infiltration test. During the 14 day loading period, steam shall be circulated through the carrier pipe alternately at ambient and 406 degrees F as in earlier test.

2.3.9.4.3 Results

Requirements shall be in accordance with paragraph Criteria for Satisfactory Results and Reporting.

2.3.9.5 Resistance to Ground Water Infiltration

This test shall be the wet environment test conducted during the second 3 weeks (61st to 120th cycles) of the test period to show that the WSL system will resist the penetration of ground water into the system.

2.3.9.5.1 Apparatus

Same as for basic apparatus used in Resistance to Water Damage and Joint Leakage phase test, plus the following:

a. One 50 gallon water reservoir with a 0 to 30 psig pressure gauge and compressed air connection.

b. Provisions to introduce pressurized red dye into the curved bottom test tank. The water/dye solution shall be mixed to a concentration in accordance with the dye manufacturer's recommendation for maximum detectability.

c. One pressure tank with 0 to 30 psig static pressure gauge.

2.3.9.5.2 Procedure

This phase shall start on the 61st cycle and continue until the 120th cycle. The test section of pipe shall be the same test segment used in the previous tests. The tank cover shall be bolted in place and the Resistance to Ground Water Infiltration test shall begin. The water/dye source shall be attached to the fill fitting and a surge tank shall be attached to the vent with a tee fitting. The pressure tank shall have a 0 to 30 psig static pressure gauge attached. The other branch of the tee fitting shall employ a shut-off valve. With the shut-off valve open, the water/dye mixture shall be admitted into the tank through the fill fitting until the tank is full and water/dye runs freely from the open valve. The valve shall be closed and the filling shall continue until the pressure reaches 8.67 psig. The tank pressure shall be maintained throughout the test period. Steam shall be circulated through the carrier pipe and cycled from ambient to 406 degrees F as in the previous test. At the end of the test, the pressure shall be relieved by opening the vent valve and the water/dye shall be drained from the tank through the drain fitting.

2.3.9.5.3 Results

Requirements shall be in accordance with paragraph Criteria for Satisfactory Results and Reporting.

2.3.9.6 Criteria for Satisfactory Results and Reporting

2.3.9.6.1 Reporting

Logs of times and temperature shall be recorded to assure compliance with test requirements and procedures. Complete photographic documentation of the construction and operation of the test facility, as well as the piping system components before and after testing, shall be produced. Data shall be analyzed to assure complete compliance with test objectives.

2.3.9.6.2 Drawing

A drawing showing details of the test apparatus and test specimen shall be provided.

2.3.9.6.3 Resistance to Water Damage and Joint Leakage Test

Joints and end seals shall be removed for examination, immediately upon completion of all test cycles. Successful results shall show that steam has not leaked out of the carrier pipe and that the components show no signs of deterioration.

2.3.9.6.4 Resistance to Mechanical or Structural Damage Test

The casing shall not be damaged or deformed enough to impair functioning of the system. The casing shall not be ruptured and shall not be deformed more than 1 inch in any direction. In casings with pipe anchors, there shall be no separation between the casing and the pipe anchor interface.

2.3.9.6.5 Resistance to Ground Water Infiltration Test

The water/dye solution shall not have entered the insulation. This shall be determined by removing and inspecting all joints and seals for dye penetration at the end of the test. Results will be deemed successful if no solution is evident in the insulation.

2.3.9.6.6 Evidence of Test Results

After completion of all tests, the test apparatus shall be dismantled for visual inspection of all critical components subjected to the heat cycling, water infiltration and loading tests. All parts will be examined thoroughly for any detrimental affects. Examinations identified shall be conducted. Log sheets, test data and color photographs shall be kept on file and made available as required to document and substantiate compliance to the test requirements.

2.3.9.6.7 Report

Submit a report from the independent testing agency. The report must include the laboratory analysis of the condition of the test section and attest that the testing conditions were followed.

2.3.10 Test of WSL Systems for Condensate Return Service

Submit test reports in booklet form showing all factory and field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Testing and certification procedures by an independent testing laboratory shall demonstrate that casings and end seals are capable of resisting penetration of water into the casing and insulation. The test shall be performed on the type of prefabricated system to be furnished. If more than one type of prefabricated system is to be used, the tests shall be performed on each type. The test shall consist of hot and cold cycle testing followed by immersion in a water filled chamber with a head pressure. The hot and cold cycle testing shall consist of 14 days of temperature cycling.

a. A fluid with a temperature of 40 degrees Fshall circulate through the carrier pipe, alternating every 24 hours with a fluid with a temperature of 200 degrees F circulating through the carrier pipe for a low temperature hot water or dual temperature service, or 75 degrees F for a chilled water service.

b. While the hot and cold cycle test is being performed, the test sample shall be either buried or encased in dry bedding sand with a minimum of 12 inches of sand all around the test sample. The carrier pipe size of the test sample shall be 3 inches in diameter and shall be restrained during the test period. The insulation thickness shall not exceed the maximum thickness provided for the piping in the project.

c. Transition time for temperature cycle testing shall not exceed 15 minutes in going from cold to hot and 30 minutes in going from hot to cold. The fluid in the carrier pipe may be water, oil or heat transfer fluid. Following the hot and cold cycling test, the test sample shall be immersed in a water filled chamber. The pressure on the highest point of the test sample shall not be less than 20 feet of water head pressure subjected over the entire length of the 8 foot test sample of prefabricated pipe.

d. The water shall contain a dye penetrant, which shall be used to check for end seal leakage. The pressure in the chamber shall be held for not less than 48 hours. Upon completion of this pressure test, the test sample shall be cut open. With the use of a light that will readily show the presence of the dye that was in the water, the test sample shall be inspected. Evidence of the dye inside the test sample shall indicate that the end seal is not acceptable and cannot be certified.

2.4 WATER SPREAD LIMITING POURED-IN-PLACE INSULATION (PIPI) SYSTEM

2.4.1 PIPI Steam and High Temperature Hot Water Carrier Pipes

Requirements shall be in accordance with paragraph HEAT DISTRIBUTION PIPING.

2.4.2 PIPI Condensate Carrier Pipes

Carrier piping for condensate return systems shall be steel, schedule 80. Pipe requirements shall be in accordance with paragraph HEAT DISTRIBUTION PIPING.

2.4.3 PIPI Carrier Pipe Insulation

Carrier pipe PIPI shall conform to minimum thickness and type listed in Table 3 as required for temperature specified under paragraph Rated Characteristics.

2.4.4 Poured-in-Place Insulation - Physical Properties

The poured-in-place insulation shall consist of calcium carbonate powder chemically modified to be hydrophobic with no particles exceeding 1 mm in any dimension. The installed density shall fall in the range of 40 to 62 lb/cubic foot when tested in accordance with ASTM D1895. Perform additional product testing at the identified installed density in accordance with ASTM C177.

2.4.5 Poured-in-Place Insulation - Thermal Properties

The thermal conductivity of the PIPI shall not exceed 0.58 Btu-in/hr-square foot-degree F at 100 degrees F, and 0.68 Btu-in/hr-square foot-degree F at 300 degrees F, when tested in accordance with ASTM C177.

2.4.6 Poured-in-Place Insulation - Electrical Properties

The electrical resistivity of the PIPI shall not be less than 1 by 10 to the 12th power ohm-cm.

2.4.7 PIPI System Piping Anchors, Supports, and Guides

The design and location of pipe anchors, pipe supports, pipe guides, and expansion cushions shall be in compliance with the most recent design manual available from the PIPI manufacturer.

2.4.8 PIPI Envelope Penetrations

The design of penetrations through the PIPI envelope shall be in compliance with the most recent design manual available from the PIPI manufacturer. All pipe anchors, pipe supports, pipe guides and manhole walls that come in contact with the PIPI shall be coated with a mastic compound. For pipe service temperatures up to 400 degrees F the mastic compound shall be bitumastic coal tar. For pipe service temperatures in excess of 400 degrees F silicone grease shall be used.

2.5 PIPE INSULATION TYPE AND MINIMUM THICKNESS

Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING. Materials containing asbestos will not be permitted. The minimum thickness of insulation for the heat distribution system shall be in accordance with Tables 1 and 2 in which the insulations listed have passed the 96 hour boiling water test.

<table>
<tr><th colspan="6">TABLE 1
MINIMUM PIPE INSULATION THICKNESS (Inches)</th></tr>
<tr><th colspan="6">For Steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F)</th></tr>
<tr><th></th><th colspan="3">INSULATIONS for Drainable/Dryable Systems</th><th colspan="2">INSULATIONS for Other Pre-Engineered Systems</th></tr>
<tr><th>Nominal Pipe Diameter (inches)</th><th>Delta</th><th>Theromo-12 Super Caltemp</th><th>MPT-PF MPT-PC</th><th>Calcium Silicate</th><th>WSL Polyurethane</th></tr>
<tr><td>1.0</td><td>2.5</td><td>4.0</td><td>2.0</td><td>N/A</td><td>N/A</td></tr>
</table>

TABLE 1
MINIMUM PIPE INSULATION THICKNESS (Inches)

For Steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F)

	INSULATIONS for Drainable/Dryable Systems			INSULATIONS for Other Pre-Engineered Systems	
Nominal Pipe Diameter (inches)	Delta	Theromo-12 Super Caltemp	MPT-PF MPT-PC	Calcium Silicate	WSL Polyurethane
1.5	2.5	4.0	2.0	N/A	N/A
2.0	3.5	4.5	2.5	N/A	N/A
2.5	3.5	4.5	2.5	N/A	N/A
3.0	4.0	5.0	3.0	1.0	+1.23
4.0	4.0	5.0	3.0	1.0	+1.23
5.0	4.0	5.0	3.0	N/A	N/A
6.0	4.5	5.5	3.5	1.5	+1.34
8.0	4.5	5.5	3.5	2.0	+1.21
10.0	5.0	6.0	4.0	2.5	+1.31
12.0	5.0	6.0	4.0	2.0	+1.29
14.0	5.0	6.0	4.0	N/A	N/A
16.0	5.0	6.0	4.0	N/A	N/A
18.0	5.0	6.0	4.0	N/A	N/A

1) Delta is available from Rockwool in Leeds, Alabama.

2) MPT is available from Mineral Products of Texas in Houston, TX

3) Thermo-12 and Super Caltemp are available from Johns Manville in Denver, Colorado.

TABLE 1A
MINIMUM PIPI THICKNESS (Inches)

For Steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F)

Nominal Pipe Diameter (inches)	Sides and Bottom	Between Pipes	Above Pipes
1.0	4.0	2.0	5.0

TABLE 1A MINIMUM PIPI THICKNESS (Inches)			
For Steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F)			
Nominal Pipe Diameter (inches)	Sides and Bottom	Between Pipes	Above Pipes
1.5	4.0	2.0	5.0
2.0	4.0	2.0	5.0
2.5	4.0	2.0	5.0
3.0	4.0	2.0	5.0
4.0	5.0	2.0	6.0
5.0	5.0	3.0	7.0
6.0	6.0	3.0	7.0
8.0	6.0	4.0	8.0
10.0	6.0	4.0	8.0
12.0	7.0	4.0	10.0
14.0	7.0	4.0	10.0
16.0	8.0	5.0	10.0
18.0	8.0	5.0	10.0

TABLE 2 MINIMUM PIPE INSULATION THICKNESS (Inches) CONDENSATE RETURN				
	INSULATIONS for Drainable/Dryable Systems			INSULATIONS for Other Pre-Engineered Systems
Nominal Pipe Diameter (inches)	Delta	Theromo-12 Super Caltemp	MPT-PF MPT-PC	Polyurethane
1.0	2.0	3.0	1.5	N/A
1.5	2.0	3.0	1.5	N/A
2.0	2.0	3.0	1.5	0.77

TABLE 2 MINIMUM PIPE INSULATION THICKNESS (Inches) CONDENSATE RETURN				
	INSULATIONS for Drainable/Dryable Systems			INSULATIONS for Other Pre-Engineered Systems
Nominal Pipe Diameter (inches)	Delta	Theromo-12 Super Caltemp	MPT-PF MPT-PC	Polyurethane
2.5	2.0	3.0	1.5	N/A
3.0	2.5	3.5	2.0	1.05
4.0	2.5	3.5	2.0	1.05
5.0	2.5	3.5	2.0	N/A
6.0	3.0	4.5	2.5	1.32
8.0	3.0	4.5	2.5	N/A
10.0	4.0	5.0	3.0	N/A
12.0	4.0	5.0	3.0	N/A
14.0	4.0	5.0	3.0	N/A
16.0	4.0	5.0	3.0	N/A
18.0	4.0	5.0	3.0	N/A
1) Delta is available from Rockwool in Leeds, Alabama.				
2) MPT is available from Mineral Products of Texas in Houston, TX				
3) Thermo-12 and Super Caltemp are available from Johns Manville in Denver, Colorado.				

TABLE 2A MINIMUM PIPI THICKNESS (Inches) CONDENSATE RETURN HIGH TEMPERATURE HOT WATER RETURN SYSTEM	
Nominal Pipe Diameter (inches)	Sides and Bottom
1.0	3.0
1.5	3.0
2.0	3.0
2.5	4.0

TABLE 2A MINIMUM PIPI THICKNESS (Inches) CONDENSATE RETURN HIGH TEMPERATURE HOT WATER RETURN SYSTEM	
Nominal Pipe Diameter (inches)	Sides and Bottom
3.0	4.0
4.0	4.0
5.0	4.0
6.0	4.0
8.0	5.0
10.0	6.0
12.0	6.0
14.0	7.0
16.0	7.0
18.0	7.0
Note: 1) For return lines only the side dimension is provided as other dimensions are taken from the tables for the supply size and operating conditions.	

2.6 HEAT DISTRIBUTION PIPING

2.6.1 Steam and High Temperature Hot Water Pipe

Pipe material shall be steel; seamless ASTM A53/A53M, Grade B or ASTM A106/A106M, Grade B; or electric resistance welded ASTM A53/A53M, Grade B; Schedule 40. Standard weight will be permitted for pipe sizes 12 inches and above. ASTM A53/A53M, Type F furnace butt welded pipe will not be allowed. Joints will not be allowed in factory fabricated straight section of carrier pipes. Factory fabricated piping sections, as part of an expansion loop or bend, shall have all welded joints 100 percent radiographically inspected in accordance with ASME B31.1. Radiographs shall be reviewed and interpreted by a Certified American Society for Nondestructive Testing (ASNT) Level III radiographer, employed by the testing firm, who shall sign the reading report.

2.6.1.1 Condensate Pipe

Pipe shall be steel; seamless ASTM A53/A53M, Grade B or ASTM A106/A106M, Grade B, schedule 80; electric resistance welded ASTM A53/A53M, Grade B; Schedule 80. ASTM A53/A53M, Type F furnace butt welded pipe will not be allowed. Joints will not be allowed in the factory fabricated straight section of the carrier pipe. Factory fabricated piping sections, as part of an expansion loop or bend shall have all welded joints 100 percent radiographically inspected in accordance with ASME B31.1. Radiographs shall be reviewed and interpreted by an ASNT Certified Level III radiographer, employed by the testing firm, who shall sign the reading report.

2.6.1.2 Joints

Joints shall be butt-weld except socket-weld joints will be permitted for pipe sizes 2 inches and smaller. Dye penetrant may be used in place of 100 percent radiographic inspection for pipe sizes 2 inches and below. Location and elevation of all field joints shall be indicated on detailed design layout drawings. Split-ring welding rings may be used.

2.6.2 Fittings

Welds in factory fittings shall be radiographically inspected. Radiographs shall be reviewed and interpreted by a Certified ASNT Level III radiographer, employed by the testing firm, who shall sign the reading report. The Contracting Officer may review all inspection records, and if any welds inspected are found unacceptable in accordance with ASME B31.1, the fitting shall be removed, replaced, and radiographically reexamined at no cost to the Government.

2.6.2.1 Butt-Welded

Fittings shall be steel; ASTM A234/A234M, Grade B or ASME B16.9, same schedule as adjoining pipe. Elbows shall be long radius unless otherwise indicated. Tees shall be full size or reducing as required, having interior surfaces smoothly contoured. Split-ring welding rings may be used.

2.6.2.2 Socket-Welded

Fittings shall be forged steel ASME B16.11; 2000 pound class shall be used for pipe sizes 2 inch and below. Dye penetrant inspection may be used in lieu of radiographic inspection of welded fittings for pipe sizes 2 inches and below.

2.7 EXPANSION LOOPS AND BENDS

Stresses shall be less than the maximum allowable stress from the Power Piping Code (ASME B31.1). Submit pipe-stress and system-expansion calculations for each expansion compensation elbow using a finite element computer generated 3 dimensional analysis, not later than [7 days] [_____] after notice to proceed. Demonstrate with calculations that pipe stresses from temperature changes are within the allowable requirements in ASME B31.1 and that the anchors and the guides will withstand the resultant forces. Detailed design layout drawings shall include all analysis node points. As a minimum, computer analysis results shall include node stresses, forces, moments and displacements. Calculations shall be stamped by a registered Professional Engineer in the employ of the UHDS manufacturer. Detailed design layout drawings and stress and anchor force calculations shall be provided for all loops and bends. Locations of all anchors, guides and supports shall be shown. The calculations shall be based on design characteristics (pressures and temperatures) specified for both the supply and return lines.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Job Conditions

Phasing of [demolition and construction] [construction] shall be as shown on contract drawings.

3.1.2 Interruption of Existing Service

Submit schedule of proposed outages and interruptions of existing services, [14 days] [_____] in advance. Arrange, phase and perform work and provide temporary facilities, materials, equipment, and connections to utilities, to ensure adequate heat distribution service for existing installations at all times. Only necessary interruptions required for making connections will be permitted, and only at times when approval is obtained from the Contracting Officer. Set all interruptions to be [between the hours of [_____] and [_____]] [as approved by the Contracting Officer].

3.1.3 Grading

Unless otherwise shown on the contract drawings or the detailed design layout drawings, steam/condensate and high temperature hot water supply/return lines shall be graded uniformly downward not less than 5.0 inches in 100 feet to the lower point of entry between manholes and/or building entries.

3.1.4 Connecting to Existing Work

Submit changes required to the UHDS design due to interferences or conflicts, upon realization of interferences or conflicts. Connect new work to existing work in a neat and workmanlike manner. Make connections only in manholes. Where an existing structure must be cut or existing utilities interfere, such obstructions shall be bypassed, removed, replaced or relocated, restored and repaired. Any changes required to the UHDS design as a result of interferences or conflicts shall be approved by the UHDS designer and the Contracting Officer. Work disturbed or damaged shall be replaced to its prior condition.

3.1.5 Coordination

The location of all items of equipment and work of all trades shall be coordinated. Operability and maintainability of the equipment and systems shall be maintained.

3.1.6 Variations

Any variations from the approved, detailed design layout drawings shall be submitted to the Contracting Officer for approval. Variations shall be signed and sealed by the UHDS manufacturers' professional engineer responsible for the complete design of the UHDS.

3.2 DEMOLITION

3.2.1 Demolition Procedures

Work shall be performed in accordance with requirements for phasing. Pipe, valves, fittings, insulation, and hangers, including the connection to the structure and any fastenings, shall be removed. Openings in manhole or building walls shall be sealed after removal of piping. Material and equipment removed shall become the property of the Contractor and shall be removed from Government property within 1 week and shall not be stored in operating areas. Flame cutting shall be performed with adequate fire protection facilities available as required by safety codes and Contracting

Officer.

3.2.2 Asbestos Removal

Asbestos removal shall conform to Section 02 82 00 ASBESTOS REMEDIATION.

3.3 PIPE, PIPING JOINTS AND FITTINGS

3.3.1 Joint Preparation

Pipe and fittings shall be cleaned inside and outside before and after assembly. Dirt, scale, and other foreign matter shall be removed from inside the piping by use of a pipe swab or pipe pig before connecting pipe sections, valves, equipment or fittings. Eccentric connectors shall be used as needed between casing sections to provide drainage of casing section between manholes and between manholes and buildings.

3.3.2 Direction Changes

Changes in direction shall be made with factory-built reinforced fittings. Field-fabricated fittings and miters will not be permitted.

3.4 WELDING

Submit Certification of Acceptability of all welds made in the field, upon completion of the project. This certification shall consist of a letter, signed by an official of the independent testing firm or firms examining welds, stating that all provisions of this specification have been complied with, and that all welds inspected radiographically have met the specified acceptability standards. The Contractor will be responsible for welding quality and shall:

a. Conduct tests of the welding procedures used in the work, determine the suitability of the procedures used, determine that the welds made will meet the required tests, and determine that the welding operators have the ability to make sound welds under standard conditions.

b. Comply with ASME B31.1.

c. Perform all welding operations required for construction and installation of the heat distribution system.

3.4.1 Qualification of Welders

Rules of procedure for qualification of all welders and general requirements for fusion welding shall conform with the applicable portions of ASME B31.1, and as outlined below.

3.4.2 Examining Welders

Examine each welder to determine the ability of the welder to meet the required qualifications. Welders shall be tested for welds in all positions, including welds with the axis horizontal (not rolled) and with the axis vertical. Each welder shall:

a. Weld only in positions in which they have qualified.

b. Identify welds with the specific code marking signifying name and number assigned.

3.4.3 Examination Results

Furnish a list of welder's names and corresponding code markings. Welders which fail to meet the prescribed welding qualifications shall be retested. Welders who fail the second test shall be disqualified for work on this project.

3.4.4 Beveling

Field and shop bevels shall be done by mechanical means or by flame cutting. Where beveling is done by flame cutting, surfaces shall be thoroughly cleaned of scale and oxidation just prior to welding.

3.4.5 Alignment

Split welding rings shall be used for field joints on carrier pipes above 2 inches to assure proper alignment, complete weld penetration, and prevention of weld spatter reaching the interior of the pipe. Field joints 2 inches and smaller shall be made with welding sockets.

3.4.6 Erection

Piping shall not be split, bent, flattened, or otherwise damaged before, during, or after installation. Where the pipe temperature falls to 32 degrees F or lower, the pipe shall be heated to approximately 00 degrees F for a distance of 1 foot on each side of the weld before welding, and the weld shall be finished before the pipe cools to 32 degrees F.

3.4.7 Defective Welds

Defective welds shall be replaced and reinspected in accordance with ASME B31.1. Repairing defective welds by adding weld material over the defect or by peening will not be permitted. Welders responsible for defective welds shall be tested for qualification.

3.4.8 Electrodes

Electrodes shall be stored in a dry, heated area, and shall be kept free of moisture and dampness during fabrication operations. Electrodes that have lost part of their coating shall not be used.

3.4.9 Radiographic Testing

An approved independent testing firm regularly engaged in radiographic testing shall perform radiographic examination of 100 percent of the field welds in the carrier piping of direct-buried systems in accordance with ASME B31.1. The following shall be furnished: a set of films showing each weld inspected, a reading report evaluating the quality of each weld, and a location plan showing the physical location where each weld is to be found in the completed project, prior to installing casing field joints, backfilling and hydrostatic testing. All radiographs shall be reviewed and interpreted by a Certified American Society for Nondestructive Testing Level III radiographer, employed by the testing firm, who shall sign the reading report. The Contracting Officer may review all inspection records, and if any welds inspected are found unacceptable they shall be removed, rewelded, and radiographically reexamined at no cost to the Government.

3.5 HEAT DISTRIBUTION SYSTEM INSTALLATION

Submit a complete description of the design and assembly of the system, materials of construction and field installation instructions, not later than [21 days] [_____] prior to the start of field measurements. Include sufficient system details to show that the specified minimum insulation thickness has been met. A detailed design layout of the system (plan and elevation views) showing size, type, elevations and location of each component to be used in the system, the design and location of anchors, pipe guides, pipe supports, expansion loops, Z-bends, L-bends, end seals, leak plates, joint locations, pipe and insulation thickness and sizes, types, and movements, connection to manhole and building wall penetrations, and including, if applicable, details of transition point to aboveground or other type systems. Also, if applicable, type and details of the cathodic protection system to be used. Detailed design layout drawings shall be stamped by a registered Professional Engineer. The UHDS manufacturer's representative shall oversee the delivery, storage, installation and testing of the system. Work shall be in accordance with the requirements specified and with the printed instructions of the manufacturer. These specifications shall take precedence over the printed instructions if conflicts arise. Printed instructions shall be submitted to the Contracting Officer prior to system installation. Submit operation and maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, procedures for recording conduit temperatures biannually, and troubleshooting guides, before completion of work. Include in the Manual as-built piping layout of the system with final elevations.

3.5.1 Verification of Final Elevations

For the PIPI system, prior to covering the top of the pipe with PIPI, measure and record the elevation of the top of each pipe at each field joint, 1/3 points along each pipe section, and the top of each elbow. For the PIPI system, elevations of the top of each pipe shall be measured and recorded. Elevations shall be taken at every completed field joint, 1/3 points along each pipe section and top of elbows. These measurements shall be checked against the contract drawings and shall confirm that the conduit system has been installed to the elevations shown on the contract drawings. Slope shall be uniform to within 0.1 percent. These measurements shall be recorded by the Contractor, included in the UHDS manufacturer's representative daily report, and given to the Contracting Officer prior to covering the casing with backfill material.

3.5.2 Excavation, Trenching, and Backfilling

Excavation, trenching, and backfilling shall be performed as required by the UHDS manufacturer's design and as specified in Section [31 00 00 EARTHWORK]. Pipe shall lay on a 12 inch minimum sand bed and shall be backfilled with sand on all sides to a minimum of 6 inches as measured from outside of casing. This sand bedding requirement does not apply to the PIPI system. Foundation for system shall be firm and stable. Foundation and backfill shall be free from rocks or substances which could damage the system coating. Concrete anchor and thrust blocks shall be installed in undisturbed earth. Backfilling shall not commence until system has been satisfactorily pressure tested (both hydrostatic test of carrier and air test of casing). Minimum depth of burial to the top of the casing (or PIPI envelope) shall be 39 inches. Maximum depth of burial to the top of the casing (or PIPI envelope) shall be 10 feet.

3.5.3 UHDS Manufacturer's Representative Responsibilities

The UHDS Manufacturer's representative shall be present at the job site and witness when the following types of work are being performed:

a. Inspection and unloading (not applicable to PIPI).

b. Inspection of trench prior to commencing installation of system.

c. Inspection of concrete anchors and thrust blocks.

d. Pneumatic and Hydrostatic testing.

e. Field joint closure work (not applicable to PIPI).

f. Air test of casing (not applicable to all WSL systems).

g. Holiday test of conduit coating (not applicable to all WSL systems).

h. Repair of any coating (not applicable to all WSL systems).

i. Installation of cathodic protection system (not applicable to all WSL systems).

j. Initial backfill up to 10 inches above the top of the casing.

k. Verification of final elevations. Elevation readings shall be witnessed and recorded.

l. Testing of cathodic protection system (not applicable to all WSL systems).

m. Operational tests.

The UHDS manufacturer's representative shall notify the Contractor immediately of any problems. The UHDS manufacturer's representative shall notify the Contracting Officer of problems requiring immediate action; otherwise, the daily reports shall note any problems encountered and indicate the corrective actions taken.

3.5.4 UHDS Manufacturer's Representative Reports

The UHDS manufacturer's representative shall: prepare and sign a written daily report; present the original daily report to the Contracting Officer no later than one working day after it is prepared; and forward 1 copy to the manufacturer's main office. The report shall state whether or not the condition and quality of the materials used and the delivery, storage, installation and testing of the system are in accordance with the drawings, specifications, and manufacturer's printed instructions and are satisfactory in all respects. When any work connected with the installation is unsatisfactory, the report shall state what corrective action has been taken or shall contain the UHDS manufacturer's recommendations for corrective action. The report shall identify any condition that could result in an unsatisfactory installation, including such items as open conduit ends left in the trench overnight and improper manhole entries. The daily reports shall be reviewed, signed and sealed, on a weekly basis, by the registered engineer responsible for the system design. Signed and sealed copies of the daily reports shall be submitted with the payment request. Requests for payment will be denied if the weekly review is not accomplished. Upon completion of the work and before final acceptance, a notarized Certificate of Compliance, signed by a principal officer of both the manufacturing and the contracting firms, stating that the installation is satisfactory and in accordance with drawings, specifications, and manufacturer's instructions shall be delivered to the Contracting Officer. The UHDS manufacturer shall retain a copy of all daily reports and the Certificate of Compliance for 5 years after final acceptance of the system by the Government.

3.5.5 Protection

Casing coating shall be protected from damage during unloading, storage, rigging and installation. Casing and carrier pipe ends shall be protected from water intrusion during unloading, storage, rigging and installation. Piping and accessories shall be protected from damage due to exposure to UV light.

3.5.6 Defective Material

The UHDS manufacturer's representative shall take prompt action to remove from the site all damaged or defective material, subject to rejection in accordance with the quality assurance provisions included in the manufacturer's submittals and printed instructions, and shall order prompt replacement of such material.

3.5.7 Cathodic Protection Installation

Provide cathodic protection for all steel casing systems and all buried exposed metal. Assume that 25 percent of the exterior of the UHDS is exposed metal. Submit design life calculations for the cathodic protection system, not later than [7 days] [_____] after notice to proceed. Calculations shall be stamped by an NACE qualified corrosion engineer. Cathodic protection systems shall have a minimum design life of 25 years and shall conform to [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM] [or] [Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM]. Dielectric pipe flanges and waterways, and isolation devices shall be provided at all points necessary. Test stations at grade shall be provided on each section of the piping system. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match the connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

3.6 TESTS

Submit a proposed test procedure and proposed samples of test data sheets for each required test, 30 days prior to the proposed test date. The procedure shall contain a complete description of the proposed test with calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in the tests. The test shall not commence until the procedure has been approved. Leak-tightness of all piping systems shall be demonstrated by performing pressure tests (hydrostatic, pneumatic) and operational tests. Heat distribution system shall be pressure tested in conformance with specified requirements and printed instructions for the system supplied; tests shall include carrier piping and casing. The carrier pipe shall be hydrostatically tested. Casings of DDT systems shall be pneumatically tested. Casing and end seals of WSL system shall be tested for intrusion of water into the casing and insulation. Mercury shall not be used in thermometers required for the tests.

3.6.1 Holiday Testing of Direct-buried System Steel Casings

Entire exterior surface of the casing, including the bottom exterior surface, shall be tested for faults in coating after installation in trench, prior to backfilling, using test method and voltage recommended by coating manufacturer. If any holidays are found, they shall be repaired and the coating retested. System shall not be backfilled until all holidays are eliminated.

3.6.2 Pneumatic, Hydrostatic and Operational Tests

Before conducting heat distribution system tests, lines shall be flushed with high pressure water until [discharge shows no foreign matter] [the Contracting Officer, after examining the discharge, stops the flush].

3.6.2.1 Pneumatic Test

The casing of DDT systems shall be pneumatically tested after welding and before field coating using air as the test medium. The test pressure shall be 5 psig. Persons not working on the test operations shall be kept out of the testing area while testing is proceeding. The test shall be made on the system as a whole or on sections that can be isolated. Joints in sections shall be tested prior to backfilling when trenches must be backfilled before the completion of other pipeline sections. The test shall continue for 24 hours from the time of the initial readings to the final readings of pressure and temperature. The initial test readings of the instrument shall not be made for at least 1 hour after the casing has been subjected to the full test pressure, and neither the initial nor final readings shall be made at times of rapid changes in atmospheric conditions. There shall be no indication of reduction of pressure during the test after corrections have been made for changes in atmospheric conditions in conformity with the relationship $T(1)P(2) = T(2)P(1)$, in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial (1) and final (2) readings. Pressure shall be measured with a pressure gauge conforming to ASME B40.100. A throttling type needle valve or a pulsation dampener and shutoff valve may be included. The diameter of the face shall be at least 4.5 inches with a measurable range of 0 to 15 psig and graduations of at least 0.5 psig. During the test, the entire system shall be completely isolated from all compressors and other sources of air pressure. Each joint shall be tested while under test pressure by means of soap and water or an equivalent nonflammable solution prior to backfilling or concealing any work. All labor, materials and equipment for conducting the tests shall be furnished by the Contractor and shall be subject to inspection at all times during the tests. Maintain proper safety precautions for air pressure testing at all times during the tests.

3.6.2.2 Hydrostatic Test

Carrier piping shall be tested hydrostatically before insulation is applied at field joints and shall be proved tight at a pressure 1.5 times the heat distribution supply pressure of [_____] psig for 2 hours. There shall be no indication of reduction of pressure during the test. Pressure shall be measured with a device calibrated to be read in increments not greater than 0.1 psi.

3.6.2.3 Operational Test

Prior to acceptance of the installation, subject system to operating tests simulating actual operating conditions to demonstrate satisfactory functional and operating efficiency. These operating tests shall cover a period of not less than 6 hours for each portion of system tested. Submit for approval a schedule of the tests to be performed [14 days] [_____] in advance. Provide calibrated instruments, equipment, facilities and labor, at no additional cost to the Government. When failures occur, problems shall be repaired and test repeated.

3.6.3 Deficiencies

Deficiencies discovered shall be corrected at the Contractor's expense. Major deficiencies, or failure to correct deficiencies, may be considered cause for rejecting the entire installation.

3.7 VALVE MANHOLES

Valve manholes, piping, and equipment in valve manholes shall be in accordance with the contract drawings and Section 33 61 13.19 VALVES,PIPING, AND EQUIPMENT IN VALVE MANHOLES.

3.8 BURIED UTILITY WARNING AND IDENTIFICATION

3.8.1 Plastic Marking Tape

Polyethylene plastic tape manufactured specifically for warning and identifying buried utility lines shall be supplied and installed. Tape shall be buried above the pipe during the trench backfilling operation and shall be buried approximately 12 inches below grade. Tape shall be [0.004 inch thick polyethylene] [polyethylene with a metallic core]. Tape shall be acid- and alkali-resistant and shall have a minimum strength of 1750 psi lengthwise and 1500 psi crosswise with an elongation factor of 350 percent. The tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 3 feet deep. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion. The tape shall be of a type specifically manufactured for marking and locating metallic underground utilities. Tape shall be 6 inches wide and printed with a caution and identification of the piping system over the entire tape length. Tape shall be yellow with bold black letters. Tape color and lettering shall be unaffected by moisture and other substances contained in the backfill material.

3.8.2 Markers for Underground Piping

Markers for underground piping shall be located along the distribution and service lines. Markers shall be placed as indicated approximately 2 feet to the right of the distribution system when facing in direction of flow in the supply line. The marker shall be concrete 6 inch square or round section [2] [3] feet long. The top edge of the marker shall have a minimum 1/2 inch chamfer all around. The letters [STEAM] [HTHW] [CONDENSATE] shall be impressed or cast on the top, and on one side of the markers to indicate the type of system that is being identified. Each letter shall be formed with a V-shaped groove and shall have a width of stroke at least 1/4 inch at the top and depth of 1/4 inch. The top of the marker shall protrude not more than [1] [2] [3] [4] inches above finished grade.

3.9 THERMAL PERFORMANCE TESTING

The equipment and procedures specified shall be used to ensure acceptable thermal performance of the installed system. Submit manufacturer's data sheets on all UHDS components and the instrumentation required for thermal performance testing, [_____] days after notice to proceed. Because of its geometry, the PIPI system is exempt from the thermal performance test requirement; the test results shall be submitted for approval. All materials and procedures described for this test shall be included as deliverables of the construction contract for the system, unless otherwise noted. Due to its geometry, the PIPI system is exempt from this requirement.

3.9.1 Equipment

3.9.1.1 Casing Temperature Measurement

Before backfilling, and after field joint closures have been welded to the casing and the coating has been applied and cured, temperature sensors shall be attached to the exterior of every other field joint closure. The sensors shall be attached with epoxy suitable for use at 500 degrees F. A sensor shall be adhered with epoxy to the coated casing near the midpoint of every other pipe section between field joints. The sensor shall not be located closer than 5 feet from any guide in the interior of the casing. After the sensors have been adhered to the casing, 2 complete wraps of duct tape shall be used to secure and protect the sensor. The radial position of the sensors shall be located 45 degrees from the top center of the casing, at either the 1:30 or 10:30 position, away from the adjacent heat distribution system pipe if present. All sensors shall be type T copper constantan 20 gauge thermocouples, made from special limits grade thermocouple wire, 0.5 degrees C or 0.4 percent maximum error, with each conductor insulated and an overall jacket on both conductors. Insulation on the thermocouple wires shall be suitable for service at 500 degrees F. The thermocouple wire between sensor location and termination point shall be continuous with no splicing or other connections. Each sensor shall be shown with a special symbol on the detailed design layout drawings and shall be identified by a number and/or letter code, starting from the upstream manhole.

3.9.1.2 Carrier Pipe Temperature Measurement

Carrier pipe temperature shall be measured within the manhole where the panel box is located. Carrier pipe temperature shall be measured by a sensor adhered with epoxy directly to the exterior of the carrier pipe. All sensors shall be type T copper constantan 20 gauge thermocouples, made from special limits grade thermocouple wire, 0.5 degrees C or 0.4 percent maximum error, with each conductor insulated and an overall jacket on both conductors. Insulation on the thermocouple wires shall be suitable for service at 500 degrees F. The thermocouple wire between sensor location and termination point shall be continuous with no splicing or other connections. The location of this sensor shall be at either the 1:30 or 10:30 position. At the location of the sensor, the carrier pipe shall be insulated with calcium silicate insulation at least 5 inches thick. This insulation shall extend at least 6 inches on each side of the actual sensor location and shall be clad with an aluminum jacket.

3.9.1.3 Terminals

The wires from each casing or carrier pipe temperature sensor shall be extended into the nearest manhole and terminated in a panel box. The panel box shall be a NEMA Type 4 waterproof enclosure, of suitable size, mounted near the top of the manhole at a location near the manhole entrance, accessible without entrance into the manhole, where possible. The termination of the sensor wires shall be with an approved connector of type [OMEGA Miniature Jack Panel (MJP-*-*-T)] [_____]. The thermocouple jack panel shall be mounted to the back plate of the panel box. The temperature sensors shall be labeled at their termination within the panel box; a drawing showing the location of each temperature sensor shall be laminated and attached to the inside of the panel box. All temperature sensors shall be verified as operational by an independent laboratory, hired by the Contractor, after backfilling is complete but before the system is accepted.

3.9.2 Thermal Performance Test

After the system construction is complete, including backfilling, and the system has reached operating condition for at least 30 days, all of the temperature sensors shall be read by an independent laboratory with experience and equipment appropriate for the sensors used. The temperature shall be recorded for each sensor. The temperatures shall be tabulated and submitted in accordance with specified requirements. If temperatures exceed values in Table 3, that portion shall be repaired and temperatures again measured and recorded.

TABLE 3

Carrier Pipe Temperature - TP (degrees F)	Acceptable Casing Temperature - TC (degrees F)
250	110
275	116
300	123
325	129
350	136
400	149
425	155
450	
The following equations were used to calculate the above values:	
T@ <(0.261) X (TP) + 44.3	
For carrier pipe temperatures between those given in Table 3, the maximum acceptable casing temperature may be either interpolated from the values in Table 3 or calculated using the equations above.	

-- End of Section --

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SECTION 33 61 13.13

PREFABRICATED UNDERGROUND HYDRONIC ENERGY DISTRIBUTION
02/16

PART 1 GENERAL

1.1 SUMMARY

The system consists of a buried prefabricated [chilled water] [and] [low temperature hot water] [dual temperature] distribution system including service connections to a point 6 inches inside of the building. The contract drawings show the specific arrangement of piping, sizes and grades of pipe, and other details. The system is designed for an operating pressure of [_____] psig and an operating temperature of [[_____] degrees F for hot water] [and] [[_____] degrees F for chilled water].

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B31.1	(2020) Power Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2015) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS B2.2/B2.2M	(2016) Specification for Brazing Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM C518	(2021) Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM D1384	(2005; R 2019) Corrosion Test for Engine Coolants in Glassware
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC)

	Plastic Piping Systems
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D2997	(2015) Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM D5685	(2019) Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2016; 14/17) Copper Tube Handbook

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication and Assembly Drawings

SD-03 Product Data

Support of the Equipment

Markers For Underground Piping

SD-07 Certificates

Welding

Written Certification

SD-10 Operation and Maintenance Data

Maintenance; G[, [_____]]

1.4 QUALITY ASSURANCE

[Weld piping in accordance with qualified procedures using performance qualified welders and welding operators. Qualify procedures and welders in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Prior to welding operations, submit a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators. Notify the Contracting Officer 24 hours in advance of tests performed at the work site, if practicable. Apply welder's personal assigned symbol near each weld made as a permanent record. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] [Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING.]

1.5 DELIVERY, STORAGE, AND HANDLING

After delivery to the jobsite, protect all materials and equipment from anything which could cause damage to the material or equipment. Seal piping at each end to keep the interior clean and free of dirt and debris. Keep fittings together and keep their interior surfaces clean at all times. Keep insulation dry and clean.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide system components which are standard products of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Provide a service organization that is, in the opinion of the Contracting Officer, convenient to the site.

Equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

a. Submit detail drawings consisting of fabrication and assembly drawings, for all parts of the work in sufficient detail to check conformity with the requirements of the contract documents, prior to installation. In the detail drawings show complete piping, wiring and schematic diagrams and any other details to demonstrate that the system has been coordinated and will properly function as a unit. Show on the drawings proposed layout, method of compensation for pipe expansion and contraction, anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances required for maintenance and operation.

b. Submit the manufacturer's or system fabricator's written certification stating that the distribution system furnished meets all the requirements of this specification. Clearly identify on the drawings any proposed deviations from the requirements of the contract documents.

2.2 PIPING AND CASING MATERIALS

2.2.1 General

Provide metallic pressure pipe, fittings, and piping accessories that conform to the requirements of ASME B31.1 and are types suitable for the temperature and pressure of the water.

2.2.2 Piping

2.2.2.1 Steel Pipe

Provide piping conforming to ASTM A53/A53M, Grade B, standard weight, black or to ASTM A106/A106M, Grade B, standard weight.

2.2.2.2 Copper Tubing

Provide tubing conforming to ASTM B88, Type K or L.

2.2.2.3 Reinforced Thermosetting Resin Pipe (RTRP)

Provide RTRP conforming to [ASTM D2996][ASTM D2997].

2.2.2.4 Polyvinyl Chloride (PVC) Pipe

Provide PVC piping conforming to ASTM D2241 with a Standard Thermoplastic Pipe Dimension Ratio (SDR) of 26 and PVC 1120 or 1220 as the material.

2.2.2.5 Joints and Fittings for Copper Tubing

Provide wrought copper and bronze solder-joint pressure fittings that conform to ASME B16.22 and ASTM B75/B75M. Provide cast copper alloy solder-joint pressure fittings conforming to ASME B16.18. Provide cast copper alloy fittings for flared copper tube conforming to ASME B16.26 and ASTM B62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Design grooved mechanical joints and fittings for not less than 125 psig service. Provide grooved mechanical joints and fittings that are the product of the same manufacturer. Provide grooved fitting and mechanical coupling housing of ductile iron conforming to ASTM A536, with molded synthetic polymer of pressure responsive design conforming to ASTM D2000 for circulating medium up to 230 degrees F and grooved joints conforming to AWWA C606. Provide steel nuts and bolts conforming to ASTM A183 for coupling for use in grooved joints..

2.2.3 Casings

2.2.3.1 Polyvinyl Chloride (PVC) Casing

Provide PVC casings that conform to ASTM D1784, Class 12454-B with a minimum thickness equal to the greater of 1/100 the diameter of the casing or 60 mils.

2.2.3.2 Polyethylene (PE) Casing

Provide polyethylene casings conforming to ASTM D3350, Type III, Class C, Category 3 or 4, Grade P 34 with thickness as follows:

Casing Diameter (inches)	Minimum Thickness (mils)
10 and smaller	125
10 to 18	150
18 through 24	200
over 24	225

2.2.3.3 Reinforced Thermosetting Resin Pipe (RTRP) Casing

Provide RTRP casing of the same material as the pipe, with casing thickness as follows:

Casing Diameter (inches)	Minimum Thickness (mils)
8 and smaller	70
10	80
12	105
14	115
16 to 18	120
20	125
24	155

2.3 PIPING CONNECTIONS

2.3.1 Steel Pipe

For pipe smaller than 0.75 inch, provide Schedule 80 steel pipe with threaded end connections conforming to ASME B1.20.1. Weld all steel pipe 0.75 inch and larger. Provide steel welding fittings conforming to the requirements of ASTM A105/A105M or ASTM A234/A234M. Provide welding fittings conforming to ASME B16.9 for buttweld fittings and ASME B16.11 for socket-weld fittings. Use long radius buttwelding elbows conforming to ASME B16.9 whenever space permits.

2.3.2 Copper Pipe

Braze or provide insulated pipe couplings for copper pipe connections with wrought copper or cast copper alloy solder joint pressure fittings conforming to AWS B2.2/B2.2M and CDA A4015. Provide cast bronze containing an O-ring seal on each end, jacketed and sealed, to act as an expansion joint for insulated pipe couplings for copper pipe.

2.3.3 Plastic Pipe

a. Provide adhesive bell and spigot type end connections for pipe, fittings, flanges, and couplings. Threaded piping, including pipe, fittings, flanges, and couplings, will not be permitted.

b. Flanged Connections: Provide flat face flanged connections between plastic piping and metal piping suitable for connection to ASME Class 150 flanges.

c. RTRP Piping Sizes: Provide the next larger size where piping sizes other than 2, 3, 4, 6, and 8 inches are indicated with piping connections of the same size or increased to meet the next size of RTRP piping.

2.3.3.1 Plastic Fittings

Provide plastic fittings of the same type and grade of material as the piping to which they will be connected and furnished by the manufacturer who supplies the pipe. Provide temperature and pressure rating for fittings not less than those of the connecting piping.

2.3.3.2 Polyvinyl Chloride (PVC)

Provide solvent welded or connected using bell and spigot connections for polyvinyl chloride (PVC) pipe with solvent used to connect fittings and pipe conforming to the requirements of ASTM D2564. Bell and spigot joints utilizing elastomeric seals conforming to the requirements of ASTM D3139. The elastomeric seals must conform to ASTM F477.

2.3.3.3 Reinforced Thermosetting Resin Plastic (RTRP)

Join reinforced thermosetting resin plastic pipe using fittings and adhesive furnished by the pipe manufacturer in accordance with ASTM D5685.

2.4 END SEALS

Provide pre-insulated sections of pipe with complete sealing of the insulation to provide a permanent water and vapor seal at each end of the pre-insulated section of piping. Provide field modified pre-insulated sections of piping with an end seal which is equivalent to the end seals furnished with the pre-insulated section of piping. Test and certify end seals in accordance with paragraph Casing and End Seal Testing and Certification.

2.4.1 Types

Provide end seals of one of the following types:

a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Provide sufficient surface bonding area between the casing and the carrier pipe.

b. Using specially designed molded caps made of polyethylene or rubber of standard manufactured thickness. Provide a minimum of 1.5 inch surface bonding area between the cap and both the casing and carrier pipe.

c. Using elastomeric-ring end seals designed and dimensioned to fit in the annular space between the casing and the carrier pipe.

d. Using a waterproof mastic seal vapor barrier over the exposed insulation ends.

e. Shrink sleeves.

2.4.2 Casing and End Seal Testing and Certification

Demonstrate that testing and certification procedures by an independent testing laboratory, for casings and end seals, are capable of resisting penetration of water into the casing and insulation. Perform the test on each type of prefabricated system to be furnished. Provide hot and cold cycle testing followed by immersion in a water filled chamber with a head pressure, consisting of 14 days of temperature cycling. Circulate a fluid with a temperature of 40 degrees F through the carrier pipe alternating every 24-hours with a fluid with a temperature of 200 degrees F circulating through the carrier pipe for a low temperature hot water or dual temperature service or 75 degrees F for a chilled water service. While the hot and cold cycle test is being performed, the test sample is either buried or encased in dry bedding sand with a minimum of 12 inches of sand all around the test sample. Restrain the 3 inches diameter carrier pipe of the test sample during the test period. Provide an insulation thickness not to exceed the maximum thickness provided for the piping in the project. Do not exceed transition times for temperature cycle testing of 15 minutes in going from cold to hot and 30 minutes in going from hot to cold. The fluid in the carrier pipe may be water, oil or heat transfer fluid. Immerse the test sample in a water filled chamber following the hot and cold cycling test. Provide a pressure of not less than 20 feet of water head pressure at the highest point over the entire length of the 8 foot test sample for a minimum of the 48 hour test period. Provide water containing a dye penetrant to check for end seal leakage. Upon completion of the pressure test, cut the test sample open using a light that will readily show the presence of the dye that was in the water, inspect the test sample. Evidence of the dye inside the test sample indicates that the end seal is not acceptable and cannot be certified.

2.5 INSULATION

2.5.1 Factory Applied Insulation

Provide factory insulated pre-fabricated pipe and fittings with polyurethane (polyisocyanurate) foam meeting the requirements of ASTM C591 having a density not less than 2 pounds per cubic foot (pcf). Provide the polyurethane (polyisocyanurate) foam completely filling the annular space between the carrier pipe and the casing with an insulation thickness of a minimum of [0.9] [_____] inches. Provide an insulation thermal conductivity factor not exceeding the numerical value of 0.15 Btu-inch/square foot-degree F-hour at 75 degrees F, when tested in accordance with ASTM C518. Provide a manufacturer's certification that the insulated pipe is free of insulation voids.

2.5.2 Field Applied Insulation

Provide polyurethane (polyisocyanurate) field applied insulation for fittings, and field casing closures and other piping system accessories, as required, with thickness matching adjacent piping insulation thickness. For buried fittings and accessories, provide field applied polyurethane (polyisocyanurate) insulation to match adjacent piping with a protective covering matching the pipe casing. Provide shrink sleeves with a minimum thickness of 50 mils over casing connection joints.

2.6 CONCRETE VALVE MANHOLES

Provide concrete valve manholes in accordance with Section 33 61 13.19 VALVES, PIPING AND EQUIPMENT IN VALVE MANHOLES and manufactured in accordance with [Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION][Section 03 41 16.08 PRECAST CONCRETE SLABS (MAX. SPAN 8 FEET O.C.)].

2.7 PIPING AND EQUIPMENT IN VALVE MANHOLES

Provide piping and equipment in valve manholes in accordance with Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES.

2.8 TREATED WATER

Provide a [_____] percent glycol concentration, by volume, of industrial grade [ethylene] [propylene] for the system. Test glycol in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. Provide corrosion inhibitors in glycol solution compatible with pump seals, water treatment chemicals used within the system, and other elements of the system. Silicate based inhibitors are not allowed.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the project, verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing the project.

3.2 INSTALLATION

For all pre-insulated, prefabricated systems, obtain the services of a trained representative of the pipe system manufacturer to instruct the Contractor's work forces in the installation procedures to ensure that the system is installed in accordance with the manufacturer's published instructions and the plans and specifications. Provide a manufacturer's representative who regularly performs such duties for the manufacturer. Furnish the Contracting Officer a list of names of personnel trained and certified by the pipe system manufacturer in the installation of this system. Only personnel whose names appear on a less than one year old list will be allowed to install the system.

3.3 PIPING SYSTEMS

3.3.1 Buried Insulated Systems

Provide carrier pipe, insulation, casing, end seals, fittings and accessories for buried insulated systems.

3.3.2 Buried Un-insulated Systems

Provide carrier pipe, fittings and accessories for buried un-insulated systems.

3.4 VALVE MANHOLES AND PIPING EQUIPMENT IN VALVE MANHOLES

Install valve manholes and piping and equipment in valve manholes in accordance with Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES.

3.5 THRUST BLOCKS

Install thrust blocks at the locations shown or recommended by the pipe system manufacturer. Provide thrust blocks in accordance with manufacturer's recommendations. For systems requiring thrust blocks, at a minimum, provide thrust blocks at all changes in direction, changes in size, valves and terminal ends, such as plugs, caps and tees with concrete having a compressive strength of not less than 2000 psi after 28 days in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Place thrust blocks between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, pour the base and the thrust bearing sides of the thrust blocks directly against undisturbed earth. The sides of the thrust blocks not subject to thrust may be poured against forms. Locate thrust blocks so that the joints for all fittings will be accessible for repair wherever possible. Do not embed joints in concrete unless the assembly has previously been hydrostatically tested. Provide thrust blocks resisted by piles or tie rods to solid foundations in muck or peat, or replace peat or muck with ballast of sufficient stability to resist the thrust blocks.

3.6 INSTALLATION OF PIPING SYSTEMS

Prepare pipe ends to match factory coated ends and install the piping system in accordance with the manufacturer's instructions without springing or forcing other than what has been calculated for cold spring allowing free expansion and contraction without damage to joints or hangers. Do not install copper tubing in a trench with ferrous piping materials. Maintain a minimum vertical separation of12 inches between pipes when nonferrous metallic pipe (e.g., copper tubing) crosses any ferrous piping material. Provide transition fittings approved by the manufacturer of the piping system for connections between different types of pipe and system components.

3.6.1 Pitching of Horizontal Piping

Pitch horizontal pipe at a grade of not less than1 inch in 20 feet toward the drain points unless otherwise indicated.

3.6.2 Open Ends

Provide an approved cap or plug for open ends of pipelines and equipment during installation.

3.6.3 Cutting Prefabricated Piping Sections

Provide new end seals similar to factory applied end seal for field cut prefabricated pipe sections in accordance with the manufacturer's instructions.

3.6.4 Joints

3.6.4.1 Welded Joints

Provide welded joints between sections of pipe and between pipe and fittings where specified or indicated.

3.6.4.2 Threaded Joints

No threaded joints are allowed to be used belowground. Make joints tight with polytetrafluoroethylene tape applied to the male threads only with no more than 3 threads showing after the joint is made up.

3.6.4.3 Grooved Mechanical Joints

Provide grooved fittings, couplings, and grooving tools with products of the same manufacturer. Prepare grooves complying with the tolerances specified by the coupling manufacturer in accordance with the coupling manufacturer's instructions. Measure field made groove diameters using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Measure and record each groove width and dimension from end of pipe for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints are not allowed in concealed locations.

3.6.4.4 Brazed Joints

Brazed joints for copper pipe and fittings must conform to CDA A4015. Utilize brazing alloys melting above 1100 degrees F.

3.6.4.5 Nonmetallic Pipe Joints

Install nonmetallic pipe joints in accordance with the written instructions of the manufacturer.

3.6.5 Expansion Loops

If expansion compensation is needed, provide expansion loops and expansion bends (Z- and L- type) factory fabricated of casing, insulation, and carrier piping identical to that furnished for straight runs. Properly design expansion loops and bends in accordance with the allowable stress limits indicated in ASME B31.1 for the type of pipe used, and size to accommodate pipe movement. Ship expansion loops and bends to the jobsite in the maximum size sections feasible to minimize the number of field joints. Make field joints in straight runs of the expansion loops and bends, keeping the number to a minimum. For steel pipe, cold springing is not allowed when sizing the expansion loops and bends. Cold spring piping one-half the calculated maximum operational expansion during field assembly is allowed. Pipe stress in expansion loops and bends must conform to ASME B31.1.

3.6.6 Anchors

Provide factory fabricated, by the prefabricated system manufacturer, anchor design in accordance with the published data of the manufacturer and for prefabricated systems. Prevent water penetration, condensation, or vapor transmission from wetting/contacting the insulation.

3.6.7 Field Casing Closures

Execution of field insulation and encasement of joints are to be accomplished after the visual and pressure tests specified are completed and in accordance with the manufacturer's written instructions. Provide foamed in place polyurethane insulation with thickness dimensions and casing materials not less than those of the adjoining prefabricated section. Install a standard polyethylene heat shrink sleeve with a 6 inch minimum overlap at each end of the casing.

3.6.8 Underground Warning Tape

Provide underground 0.004 inch thick, 6 inches wide, printed with repetitive caution warnings along its length, [polyethylene tape] [polyethylene tape with metallic core] warning tape buried above the piping during the trench backfilling approximately12 inchesdeep. Provide tapes, yellow in color with black letters; color and lettering must not be affected by moisture or other substances contained in the backfill material.

3.6.9 Markers for Underground Piping

Submit catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents. Place markers for underground piping approximately 2 feet to the right of the distribution system in reference to the fluid flow direction.

Provide concrete markers 6 inch square or round section [2] [3] feet long with the top edge of the marker chamfered at a minimum of .5 inch all around. Impress of cast letters on the top of the marker with letters [CHW] [LHW] [DTW] to indicate the type of system that is being identified. Form each letter with a V-shaped groove with a width of stroke at least .25 inch at the top and depth of .25 inch. Provide elevation of markers no more than [1] [2] [3] [4] inches above finished grade.

3.7 EARTHWORK

Perform earthwork in accordance with Section 31 00 00 EARTHWORK.

3.8 ELECTRICAL WORK

Perform electrical work in accordance with either Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION or Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.9 TESTING

Conduct tests before, during, and after installation of the system. Provide all instruments, equipment, facilities, and labor required to properly conduct the tests. Provide test pressure gauges for a specific test with dials indicating not less than 1.5 times nor more than 2 times the test pressure.

3.9.1 Metallic Pipe Welds

Perform radiographic testing in accordance with ASME B31.1. Perform radiographic examination of field welds by an approved independent testing firm or firms regularly engaged in radiographic testing, and interpreted by a Certified Level III Radiographer employed by the testing firm. Review and interpretation of all radiographs must be by a Certified Level III Radiographer employed by the testing firm. Remove, reweld and radiographically examine any welds found to be unacceptable in accordance with the above criteria.

3.9.2 Carrier Pipe Cleaning and Testing

Test distribution piping as required before backfilling, with all joints exposed. The area between joints may be backfilled as necessary to prevent pipe movement.

3.9.2.1 Cleaning Carrier Pipe

Prior to testing, clean the interior of the carrier pipe of foreign materials by thorough flushing with clean water with a circulating water velocity between 2 and 3 m/s (7 and 10 feet per second) for a minimum of 4 hours. Provide temporary and/or supplementary pumps if required to ensure that required velocity is achieved. Clean system strainers after the flushing operation is complete. Temporary strainers must be installed as required. Leave water in the system after flushing for testing of the system to ensure the pipe will maintain pressure and is not leaking.

3.9.2.2 Hydrostatic Pressure Cycling and Tests

Hydrostatic pressure tests consist of 4 cycles; .each cycle consisting of a 10 minute period with the first cycle at 150 psig followed by a 5 minute period at a pressure less than 50 psig. Begin the next cycle immediately following the completion of the previous cycle with the pressure rise and drop no more than 100 psi per minute. Locate the pressure gauge and take the pressure measurement at the opposite end of the system from where the pressure is applied. After completion of the hydrostatic pressure cycling, perform the first hydrostatic pressure test proving the system tight at a pressure of 1.5 times the working pressure up to 150 psig and held for a minimum of 1 hour. Disconnect the pressurizing apparatus from the system before starting the 1 hour pressure holding period. Correct any test failures and repeat the hydrostatic pressure cycling and first hydrostatic pressure test until the system can hold the required pressure for at least 1 hour. After successful completion of the first hydrostatic pressure test, drain piping system and fill the piping system as defined in paragraph TREATED WATER for the remaining tests and for permanent operation of the system. Repeat the hydrostatic pressure cycling and tests for the system after the system has been filled with treated water, using the same test conditions and criteria.

3.9.2.3 Operational Test

Perform operational test on the complete system or testable portions thereof and conduct with full design flows and operating temperatures in all runs of piping as if in service, to demonstrate satisfactory function and operating effectiveness. The operational test will have two cycles. Each cycle must consist of a 6-hour period with treated water in the system at the maximum operating temperature of [_____] degrees F and maximum flow rate, and a period of at least 6-hours with no flow. For dual temperature systems, the first cycle must use the heating temperature of [_____] degrees F and the second cycle the cooling temperature of [_____] degrees F of the designed system. Supply temporary pumps, piping connections, boilers, chillers and the gauges required to circulate the water at the desired temperatures and flow rates. Re-circulate water through supply lines and return through the return piping to demonstrate that the pressure drop is compatible with the flow rate and size of pipe and to show that obstructions do not exist in the piping system. Any unusual indicated pressure drop will be investigated and any obstructions removed. Repair any leaks found. After any obstructions have been removed and any leaks repaired, repeat the operational test until successfully passed.

3.9.2.4 Final Hydrostatic Test

After successful completion of the operational test, pressurize system to

1.5 times the working pressure up to 150 psig and hold for a minimum of 4 hours. Disconnect pressurizing apparatus prior to the start of the 4-hour pressure holding period. Upon test failure, determine the cause of the failure, correct and repeat all of the hydrostatic pressure cycling and pressure tests.

3.10 MAINTENANCE

Submit [6] [_____] [hard] [optic disk] copies of operation and [6] [_____] copies of maintenance manuals for the equipment furnished, 1 complete set prior to performance testing and the remainder upon acceptance. Provide details in the operation manuals showing the step-by-step procedures required for equipment startup, operation, and shutdown. Include in the operation manuals the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include in the maintenance manuals piping and equipment layout and simplified wiring and control diagrams of the equipment system as installed. Provide approved manuals prior to the field performance testing.

-- End of Section --

SECTION 33 61 13.19

VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES
02/16

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA H35.1/35.1M	(2017) American National Standard Alloy and Temper Designation Systems for Aluminum

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.20	(2017) Metallic Gaskets for Pipe Flanges
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C449	(2007; R 2013) Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C547	(2019) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2022) Standard Specification for Cellular Glass Thermal Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM D2822/D2822M	(2005; R 2011; E 2011) Standard Specification for Asphalt Roof Cement, Asbestos-Containing
ASTM D3278	(1996; R 2011) Flash Point of Liquids by Small Scale Closed-Cup Apparatus
ASTM D3359	(2017) Standard Test Methods for Rating Adhesion by Tape Test
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2022) Standard Test Methods for Gravimetric Determination ofWater Vapor Transmission Rate of Materials

ASTM F1139	(1988; R 2019) Steam Traps and Drains

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-45	(2020) Bypass and Drain Connections
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	(2014) Class 3000 Steel Pipe Unions Socket Welding and Threaded
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 16	(2006; R 2015; E 2015) Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint
SSPC Paint 29	(2002; E 2004) Zinc Dust Sacrificial Primer, Performance-Based
SSPC SP 10/NACE No. 2	(2015) Near-White Blast Cleaning

UNDERWRITERS LABORATORIES (UL)

UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G[, [_____]]

SD-03 Product Data

Support of the Equipment

Piping and Fittings

Valves

Insulating Flanges

Insulation

Sump Pumps and Drainers

Expansion Joints

SD-04 Samples

Insulated Sections; G[, [_____]]

SD-10 Operation and Maintenance Data

Valve Manholes and Accessories; G[, [_____]]

Data Package 2; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 Detail Drawings

Submit detail drawings [_____] days after notice to proceed for valve manholes and the piping and equipment in the valve manholes, such as steam traps, valves, sump pumps, pressure gauges, thermometers and insulation, including a complete list of equipment and materials, manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, installation instructions, and complete wiring and schematic diagrams. Show on the drawings pipe anchors and guides, and layout and anchorage of equipment and appurtenances in valve manholes, and equipment relationship to other parts of the work including clearances for maintenance and operation.

1.3.2 Insulated Sections

Submit sample sections, [_____] days after notice to proceed, for insulation of pipe, elbow, tee, valve, support point, and terminating points. After approval of materials and prior to insulation of piping, prepare a display of insulated sections showing compliance with specifications and showing fastening, sealing, jacketing, straps, waterproofing, supports, hangers, anchors, and saddles. Display approved display sample sections at the jobsite during the construction period until no longer needed by Contracting Officer, then removed.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all materials and equipment delivered and placed in storage from the weather, excessive humidity, and excessive temperature variation; dirt, dust, or other contaminants.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

Equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.2 NAMEPLATES

Supply each major item of equipment such as sump pump, motor, steam trap, and pressure reducing valve with the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.3 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products are not allowed.

2.4 ELECTRICAL WORK

Provide motors, manual or automatic motor control equipment, and protective or signal devices required for the operation specified under this section in accordance with NFPA 70 and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.5 PIPING AND FITTINGS

2.5.1 General Requirements

Provide piping, fittings and piping accessories inside the valve manholes suitable for the working pressure and temperature requirements of the system conforming to ASME B31.1. To the greatest extent possible, match the piping and fittings inside the valve manholes to the piping and fittings located on the outside of the valve manhole. Provide steel piping in valve manholes with joints welded except that joints 3/4 inch and smaller may be threaded. When threaded joints are used on High Temperature Water Systems, seal weld (continuous fillet weld) the interface area where the pipe threads meet the threaded fittings to preclude any water leakage. Do not attach supports, anchors, or stays to any piping system in places where either the installation of or the movement of the pipe and its contents will cause damage to the construction.

2.5.2 Steel Pipe

Provide black steel, seamless or electric-resistance welded, conforming to the requirements of ASTM A53/A53M, Grade B or ASTM A106/A106M, Grade B. Provide schedule 40 type for pipe up to and including 10 inches in diameter. Provide 0.375 inch nominal wall thickness for pipe 12 inches in diameter and greater. Provide schedule 80 type for gauge piping [, condensate piping,] [drip piping,] [sump pump discharge] and piping 3/4 inch in diameter and smaller.

2.5.2.1 Nipples

Provide nipples that conform to ASTM A733 as required to match adjacent piping.

2.5.2.2 Pipe Threads

Provide pipe threads that conform to ASME B1.20.1. Use pipe threads only on pipe 3/4 inch or smaller.

2.5.3 Fittings

Provide fittings, valves, flanges and unions with the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.5.3.1 Welded Fittings

Provide welded fittings to match connecting pipes with butt welded fittings, conforming to ASME B16.9, and socket welded fittings, conforming to ASME B16.11.

2.5.3.2 Unions

Provide unions that conform to MSS SP-83 as required to match adjacent piping.

2.5.3.3 Ball Valves

Provide ball valves having flanged or buttwelded end connections conforming to MSS SP-72; provide ball valves having threaded end connections conforming to MSS SP-110.

2.5.4 Insulating Flanges and Dielectric Waterways

2.5.4.1 Insulating Flanges

For systems in which cathodic protection is used, provide insulating flanges or flange gasket kits in the valve manhole at the pipe connection to or from the heat distribution system, at the interface of dissimilar metals, and when the carrier pipe and appurtenances are supported in such a way as to electrically ground or alter the cathodic protection system voltages or currents. Provide a kit that consists of flanges, a flange gasket, nuts and bolts, bolt sleeves, and one insulating washer and one steel washer for both ends of each bolt. Provide manufacturer certified gasket kits capable of electrically isolating the pipe at the [_____] psig pressure and [_____] degrees F temperature of the heating medium at the point of application. Submit evidence of satisfactory installations operating not less than 2 years, in accordance with paragraph SUBMITTALS, before materials are delivered. Ensure that these kits are provided and properly installed according to manufacturer's published instructions. Provide bolts torqued to the correct tightness and in the correct bolt pattern as recommended by the manufacturer's published instructions. Provide steel flanges that conform to ASME B16.5 Class [150] [and] [or] [300] and that match valves or flanged fittings on which used. Provide flat faced steel flanges. Provide non-asbestos compressed material gaskets in accordance with ASME B16.21. Provide bolts that conform to the requirements of ASTM A193/A193M, Grade B7. Provide bolt heads marked to identify the manufacturer and the standard to which the bolt complies. Extend bolt lengths to no less then 2 full threads beyond the nut at the required tension with the washer seated. Provide nuts that conform to the requirements of ASTM A194/A194M, Grade 7.

2.5.4.2 Dielectric Waterways

Provide dielectric waterways that have temperature and pressure rating equal to or greater than that specified for the connecting piping and used for joining dissimilar metals on 3/4 inch and smaller threaded pipe. Provide waterways that have metal connections on both ends suited to match connecting piping. Provide dielectric waterways that are internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Provide dielectric flanges that meet the performance requirements described herein for dielectric waterways.

2.5.4.3 Gaskets Non-Insulating

Provide spiral wound, non-asbestos gasket with centering ring that conform to ASME B16.20.

2.6 VALVES

Provide valves that conform to the material, fabrication, and operating requirements of ASME B31.1, unless otherwise specified. Provide valves suitable for the service temperatures and pressures utilized. Provide valves for [steam] [hot water] that conform to ASME B31.1 Class [150] [and] [or] [300], as suitable for service temperatures and pressures utilized. [Provide valves for condensate services that conform to ASME B31.1 Class 150.] Valves 3/4 inch and smaller may be bronze where seal welding is not required. Provide valves 6 inches and larger with a 1 inch minimum gate or globe bypass valve sized in conformance with MSS SP-45.

2.6.1 Steel Valves

Provide steel globe, gate, angle, and check valves that conform to the requirements of ASME B16.34 and ASME B31.1 for the service temperatures and pressures utilized. Provide gate valves 2-1/2 inches and smaller with a rising stem. Provide gate valves 3 inches and larger with an outside screw and yoke.

2.6.2 Bronze Valves

2.6.2.1 Globe, Gate, and Angle Valves

Provide bronze globe, gate, and angle valves that conform to MSS SP-80, union bonnet type.

2.6.2.2 Check Valves

Provide bronze check valves that conform to MSS SP-80.

2.6.3 Packing

Provide asbestos free valve packing. Provide die-formed, ring type specifically designated valve stem packing suitable for service temperatures and pressures utilized. Provide polytetrafluoroethylene packing that has a with minimum 50 percent graphite filament. Provide valves 1-1/2 inches and smaller with four or five packing rings and provide valves 2 inches and larger with at least six packing rings. Spiral or continuous packing will not be acceptable. Provide a metal insert having proper clearance around the valve stem at the bottom of the stuffing box and acting as a base for the packing material. Provide one piece construction with provisions for not less than two bolts for packing adjustment, with a liner of noncorrosive material for packing glands.

2.7 STEAM TRAPS

Provide fail open traps with trap bodies suitable for a working pressure of not less than 1.5 times the steam supply pressure, but not less than 200 psi.

2.7.1 Bucket Traps

Provide inverted-bucket type bucket traps with automatic air discharge conforming to ASTM F1139.

2.7.2 Thermostatic Traps

Provide thermostatic traps that have a bimetallic element with automatic air discharge conforming to ASTM F1139.

[2.8 STRAINERS

Provide basket or y-type strainers with connections the same size as the pipe lines in which the connections are installed. Provide heavy and durable strainer bodies, of cast steel, with bottoms drilled and plugged suitable for service temperatures and pressures utilized. Provide each strainer body with arrows clearly cast on the sides to indicate the direction of flow. Provide each strainer with an easily removable cover and sediment basket. Provide each strainer body or bottom opening with a nipple and gate valve for blowdown. Provide 0.025 inch thick stainless steel, monel or sheet brass strainer basket with small perforations of sufficient number to provide a net free area at least 2.5 times that of the entering pipe. Provide cast steel bodies and stainless or Monel baskets for high temperature hot water systems.

]2.9 PRESSURE GAUGES

Provide pressure gauges that conform to ASME B40.100 with a minimum dial size of 4-1/4 inches. Provide each gauge with a throttling type needle valve or a pulsation dampener and shut-off valve.

2.10 DIAL THERMOMETERS

Provide dial type thermometers 3-1/2 inches in diameter with stainless steel case, remote-type bulb or direct-type bulb as required. Provide thermometers that have an accuracy of plus or minus 2 degrees F. Provide thermometer wells of the separable socket type for each thermometer with a direct-type bulb. Provide thermometer with a white face with black digits graduated in 2 degrees F increments.

2.11 COATINGS

Coat steel manhole piping with an organic zinc undercoat that conforms to SSPC Paint 29 Type II followed by a thermal barrier coating having a manufacturer's documented minimum thermal conductivity of 0.058 Btu/hr•ft•°F. Provide the undercoat and thermal barrier coating with a continuous use service temperature rating that exceeds the nominal system operating temperature by a minimum of 50 degrees F.

2.12 INSULATION AND JACKETING

2.12.1 General Provisions

Insulate piping, fittings, valves, etc., in the valve manholes. Provide insulation premolded, precut or job fabricated to fit and be removable and reusable. Provide thickness of insulation in accordance with Tables 1 and 2. Provide insulation jackets for all pipe and fitting insulation. Provide insulation that conforms to EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING.

2.12.2 Insulation

Provide piping, fittings, and valves with molded calcium silicate insulation conforming to ASTM C533, Type I, or molded mineral fiber insulation conforming to ASTM C547, Class 2, or cellular glass insulation conforming to ASTM C552. Do not use laminated construction unless the thickness exceeds 4 inches. Insulation manufacturers approved for use are:

a. Delta, available from Rockwool in Leeds, Alabama.

b. MPT-PC and MPT-PF, available from Mineral Products of Texas in Houston, TX.

c. Thermo-12, Super Caltemp, available from Johns Manville in Denver, Colorado.

d. Foamglass (cellular glass), available from Pittsburgh Corning Corporation.

2.12.3 Aluminum Jackets

Provide aluminum jackets of smooth sheet, 0.016 inch nominal thickness, that conform to the requirements of ASTM B209, Type 3003, 3105, or 5005.[Supply aluminum jackets that have a factory installed moisture barrier that consists of at least 40 pound kraft paper coated on one side with a 1 mil thick polyethylene film. ProviDe a jacket with the moisture barrier adhered to the jacket over the entire area of the insulation-side surface.]

2.12.4 Bands

Provide bands for aluminum jacket 3/8 inch wide and 32 gauge thickness made of aluminum or annealed stainless steel. Provide bands for insulation 1/2 inch wide and 32 gauge thickness made of annealed stainless steel.

2.12.5 Insulation for Flanges, Unions, Valves, and Fittings

Insulate flanges, unions, valves, and fittings with premolded, prefabricated, or field fabricated segments of insulation of the same material and thickness as the manhole pipe insulation. Provide insulation with essentially the same thermal characteristics and thickness as the adjoining piping.

2.12.6 Vapor Barrier Coating

Provide insulation with a vapor barrier coating that is water resistant, appropriately selected for either outdoor or indoor service, colored white, and has a water vapor permeance of the compound not exceeding 0.05 perm as determined according to Procedure B of ASTM E96/E96M. Provide a coating that is the nonflammable, fire resistant type conforming to ASTM E84, NFPA 90A and UL 723 and has a flash point not less than 80 degrees F as determined in accordance with ASTM D3278. Provide a coating that conforms to ASTM C647; excluding the previous fire resistant requirements.

2.12.7 Finishing Cement

Provide mineral fiber hydraulic-setting thermal insulating cement that conforms with ASTM C449.

2.12.8 Glass Tape

Provide tape that conforms to the requirements of UL 723 and ASTM E84.

2.12.9 Plain Weave, Untreated

Provide with the ends interlocked with the picks to ensure no raveling of the tape edges. Provide tape that is an average weight of 5.8 plus or minus 10 percent ounces per square yard, and average thickness of 0.007 plus or minus 0.001 inches. Provide with warp ends or wales of 42 plus or minus 2 per inch or filling picks or courses of 32 plus or minus 2 per inch; a minimum breaking strength of 150 pounds per inch of width; and after heating to 900 degrees F for 2 hours, a minimum breaking strength of 40 pounds per inch of width.

2.12.10 Knitted, Untreated

Provide with the wales interlocked with the courses to ensure no raveling of the tape edges. Provide tape that is an average weight of 4.5 plus or minus 10 percent ounces per square yard; average thickness of 0.007 plus or minus 0.001 inches; and warp ends/wales of 16 plus or minus 2 per inch. Use material with minimum breaking strength of 40 pounds per inch of width and, after heating to 900 degrees F for 2 hours, minimum breaking strength of 21 pounds per inch of width.

2.12.11 Distortion Requirements

Distortion of the tape when a sample 24 inches in length is spread across a flat horizontal surface and observed for evidence of distortion (such as tendency to curl rather than lie flat) is not acceptable. The width tolerance is plus or minus 1/8 inch.

2.12.12 Open-Weave Tape

Provide open-weave type tape, used for embedding between coats of adhesive or coating materials, that has an average weight of [_____] ounce per square yard.

2.13 SUMP PUMPS AND DRAINERS

2.13.1 Sump Pumps

Provide a manufacturer's standard commercial product that is electrically driven and submersible, capable of operating while completely submerged, and capable of running without damage when not submerged. The pumps and motors must be capable of continuously pumping liquids at a temperature of 200 degrees F. Provide sump pumps with permanently lubricated bearings, [monel] [stainless steel] shafts, [bronze] [stainless steel] [cast iron] impellers, screened inlets and housings of [bronze] [stainless steel] [cast iron]. Each sump pump must be capable of passing a 3/8 inch sphere.

2.13.1.1 Motors

Provide motors with overload protection. Provide pump[s] that are automatically controlled, using control components provided by the pump manufacturer, by a submersible switch assembly with pump wiring and switch suitable for submersion in 200 degrees F liquids.[Provide duplex (one on - one standby) arrangement with automatic alternating lead-lag controller.] Provide [cord and plug] [hardwired] motor electrical connections.

2.13.1.2 Controls

Provide controls, controllers, water level switches, and electrical connections suitable for service at 100 percent humidity, at 200 degrees F temperature, and occasional water submersion. The sump pumps automatic control switches must have demonstrated 200,000 cycles at 200 degrees F and 100 percent relative humidity while totally submersed in water at 200 degrees F.

2.13.2 High Level Alarm Indicator

Provide another switch to indicate high water level, connected to an emergency warning light mounted on or adjacent to the valve manhole. Set this high water level alarm at a level which is below the bottom of any pipe in the valve manhole. Provide auxiliary contacts in a separate junction box to permit connection to a [future] Energy Monitoring and Control System (EMCS) for monitoring the operation of each pump motor and the high water level alarm system.

2.13.3 Drainers

Provide automatic type drainers to operate on 125 psig steam supply pressure and actuating when the water level rises sufficiently in the sump, raising the float opening the steam control valve to admit steam to the drainer, resulting in pumping the water from the sump. When the float is lowered by the pumping action, it closes the steam valve, stopping the pumping action until the rising water causes the to float rise again and open the steam valve, starting the cycle over again. Provide each drainer with controls to accomplish the above sequence of operation. Design the automatic float-operated steam valve to prevent dead centering under field conditions and to lengthen the life of the valve seat. Provide the valve with a high grade, renewable composition disc and a stainless steel or hard, noncorrosive bronze renewable seat inserted in the valve body with the drainer constructed of corrosion-resistant copper and bronze. Provide piping from manhole drainers that conforms to ASTM A53/A53M, Weight Class XS (Extra Strong), hot-dip galvanized steel pipe with ASME B16.11 or ASME B16.3, Class 300, hot-dip galvanized threaded fittings. Provide a steam pressure regulating valve assembly for manhole drainers for operation on steam system above 125 psig.

2.14 CONCRETE VALVE MANHOLES AND ACCESSORIES

2.14.1 Wall and Floor Construction

Provide manhole in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION. Construct walls and floors of reinforced concrete not less than 8 inches thick. Construct walls using one monolithic pour. Extend walls [not less than 6 inches above grade][flush with finished grade][flush with trench top] [_____]. Provide floor with an internal sump; slope the floor in all directions to the sump to allow water collection. Provide construction joints with water stops. Waterproof manhole exterior in accordance with Section 07 13 53 ELASTOMERIC SHEET WATERPROOFING.

2.14.2 Manhole Supported Cover(s)

Provide [a hot-dipped galvanized steel open grate] [an 5/16 inch thick checker pattern, aluminum solid plate cover that conforms to AA H35.1/35.1M] [_____] cover that is supported by and is flush with the top of the manhole walls. Construct cover(s) to be removable and sectionalized as indicated. Provide hot-dipped galvanized structural steel supports, anchor bolts, nuts, and washers. Provide a cover and support system that can support a load up to[150 psf] [_____]. [Install an 5/16 inch thick checker pattern, aluminum solid plate cover that conforms to AA H35.1/35.1M on top of the open grating. Attach the checkered plate to the grating with removable, galvanized steel fasteners.]

2.14.3 Raised Frame Cover(s)

Provide a raised support structure constructed out of hot-dipped galvanized steel that is designed to sit on top of the manhole walls. Provide an 5/16 inch thick checker pattern, aluminum solid plate cover that conforms to AA H35.1/35.1M. Construct cover(s) to be removable and sectionalized as indicated. Provide ventilation openings as indicated around the entire perimeter below the raised top. Provide hot-dipped galvanized steel lifting lugs on the cover.

2.14.4 Concrete Cover

Provide a[6 inches] [_____] thick cast concrete cover designed to support loads up to[150 psf] [_____]. Provide a[4 by 4 foot aluminum access door] [30 inch diameter standard cast iron manhole frame and removable cover] [36 by 36 inch watertight, hinged steel cover not less than 1/2 inch thick] in the concrete top. [Provide two 6 inch goosenecks; terminate one gooseneck inside the manhole within 2 feet of the manhole's floor; terminate the other gooseneck inside the manhole just below the manhole top.] [Provide a single 6 inch gooseneck pipe to allow heat/steam to exit the valve manhole; install the gooseneck off to one side of the valve manhole concrete top to minimize pedestrian traffic interference. Terminate gooseneck within 2 feet above finished grade.]

2.14.5 Ladders

Provide steel valve manhole ladders, with nonslip surfaces, and consisting of uprights with steps or rungs. fabricate ladders with two stringers a minimum 3/8 inch thick and 2-1/2 inches wide, and rungs not be less than 16 inches in width, 3/4 inch diameter, spaced 12 inches apart. Anchor the ladders to the wall by means of steel inserts spaced not more than 6 feet apart vertically, and install to provide at least 6 inches of space between the wall and rungs. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

2.14.6 Pipe Sleeves

Provide zinc-coated steel pipe, conforming to ASTM A53/A53M, Schedule 40 or standard weight. Install so there is no electrical continuity between the pipe sleeve and the pipe casing.

2.14.6.1 Pipe Sleeves Through Valve Manhole Cover

Provide insulation continuously through sleeves and provide aluminum jacket over the insulation. Provide smooth sheet 0.016 inch nominal thickness aluminum jacket conforming to ASTM B209. Where penetrations in valve manhole tops are required, insulate piping and seal with waterproof coating up to a point flush with the top of the flashing and the end of the insulation. Butt insulation exposed to the weather tightly against the flashing and valve manhole insulation, and extend the aluminum jacket required for piping exposed to the weather 2 inches beyond the insulation to form a counterflashing. Flash and counterflash valve manhole penetrations and apply waterproof coating conforming to ASTM D2822/D2822M, Type I.

2.14.6.2 Pipe Sleeves for Conduit Penetrations

Provide a modular mechanical type sealing assembly between the valve manhole pipe sleeve and the [conduit casing] [or] [uninsulated chilled water pipe]. The mechanical seal consists of interlocking elastomeric links shaped to continuously fill the annular space between the [casing] [or] [uninsulated chilled water pipe] and sleeve. The link material is a synthetic elastomeric capable of withstanding long term exposure at 400 degrees F without deterioration. Attach the links to each other with corrosion resistant steel bolts, nuts and pressure plates. The link, bolts, nuts and pressure plates must be the product of single manufacturer and furnished as the product of single manufacturer as a package or kit.

2.14.7 Pipe Supports

Provide pipe supports in accordance with MSS SP-58. Galvanize all pipe supports, including structural cross support members, in accordance with Section 08 31 00 ACCESS DOORS AND PANELS. Chains, straps, or single point supports are not allowed.

2.15 EXPANSION JOINTS

Submit manufacturer's descriptive data and technical literature, performance charts, catalog cuts and installation instructions.

[2.15.1 Guided Slip Tube

Internally-externally guided type, injected semiplastic type packing, with service outlets. Construct joints for minimum working pressure of ASME Class 150. Provide single or double slip tube type as indicated. Provide flanged or buttwelding end connections as indicated.

][2.15.2 Flexible Ball

Provide chromium plated steel balls capable of 360-degree rotation plus 15-degree angular flex movement. Provide pressure molded composition gaskets designed for continuous operation temperature of 525 degrees F. Construct joints for minimum working pressure of ASME Class 150. Provide flanged or buttwelding end connections as indicated.

][2.15.3 Bellows-Type

Type 304 stainless steel corrugated bellows, reinforced with rings, internal sleeves, and external protective covers, designed to withstand 10,000 cycles over a 20 year period and a minimum working pressure of ASME Class 150. Provide limit stops to limit total movement in both directions. Cold set the joints to compensate for temperature at time of installation. Provide single or double bellows expansion joint as indicated. Provide first pipe alignment guide no more than four pipe diameters from the expansion joint; provide second pipe alignment guide no more than 14 pipe diameters from the first guide. Provide flanged or buttwelding end connections as indicated.

]2.16 MISCELLANEOUS METAL

Conform miscellaneous metal, not otherwise specified, to Section 08 31 00 ACCESS DOORS AND PANELS. Hot-dip galvanize miscellaneous metal bolted together, shop welded, or assembled in the field, and pipe supports, including structural cross support members and anchors, in accordance with Section 08 31 00 ACCESS DOORS AND PANELS.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 SITE WORK

3.2.1 Excavation, Trenching, and Backfilling

Excavate, trench, and backfill the valve manholes as indicated and in accordance with Section 31 00 00 EARTHWORK.

3.2.2 Electric Work

Provide any wiring required for the operation of the equipment specified, but not indicated on the electrical drawings or under this section, in accordance with Sections 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.3 Painting

Clean the heat affected zone of field welded galvanized surfaces and other galvanized surfaces damaged during installation in compliance with SSPC SP 10/NACE No. 2, and paint in accordance with Section 09 90 00 PAINTS AND COATINGS. Clean steel and iron appurtenances, piping, and supports in compliance with SSPC SP 10/NACE No. 2, and paint in accordance with SSPC Paint 16.

3.3 PIPING

3.3.1 General

Use steel piping and insulate in valve manholes. Protect insulation with [an aluminum] [a galvanized steel] jacket [, except for chilled water lines where indicated not to be insulated.] Cut pipe to measurements established at the site and work into place without springing or forcing. Clear all openings and equipment, and avoid cutting or other weakening of structural members to facilitate piping installation. Remove burrs from ends of pipe by reaming. Install to permit free expansion and contraction without damage to joints or hangers and in accordance with ASME B31.1. Do not attach supports, anchors, or stays where either expansion or the weight of the pipe could cause damage to permanent construction. The method of attaching supports must not interfere with the operation of the cathodic protection system.

3.3.2 Welded Joints

Weld all pipe joints for piping in valve manholes[, except joints at traps, strainers, and at valves and piping 3/4 inch and smaller which may be threaded]. Conform welding to the requirements specified in paragraph WELDING.

3.3.3 Flanged and Threaded Joints

3.3.3.1 Flanged Joints

[Flanged joints are permitted for dielectric isolation only.]Construct flanged joints to be faced true, provided with gaskets, and made perfectly square and tight. Use flanged joints only for electrical isolation and in other special cases where connected equipment is available with only flanged joints, or when specifically indicated. Provide electrically isolated flange joints at all connections to or from the heat distribution system and between dissimilar metals.

3.3.3.2 Threaded Joints

Apply graphite or inert filler and oil, graphite compound, or polytetrafluoroethylene tape to the male threads only. Provide unions at all screwed valves, strainers and connections to equipment 3/4 inch and smaller. Use dielectric unions at connections of dissimilar metals in 3/4 inch and smaller piping. When used on High Temperature Water Systems, seal weld threaded joints.

3.3.4 Reducing Fittings

3.3.4.1 Horizontal Water Heating Lines

Provide eccentric reducers for all pipe size changes. Provide eccentric type reducing fittings to maintain the tops of adjoining pipes at the same level.

3.3.4.2 Horizontal Steam Lines

Provide eccentric reducers for all pipe size changes. Provide eccentric type reducing fittings to maintain the bottoms of adjoining pipes at the same level.

3.3.5 Branch Connections

Branch off top of mains as indicated providing unrestricted circulation, elimination of air pockets, and permitting the complete drainage of the system. Branch connections may be made with either welding tees or forged branch outlet fittings. If branch outlet fittings are used, provide forged fittings no larger than two nominal pipe sizes smaller than the main run. Reinforce branch outlet fittings to withstand external strains and designed to withstand full pipe bursting strength.

3.3.6 Pipe Supports in Valve Manholes

Securely support horizontal and vertical runs of pipe in valve manholes.

3.4 WELDING

[Weld pipe in accordance with qualified procedures, using performance qualified welders and welding operators. Procedures and welders must be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests and perform the tests at the work site. The welder or welding operator must apply his assigned symbol near each weld he makes as a permanent record.] [Perform welding and nondestructive testing procedures for piping as specified in Section [40 05 13.96] [40 17 26.00 20] WELDING PROCESS PIPING.] Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

3.5 COATINGS

Prepare the steel piping surface by abrasive blasting to the near-white metal grade in conformance with SSPC SP 10/NACE No. 2. Within eight hours of blasting, or prior to any condensation of moisture or other surface deterioration whichever occurs first, coat all surfaces with an organic zinc primer conforming to SSPC Paint 29 Type II. Spray apply the primer to a minimum thickness at any point of 4 mils. Allow the primer to cure according to the manufacturer’s recommendations prior to overcoating with the thermal barrier coating. Provide thermal barrier coating having film forming properties, an adhesion value of 5 when tested according to ASTM D3359 and a minimum thermal conductivity of 0.058 Btu/hr•ft•°F. Spray apply the thermal barrier coating in accordance with manufacturers recommendations to a minimum thickness at any point of 50 mils.

3.6 INSULATION

Install insulation so that it is not damaged by pipe expansion or contraction. Keep insulation drybefore, during, and after installation. Groove insulation installed over welds to assure a snug fit. Hold insulation in place with stainless steel straps. Install a minimum of 2 bands on each individual length of insulation, with maximum spacing not exceeding 18 inch centers.

3.6.1 Installation

Install material in accordance with published installation instructions of the manufacturer. Do not apply insulation materials until piping tests are complete. Prior to application, thoroughly clean surfaces of moisture, grease, dirt, rust, and scale; paint where required.

3.6.2 Insulation on Pipes Passing Through Sleeves

Provide continuous insulation, as required by paragraph PIPE SLEEVES THROUGH VALVE MANHOLE COVER. Provide aluminum jackets over the insulation. When penetrating valve manhole walls, extend aluminum jacket not less than 2 inches beyond the sleeve on each side of the wall and secure with an aluminum band on each side of the wall. Where flashing is provided, secure the jacket with not less than one band located not more than 1 inch from the end of the jacket. When penetrating valve manhole tops, insulate pipe as required for valve manhole service.

3.6.3 Covering of Insulation in Valve Manholes

Cover insulation for pipe, flanges, valves, and fittings with [aluminum] [galvanized steel] jackets.

3.6.4 Insulation of Piping Accessories in Valve Manholes

Insulate flanges, couplings, unions, valves, fittings, and other pipe accessories, unless otherwise indicated, with removable and reusable factory premolded, prefabricated, or field fabricated insulation. Provide [aluminum] [galvanized steel] sheet over insulation manholes and neatly terminate for accessories that are not to be insulated.

3.6.5 Insulation Sealing for Chilled Water Systems

Seal the ends of insulation with vapor barrier, caulk penetrations and apply caulking to parting line between equipment and removable section insulation. Upon completion of installation of the insulation, including removable sections, apply two coats of vapor barrier coating with a layer of glass cloth embedded between the coats, providing a total dry thickness of the finish of 1/16 inch while maintaining removability of the sections as designed. Apply coating to flanges, unions, valves, anchors, fittings and accessories, all terminations, and all insulation not protected by factory vapor barrier jackets or PVC fitting covers. Overlap tape seams 1 inch. Extend the coating out onto the adjoining pipe insulation 2 inches. Taper insulation terminations to unions at a 45-degree angle.

3.6.6 Insulation Thickness

Provide the minimum thickness of insulation for [the heat distribution system] [and] [condensate return system] [each section of pipe] in accordance with Tables 1 and 2.

TABLE 1 Minimum Pipe Insulation Thickness (In inches)				
For steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F)				
Nominal Pipe Diameter (inches)	MPT-PC MPT-PF	Delta	Thermo-12 Super Caltemp	Foamglass
1.0	2.0	2.5	4.0	4.5
1.5	2.0	2.5	4.0	4.5

TABLE 1 Minimum Pipe Insulation Thickness (In inches)				
For steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F)				
2.0	2.5	3.5	4.5	5.0
2.5	2.5	3.5	4.5	5.0
3.0	3.0	4.0	5.0	6.0
4.0	3.0	4.0	5.0	6.0
5.0	3.0	4.0	5.0	6.0
6.0	3.5	4.5	5.5	6.0
8.0	3.5	4.5	5.5	6.0
10.0	4.0	5.0	6.0	6.5
12.0	4.0	5.0	6.0	6.5
14.0	4.0	5.0	6.0	6.5
16.0	4.0	5.0	6.0	6.5
18.0	4.0	5.0	6.0	6.5

TABLE 2 Minimum Pipe Insulation Thickness (In inches)				
For Low Pressure Steam (less than 16 psig), Condensate Return and Low Temperature Hot Water (less than 250 degrees F)				
Nominal Pipe Diameter (inches)	MPT-PC MPT-PF	Delta	Thermo-12 Super Caltemp	Foamglass
1.0	1.5	2.0	3.0	3.0
1.5	1.5	2.0	3.0	3.0
2.0	1.5	2.0	3.0	3.0
2.5	1.5	2.0	3.0	3.0
3.0	2.0	2.5	3.5	3.5
4.0	2.0	2.5	3.5	3.5
5.0	2.0	2.5	3.5	3.5
6.0	2.5	3.0	4.5	4.5

TABLE 2 Minimum Pipe Insulation Thickness (In inches)				
For Low Pressure Steam (less than 16 psig), Condensate Return and Low Temperature Hot Water (less than 250 degrees F)				
8.0	2.5	3.0	4.5	4.5
10.0	3.0	4.0	5.0	5.0
12.0	3.0	4.0	5.0	5.0
14.0	3.0	4.0	5.0	5.0
16.0	3.0	4.0	5.0	5.0
18.0	3.0	4.0	5.0	5.0

3.7 VALVE MANHOLES AND ACCESSORIES

3.7.1 Piping and Equipment in Valve Manholes

Provide easy access in valve manholes without stepping on piping or equipment, and allow sufficient working area for maintenance work. Refer to drawings of piping and equipment in valve manholes for installation and support details. Install all globe, angle and gate valves with the stems horizontal or above.

Submit Data Package 2 as related to all equipment provided for the project in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Detail in the operation manuals the step-by-step procedures required for equipment startup, operation, and shutdown. Include in the operation manuals the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include in the maintenance manuals piping and equipment layout and simplified wiring and control diagrams indicating location of electrical components with terminals designated for wiring, as installed.

3.7.2 Sump Pumps Installation

Install sump pumps as indicated, with all electrical connections hard wired.[Connect monitoring of each pump motor and the high water alarm to the Energy Monitoring and Control System (EMCS). Coordinate electrical requirements of EMCS with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM]. Provide dedicated electrical circuits to the sump pumps. Provide all circuit breakers and switches in the electrical power distribution to the sump pumps with the capability of being locked in the "ON" position to be signed as follows. Stamp the words for the sign on a corrosion resistant metal plate with letters 3/8 inch high, and affix the plate permanently near the switch or circuit breaker.

THIS CIRCUIT SUPPLIES POWER TO THE ELECTRIC SUMP PUMPS IN THE UNDERGROUND DISTRIBUTION SYSTEM. THIS CIRCUIT MUST BE "ON" AT ALL TIMES; OTHERWISE EXTENSIVE DAMAGE WILL OCCUR TO THE UNDERGROUND HEAT DISTRIBUTION SYSTEM AND PREMATURE FAILURE WILL OCCUR.

3.8 TESTS

Perform tests of piping in the valve manholes as part of the testing of the direct buried conduit system. Iinclude the piping in the valve manhole in these tests and perform in accordance with the system supplier's Approved Brochure or the contract specifications.

-- End of Section --

SECTION 33 61 14

EXTERIOR BURIED PREINSULATED WATER PIPING
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.24	(2022) Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500
ASME B31.1	(2020) Power Piping

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM B32	(2020) Standard Specification for Solder Metal

ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM D229	(2019) Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation
ASTM D1330	(2004; R 2010) Rubber Sheet Gaskets
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

1.2 SYSTEM DESCRIPTION

Provide [new and modify existing] exterior buried factory-prefabricated preinsulated water piping system to the first piping connection aboveground or within each building complete and ready for operation. Piping system includes [hot domestic water piping,] [recirculating hot domestic water piping,] [chilled water piping,] [chilled-hot (dual temperature) water piping,] [hot water piping,] and related work [from heat exchanges to each building]. [Hot domestic water piping within each building is specified under Section 22 00 00 PLUMBING, GENERAL PURPOSE.] [Chilled water piping, chilled-hot water piping, and hot water piping within each building is specified under] [Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS].

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Factory-prefabricated preinsulated water piping system

Preinsulated plastic pipe field joints

Show layout of piping system. Drawings must have Professional Engineer Seal.

SD-03 Product Data

Pipe, fittings, and end connections

Factory-prefabricated preinsulated water piping system

Plastic reinforced thermosetting resin (RTR) piping

SD-07 Certificates

Certification of welders' qualifications

SD-08 Manufacturer's Instructions

Installation manual for buried factory-prefabricated preinsulated water piping system

1.4 QUALITY ASSURANCE

1.4.1 Certification of Welders' Qualifications

Submit prior to site welding of steel piping; certifications shall be not more than one year old.

PART 2 PRODUCTS

2.1 BURIED FACTORY-PREFABRICATED PREINSULATED WATER PIPING SYSTEM

Piping (pipe, fittings, and end connections) system shall be suitable for working pressure of 125 psig at 250 degrees F, except plastic polyvinyl chloride (PVC) chilled water piping shall be suitable for working pressure of 125 psig at 75 degrees F. Piping system shall withstand H-20 highway loading with 2 feet of compacted backfill over top of conduit. Mark each section of conduit with fabricator's name, product identification, and publications to which the items conform. Provide each section of carrier pipe including factory-applied insulation and conduit, with waterproof conduit ends at both ends of each section of carrier pipe, except for piping systems which have the field joints insulated and covered with waterproof shrink sleeves.

2.1.1 Factory-Applied Insulation

Polyurethane or polyisocyanate insulation, minimum density of 1.7 pcf, rated for not less than 250 degrees F, completely filling space between carrier pipe and conduit.

2.1.2 Factory-Applied Conduit

Conduit material, size, and thickness shall be as follows:

Carrier Pipe (Inches)	Minimum Conduit Size (Inches)	Minimum Conduit Thickness (Inches)
2	4	0.060
3	6	0.060
4	8	0.080
6	10	0.100
8	12	0.120
10	14	0.120

a. Plastic PVC pipe conduit: ASTM D1784, Class 12454-B compound extruded seamless PVC plastic pipe.

b. Plastic RTR pipe conduit: ASTM D2996, filament-wound, fiberglass RTR plastic pipe, without liner.

c. Plastic RTR factory lay-up conduit: Conduit shall be machine-applied continuous rovings of fiberglass strands saturated with isophthalic polyester or epoxy resin filament wound in helical pattern directly to the outer surface of the pipe insulation. In lieu of minimum conduit size for each size of carrier pipe, provide minimum of one inch thick insulation for 2 inch carrier pipe and provide minimum of 1.5 inch thick insulation for 3 inch and larger carrier pipe.

2.1.3 Factory-Applied End Seals

Provide watertight end seal, or factory lay-up type end seal between carrier pipe and conduit. Provide sufficient surface bonding area between carrier pipe and conduit to ensure permanent watertight end seal suitable for use with temperature limits of carrier pipe.

2.1.4 Factory-Prefabricated Carrier Piping

Pipe, fittings, flanges, and couplings shall be marked with manufacturer's name, product identification, and publication to which items conform. Carrier piping shall be as specified in this section. Buried carrier pipe connections between straight sections of pipe beyond 5 feetexterior of buildings may be manufacturer's standard O-ring connections designed to absorb pipe expansion and contraction at working pressure of 125 psig with no leakage. Connections at elbows and tees shall be other than O-ring connections.

2.2 CARRIER PIPING

2.2.1 Copper Tubing

Provide copper tubing for hot domestic water piping, recirculating hot domestic water piping, chilled water piping, chilled-hot water piping, and hot water piping.

a. Copper tubing: Provide ASTM B88, Type L or M copper tubing for buried factory-prefabricated preinsulated piping and for aboveground piping. Provide ASME B16.18 or ASME B16.22 solder joint fittings, unions, and flanges; provide adapters as required.

b. Solder for copper tubing: Provide ASTM B32, 95-5 tin-antimony solder or provide Plumbing Code approved lead-free solder.

c. Flanged connections: Provide ASME B16.24, Class 150, solder joint flat face flanged connections.

d. O-ring connections: Provide between straight sections of pipe beyond 5 feet of exterior of buildings.

2.2.2 Steel Piping

Provide steel piping for chilled water piping, chilled-hot water piping, and hot water piping.

a. Steel pipe: Provide ASTM A53/A53M, Type E (electric-resistance welded, Grade A or B), ASTM A53/A53M, Type S (seamless, Grade A or B), or ASTM A106/A106M (seamless, Grade A or B). Provide Weight Class STD (Standard) or Schedule No. 40 black steel pipe for welding end connections. Provide Weight Class XS (Extra Strong) or Schedule No. 80 black steel pipe for threaded end connections.

b. Steel pipe fittings: Provide ASME B16.9 buttwelding fittings of the same material and weight as the piping in which fittings are installed. Provide ASME B16.11 socket welding fittings.

c. Steel pipe flanges: Provide ASME B16.5, Class 150 flanges.

d. O-ring connections: Provide between straight sections of pipe beyond 5 feet of exterior of buildings.

2.2.3 Plastic Reinforced Thermosetting Resin (RTR) Piping

Provide plastic RTR piping for hot domestic water piping, recirculating hot domestic water piping, chilled water piping, chilled-hot water piping, and hot water piping.

a. Plastic carrier pipe, fittings, and adhesive: Provide plastic carrier piping conforming to the Federal Agency Approved Brochure. Pipe, fittings, and adhesive shall be supplied by same manufacturer. Pipe, fittings, flanges, and couplings shall have end connections of the adhesive bell and spigot type. Threaded piping, including pipe, fittings, flanges, and couplings, will not be permitted.

b. Flanged connections: Provide flat face flanged connections between plastic piping and metal piping. Plastic flanges shall be suitable for connecting to ASME Class 150 flanges.

c. Plastic RTR piping sizes: When piping sizes other than 2, 3, 4, 6, and 8 inches are indicated, provide next larger piping size. The connecting system piping shall be of the same size or increased to meet next size of RTR piping.

2.2.4 Plastic PVC Piping

Provide plastic PVC piping only for chilled water piping.

a. Plastic PVC carrier pipe, fittings, and cement: ASTM D1785pipe, ASTM D2466 socket type fittings, and ASTM D2564solvent cement shall be supplied by the same manufacturer. Pipe, fittings, flanges, and couplings shall have solvent cement socket end connections, except piping beyond 5 feet outside of buildings shall have O-ring connections. Plastic PVC piping shall be suitable for working pressure of 125 psig at 75 degrees F.

b. Flanged connections: Provide flat face flanged connections between plastic piping and metal piping. Plastic flanges shall be suitable for connecting to ASME Class 150 flanges.

c. O-ring connections: Provide between straight sections of pipe beyond 5 feet of exterior of buildings.

2.3 FLANGED CONNECTIONS

Provide ASME Class 150 flat face flanged connections.

a. Gaskets: ASTM D1330, except Shore A durometer hardness shall be 55 to 65, 0.125 inch thick ethylene propylene. Provide one piece factory cut full-face gaskets.

b. Bolts: ASTM A193/A193M, Grade B7. Extend minimum of two full threads beyond nut with bolts tightened to required torque.

c. Nuts: ASTM A194/A194M, Grade 7, with Teflon coated threads.

d. Washers: Provide galvanized steel flat circular washers under bolt heads and nuts.

e. Electrically isolating (insulating) gaskets for connections between metal flanges: Provide ASTM D229 electrical insulating material of 1000 ohms minimum resistance. Provide one piece factory cut insulating gaskets between flanges. Provide silicon-coated fiberglass insulating sleeves between bolts and holes in flanges; bolts may have reduced shanks of diameter not less than diameter at root of threads. Provide 0.125 inch thick high-strength insulating washers next to flanges and provide stainless steel flat circular steel washers over insulating washers and under bolt heads and nuts. Provide bolts 0.5 inch longer than standard length to compensate for thicker insulating gaskets and washers under bolt heads and nuts.

2.4 BURIED WARNING AND IDENTIFICATION TAPE

Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inches minimum width, color coded for the utility involved with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall read "CAUTION BURIED PREINSULATED WATER PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2.5 CONCRETE THRUST BLOCKS

Provide concrete thrust blocks as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Concrete shall be of 4000 psi minimum 28 day compressive strength, air-entrained admixture (3.6 ounces per cubic yard) with water-reducing admixture (22 ounces per cubic yard).

2.6 PIPE SLEEVES

Provide where piping passes entirely through walls and floors. Provide sleeves of sufficient length to pass through entire thickness of walls and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

a. Sleeves in masonry and concrete walls and floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron sleeves. Core drilling of masonry and concrete may be provided in lieu of sleeves when cavities in the core-drilled hole are grouted smooth.

b. Sleeves in other than masonry and Concrete walls and floors: Provide 26 gage galvanized steel sheet.

2.7 ESCUTCHEON PLATES

Provide split hinge type metal plates for piping entering walls and floors in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of exterior buried factory-prefabricated preinsulated water piping systems shall be in accordance with manufacturer's installation manual. Welding of steel piping including qualification of welders shall be in accordance with ASME B31.1, metallic arc process. Deviations shall not be permitted unless authorized in writing by Contracting Officer. Install piping straight and true to bear evenly on sand bedding material. Installation and field assembly of plastic RTR piping shall be in accordance with the Federal Agency Approved Brochure.

a. Cleaning of piping: Keep interior and ends of new piping and existing piping affected by the Contractor's operations, cleaned of water and foreign matter during installation by means of plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.

b. Demolition: Remove materials so as not to damage materials which are to remain. Replace existing work damaged by the Contractor's operations with new work of the same construction.

3.2 FIELD JOINTS

a. Carrier piping joints without concrete anchor: Pressure test and approve piping joints. Provide joints with polyurethane or polyisocyanate insulation of same type and thickness as insulation on carrier piping. Provide waterproof shrink sleeves to cover insulation and overlap not less than 6 inches of each end of conduit section.

b. Carrier piping joints with concrete anchor: Pressure test and approve piping joints. Provide each elbow and tee with concrete anchors (thrust blocks). Provide waterproof end seals between carrier piping and conduit adjacent to each carrier pipe fitting. Encase carrier pipe fitting and at least 2 inches of each end of conduit with a minimum of 6 inches of concrete.

3.3 BURIED FACTORY-PREFABRICATED PREINSULATED PIPE INSTALLATION

a. Assembly and alignment: Assemble carrier pipe and fittings according to manufacturer's installation manual; assemble plastic RTR piping in accordance with the Federal Agency Approved Brochure. Maintain proper alignment during assembly of joints.

b. Bedding: Accurately grade trench bedding with a minimum of 6 inches of manufactured or natural sand. Backfill sand to a minimum of 6 inches above and below conduit. Lay bedding to firmly support conduit along entire length.

c. Concrete thrust blocks: Encase each elbow and tee of carrier pipe in thrust block with minimum of 3 square feet of thrust-bearing surface cast against undisturbed soil, minimum pipe-to-bearing surface single dimension of 10 inches perpendicular to bearing surface, and minimum volume of 9 cubic feet, except as indicated otherwise. Disturbed soil under and around thrust blocks shall be compacted.

3.4 FIELD QUALITY CONTROL

Before final acceptance of work, test each system to demonstrate compliance with contract requirements. Thoroughly flush and clean piping before placing in operation. Flush piping at minimum velocity of 8 fps. Correct defects in the work and repeat tests until work is in compliance with contract requirements. Furnish potable water, electricity, instruments, connecting devices, and personnel for tests.

a. Field tests of carrier piping: Do not cover carrier piping joints with insulation or concrete anchors (thrust blocks), until carrier piping joints pass field tests.

b. Hydrostatic pressure test: Test piping system at 200 psig for minimum holding period of 2 hours during which time pressure shall not drop more than 4 psi; test plastic RTR piping in accordance with Federal Agency Approved Brochure. Pressure drop greater than 4 psicorrected for temperature variation constitutes failure. Valve off piping system and disconnect method of piping system pressurization before starting the 2 hour pressure holding period. During hydrostatic pressure test, examine piping system for leaks. Repair leaking joints, replace damaged and porous pipe and fittings with new materials, and repeat tests.

c. Thrust blocks: If O-ring connections are used, provide temporary thrust blocks prior to hydrostatic pressure testing of piping system. Place bedding and backfill around center portion of piping system, leaving thrust blocks and field joints clear for observation. After successful completion of hydrostatic pressure test, cast concrete thrust blocks.

d. Field inspections: Prior to initial operation, inspect piping system for compliance with drawings, specifications, and manufacturer's submittals.

3.5 DISINFECTION

Disinfect new hot domestic water piping under Section 22 00 00 PLUMBING, GENERAL PURPOSE.

-- End of Section --

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SECTION 33 63 13

EXTERIOR UNDERGROUND STEAM DISTRIBUTION SYSTEM
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 300	(2003; R 2017) Standard Specification for Inorganic Zinc-Rich Primer

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A134/A134M	(2019) Standard Specification for Pipe, Steel, Electric-Fusion (Arc)-Welded (Sizes NPS 16 and Over)
ASTM A135/A135M	(2021) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A139/A139M	(2016) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting

	Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM C518	(2021) Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM D2310	(2006; R 2012) Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA MC96.1	(1982) Temperature Measurement Thermocouples

NACE INTERNATIONAL (NACE)

NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 4	(2015) Application Guideline for Terminal Blocks

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS L-S-125	(Rev B; Notice 1) Screening, Insect, Nonmetallic

1.2 DEFINITIONS

The following definitions are applicable:

1.2.1 Pre-engineered System

A complete underground [heat distribution] [and] [condensate return] system including all required components such as carrier pipes, [steam pipe], [high temperature hot water supply pipe], [condensate return pipe], and [high temperature hot water return pipe], fittings, anchors, pipe supports, insulation, protective casing, and cathodic protection, for the system supplied. The pre-engineered system does not include valve manholes and the piping and equipment inside the valve manholes; see Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES. The pre-engineered system shall include all piping and components to a point at least six inches inside the building and valve manhole. The UHDS shall not use any part of the building or valve manhole structure as an anchor point.

1.2.2 Direct-Buried

A system which is buried without the need for a field-fabricated protective enclosure such as a concrete trench or tunnel.

1.2.3 UHDS Types

1.2.3.1 Drainable-Dryable-Testable (DDT) Direct-Buried System

A factory-fabricated system including an air and water-tight outer protective casing, air space and an insulated carrier pipe. Drains and vents are provided at the end plates of the system (in manholes or buildings). The drains are normally plugged but the plugs can be removed to drain water which may leak into the air space if there is a failure in the casing or the carrier pipe. The vents allow water vapor to escape and provide a tell-tale sign of leakage.

1.2.3.2 [Water Spread Limiting (WSL) Direct-Buried System

A factory-fabricated system including an outer protective casing and an insulated carrier pipe. The system is fabricated in sections which are independent from each other; ground water or condensate which leaks from or into one section cannot travel into the next section. Field-assembly of the sections requires no welding as the sections push together and are sealed with a system of couplings and seals.

]1.2.4 UHDS Manufacturer Certification

The UHDS manufacturer is the company responsible for the design and manufacture of the pre-engineered system. The UHDS manufacturer directs the installation of their system and has a representative on the job site.Certification includes that the UHDS manufacturer regularly and currently manufactures direct-buried systems, and that the designs of the system and equipment to be provided for this project conform to specification requirements. This certification shall be an original signed by a principal officer of the UHDS manufacturer and shall be submitted at minimum of [2] [_____] weeks prior to start of work.

1.2.5 UHDS Manufacturer's Representative

The UHDS manufacturer's representative shall be a person who regularly performs the duties specified herein, is certified in writing by the UHDS manufacturer to be technically qualified and experienced in the installation of the system, and shall be authorized by the manufacturer to make and sign the daily reports specified herein. The UHDS manufacturer's representative shall be under the direct employ and supervision of the UHDS manufacturer.

1.2.6 Corrosion Engineer

Corrosion engineer refers to a person who by knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control. Such person may be a licensed professional corrosion engineer or certified as being qualified by the National Association of Corrosion Engineers (NACE), if such licensing or certification includes 3 years experience in corrosion control on underground metallic surfaces of the type under this contract. NACE certification shall be technologist, corrosion specialist, or cathodic protection specialist. The corrosion engineer shall make at least 3 visits to the project site. The first of these visits shall include obtaining soil resistivity data, acknowledging the type of pipeline coatings to be used and reporting to the Contractor the type of cathodic protection required. Once the submittals are approved and the materials delivered, the corrosion engineer shall revisit the site to ensure the Contractor understands installation practices and laying out the components. The third visit shall involve testing the installed cathodic protection systems and training applicable personnel on proper maintenance techniques. The corrosion engineer shall supervise, inspect, and test the installation and performance of the cathodic protection system.

1.2.7 Pipe-Stress and System Expansion Calculations

Pipe-stress and system-expansion calculations for each expansion compensation elbow using a finite element computer generated three-dimensional analysis, not later than [7 days] [_____] after notice to proceed.

Calculations (including heat loss calculations) shall demonstrate that pipe stresses from temperature changes are within the allowable requirements in ASME B31.1 and the anchors and the guides will withstand the resultant forces. Submitted detailed design layout drawings including the location of all anchors and guides. Layout shall also include all analysis node points. As a minimum, the computer analysis results include node stresses, forces, moments and displacements. Calculations shall be approved, certified, stamped and signed by a registered Professional Engineer in the employ of the UHDS manufacturer.

1.2.8 Cathodic Protection System Calculations

Design life calculations for cathodic protection system in accordance with NACE SP0169, not later than [7 days] [_____] after notice to proceed. Calculations shall be stamped and signed by a NACE qualified corrosion engineer.

1.2.9 Manufacturer's Data Sheets

Manufacturer's data sheets on all components of the UHDS and the instrumentation required for thermal performance testing.

Manufacturer's data sheets for all coatings and for carrier pipe insulation, indicate thicknesses not later than [7 days] [_____] after notice to proceed.

1.2.10 Work Plan

A proposed schedule of activities indicating when various items of work and tests are to be carried out and when the representative of the UHDS manufacturer shall be present at job site. The UHDS manufacturer shall submit a list of what characteristics shall be considered damaged or defective materials that must be replaced.

1.2.11 Quality Assurance Plan

Manufacturer's quality assurance plan for fabrication, delivery, storage, installation and testing of system.

1.2.12 Thermal Performance Testing

A proposed test procedure and proposed samples of test data sheets for each required test, 30 days prior to the proposed test date. The procedure shall contain a complete description of the proposed test with calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in the tests. The test shall not commence until the procedure has been approved.

1.2.13 Certificate of Compliance

Upon completion of the work, and before final acceptance, a notarized statement signed by a principal officer of both the UHDS manufacturer and the contractor, certifying that the system has been installed satisfactorily and in accordance with the contract drawings, specifications, UHDS manufacturer's detailed design layout drawings and with the UHDS manufacturer's recommendations.

1.2.14 Testing Firm Qualification

A Certificate of the Testing Firm Qualification from the independent testing firm or firms, not later than [_____] days after notice to proceed, certifying that: weld examination methods and procedures, and the interpretation of radiographic films will be performed in accordance with ASME B31.1; the firm intends to utilize the proper film exposure, techniques, and penetrameter to produce density and geometric sharpness in sufficient clarity to determine presence of defects; and that all radiographic films will be reviewed and interpreted, and reading reports signed, by not less than a Certified American Society for Nondestructive Testing Level III Radiographer.

1.2.15 Welds

A Certification of Acceptability of all welds made in the field, upon completion of the project. This certification shall consist of a letter signed by an official of the independent testing firm or firms examining welds, stating that all provisions of this specification have been complied with, and that all welds inspected radiographically have met the acceptability standards specified.

1.2.16 Daily Written Report

A daily written report from the representative of the UHDS manufacturer whenever the representative is required to be on the jobsite. The report shall be checked for accuracy and the original shall be submitted no later than the next working day after the date of the report. One copy shall be forwarded to the UHDS manufacturer's main office. The report shall be signed by the representative. The report shall state whether or not the condition and quality of the materials and methods used and the installation of the system are in accordance with the contract drawings, specifications, and the UHDS manufacturers detailed design layout drawings and requirements. If anything connected with the installation is unsatisfactory, the report shall state what corrective action has been taken or shall contain the UHDS manufacturer's recommendations for corrective action and when the unsatisfactory condition is to be corrected. The daily report will track and report all unsatisfactory conditions and corrective measured being taken. The report shall identify any conditions that could result in an unsatisfactory installation, including such items as open conduit ends left in the trench overnight and improper valve manhole entries and changes required to the UHDS design due to interferences or conflicts, upon realization of interferences or conflicts. On a weekly basis the daily reports shall be reviewed, approved, signed and sealed by the registered Professional Engineer responsible for the system design and shall be submitted to the Contracting Officer.

1.2.17 Heat Distribution System, Data Package 2

The operation and maintenance manual for the heat distribution system shall list routine maintenance procedures, possible breakdowns and repairs, procedures for recording conduit temperatures biannually, and troubleshooting guides. Manual shall include as-built piping layout of the system including final elevations. Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.3 DESCRIPTION

1.3.1 Scope

The work includes the design and fabrication; furnishing; installing, and testing of a direct buried underground [insulated heat-distribution system] [and] [insulated steam pipe], [insulated high temperature hot water supply pipe], [insulated steel condensate return pipe], [insulated high temperature hot water return pipe] consisting of piping as indicated, cathodic protection system(where required by this specification), together with all fittings and appurtenances necessary for a complete and operable system. Gland type end seals shall not be permitted. Drainable, dryable, testable (DDT) systems with fiberglass casings shall not be provided.

1.3.2 UHDS Design

The UHDS manufacturer shall be responsible for the complete design of the UHDS, the product to be supplied, fabrication, witnessing installation and testing of the system within the design parameters established by the contract drawings and specifications, and in compliance with the detailed design. The complete design of the UHDS shall be sealed by a Professional Engineer in the employ of the UHDS manufacturer.A Certificate of Satisfactory Operation shall be submitted certifying that at least 3 systems installed by the UHDS manufacturer within the previous 10 years have and are operating satisfactorily for not less than 5 years, not later than [_____] days after notice to proceed. The certificate shall indicate the location, type of system, size of system, point of contact (POC) including phone number, for information verification. This certificate of satisfactory operation shall be an original signed by a principal officer of the UHDS manufacturer.

1.3.3 Contract Drawings

The contract drawings accompanying this specification provide information on:

a. The size of carrier pipes, approximate length, and site location of the system.

b. The routing and elevation of the piping along the route.

c. Location and design of manholes.

d. The obstacles that must be avoided along the path.

e. Location of piping anchors (anchors will be no closer than 3 feet nor further than 5 feet from entrance to manholes and buildings) at manholes and/or buildings. The UHDS manufacturer shall incorporate any additional anchors as needed for their system.

f. Operating pressure and temperature of system.

1.4 SYSTEM REQUIREMENTS

1.4.1 Cathodic Protection

Cathodic protection shall be provided for systems with coated steel casings.

1.4.2 Operating Characteristics

The [steam] [high temperature hot water] supply system shall have an operating temperature of [_____] degrees F and an operating pressure of [_____] psig. [[Condensate] [High Temperature hot water] return system shall have an operating temperature of [_____] degrees F and an operating pressure of [_____] psig.]

1.4.3 Rated Characteristics

All thermal expansion calculations shall be computed for the supply and return piping using the following design characteristics and installation temperature. The system design conditions for [steam], [condensate], [high temperature hot water] supply and/or return at a temperature of [500 degrees F] and a pressure of [665 psig.] For calculation purposes the installation temperature (the ambient temperature at the site) shall be no higher than a temperature of [[_____] degrees F].

1.4.4 Heat Distribution System design

A complete description of the Heat Distribution System design and assembly of the system, materials of construction and field installation instructions minimum of [2] [_____] days prior to the start of field measurements. Also submittal shall include sufficient system details required to show that the specified minimum insulation thickness has been met. A detailed design layout of the system (plan and elevation views) showing size, type, elevations and location of each component to be used in the system, the design and location of anchors, pipe guides, pipe supports, expansion loops, Z-bends, L-bends, end seals, leak plates, joint locations, pipe and insulation thickness and sizes, types, and movements, connection to manhole and building wall penetrations, and including, if applicable, transition point design to aboveground or other type systems. Also, if applicable, type and details of the cathodic protection system to be used. Detailed design layout drawings shall be prepared and approved by a registered Professional Engineer as certified by their stamp.

1.5 STANDARD PRODUCTS

Approval by Contracting Officer is required for products or services of the UHDS manufacturer. The design of the system and equipment provided for this project shall conform to specification requirements, shall be of current production and shall essentially duplicate systems that have been in satisfactory use for at least 5 years, prior to bid opening, at three locations. The systems must have been operated under pressure, temperature and site characteristics that are equal to or more severe than the operating conditions in this specification and must have distributed the same medium. The system shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heat Distribution System design; G[, [_____]]

SD-03 Product Data

Pipe; G[, [_____]]

Insulation; G[, [_____]]

Fittings; G[, [_____]]

Cathodic protection; G[, [_____]]

Anchors; G[, [_____]]

Expansion joints; G[, [_____]]

Coatings; G[, [_____]]

Conduit; G[, [_____]]

Field Connection of Casing Sections; G[, [_____]]

SD-05 Design Data

Pipe-stress and system expansion calculations; G[, [_____]]

Cathodic protection system calculations; G[, [_____]]

Manufacturer's data sheets; G[, [_____]]

SD-06 Test Reports

WSL system tests; G[, [_____]]

SD-07 Certificates

Work plan; G[, [_____]]

Quality assurance; G[, [_____]]

Thermal performance testing; G[, [_____]]

UHDS manufacturer certification; G[, [_____]]

UHDS design; G[, [_____]]

Certificate of compliance; G[, [_____]]

Testing firm qualification; G[, [_____]]

Welds; G[, [_____]]

SD-10 Operation and Maintenance Data

Heat distribution system, Data Package 2; ; G[, [_____]]

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Daily written report

1.7 SITE CLASSIFICATION

Classification of the site conditions for the UHDS was based on ASTM D2487 and the following criteria: [_____].

TABLE A - SITE CLASSIFICATION DEFINITION BASED ON KNOWN UNDERGROUND WATER CONDITIONS

Site Classification	General Conditions for Classification
Severe	The water table is expected to be frequently above the bottom of the system and surface water is expected to accumulate and remain for long periods in the soil surrounding the system.
	OR
	The water table is expected to be occasionally above the bottom of the system and surface water is expected to accumulate and remain for long periods in the soil surrounding the system.
Bad	The water table is expected to be occasionally above the bottom of the system and surface water is expected to accumulate and remain for short periods (or not at all) in the soil surrounding the system.
	OR
	The water table is expected never to be above the bottom of the system but surface water is expected to accumulate and remain for short periods in the soil surrounding the system.
Moderate	The water table is expected never to be above the bottom of the system but surface water is expected to accumulate and remain for short periods (or not at all) in the soil surrounding the system.
	OR
	The water table is expected never to be above the bottom of the system but surface water is expected to accumulate and remain for brief or occasional periods in the soil surrounding the system.
	OR
	The water table is expected never to be above the bottom of the system and surface water is not expected to accumulate or remain in the soil surrounding the system.

TABLE B - SITE CLASSIFICATION CRITERIA BASED ON SUBSURFACE SOIL INVESTIGATION				
Site Classification	Water Table Level	Soil Types	Terrain	Precipitation Rates or Irrigation Pratices in Area
SEVERE	Water table within 1 foot of bottom or system	Any	Any	Any
	OR			
	Water table within 5 feet of bottom of system	GC, SC CL, CH OH	Any	Any
BAD	Water table within 5 feet of bottom of system	GW, GP SW, SP	Any	Any
	OR			
	No groundwater encountered	GC, SC, SW, CH, OH	Any	Equivalent to 3 inches or more in any one month or 20 inches or more in one year.

TABLE B - SITE CLASSIFICATION CRITERIA BASED ON SUBSURFACE SOIL INVESTIGATION				
Site Classification	Water Table Level	Soil Types	Terrain	Precipitation Rates or Irrigation Pratices in Area
MODERATE	No groundwater encountered	GM, SM, ML, OL, MH	Any	Equivalent to 3 inches or more in any one month or 20 inches or more in one year.
	OR			
	No groundwater encountered	GC, SC, SL, CH, OH	Any except low areas	Equivalent to 3 inches or more in any one month or 20 inches or more in one year.
	OR			
	No groundwater encountered	GW, GP, SW, SP	Any	Any
	OR			
	No groundwater encountered	GM, SM, ML, SM	Any	Equivalent to 3 inches or more in any one month or 20 inches or more in one year.

PART 2 PRODUCTS

2.1 FACTORY FABRICATED, DIRECT-BURIED, DRAINABLE, DRYABLE, TESTABLE (DDT) SYSTEMS

2.1.1 DDT Steam and High Temperature Hot Water Carrier Pipes

Requirements shall be in accordance with the "Heat Distribution Piping" paragraph.

2.1.2 DDT Condensate Carrier Pipes

Carrier piping for condensate return systems shall be steel, schedule 80. Pipe requirements shall be in accordance with the "Heat Distribution Piping" paragraph.

Do not locate condensate pipes in conduit casings which contain steam pipes or any other piping.

2.1.3 DDT Carrier Pipe Insulation

Carrier pipe insulation shall conform to minimum thicknesses and type listed in Tables 1 and 2 as required for temperature in carrier pipe specified under the "Rated Conditions" paragraph.

2.1.4 Insulation Banding and Scrim

Stainless steel bands and clips, at least 0.5 inches wide, ASTM A167 (304 stainless steel), maximum spacing 18 inches shall be used over the scrim to secure the insulation onto the carrier pipe. A minimum of two bands are required for each 4 foot section of insulation. Vinyl-coated fiberglass scrim, FS L-S-125, Type II, Class 2, with 18 by 16 mesh (number of filaments per inch) and made of 0.013 inch diameter vinyl-coated fibrous glass yarn. Bands are used over the scrim to secure the insulation onto the carrier pipe.

2.1.5 Casing

Smooth-wall steel, electric resistance spiral welded, conforming to ASTM A134/A134M, ASTM A135/A135M, or ASTM A139/A139M and the values tabulated below. Provide eccentric connectors as necessary between casing sections to provide drainage of casing section between manholes and between manholes and buildings.

Casing Diameter (inches)	Minimum Thickness (inches)
6 - 26	0.250
27 - 36	0.250
37 - 42	0.250
46	0.250

2.1.6 Casing End Plates, Vents, and Drains

End plates shall be made of ASTM A36/A36M steel, minimum thickness 0.5 inches for conduit pipe sizes above 12 inches and 0.375 inches for conduit pipe sizes 12 inches and less. Provide 1 inch ASTM A53/A53M, Schedule 40, galvanized vent riser pipe on end plate vent opening. Vent pipe shall extend to top of manhole and terminate 12 inches above grade with a 180 degree bend. Provide one inch drain at the bottom and vent at the top. Construct with welded steel half coupling welded to the end plate, and brass plugs. Plug drains, do not plug vents.

2.1.7 Air Space

Provide continuous one inch minimum air space between carrier pipe insulation and casing.

2.1.8 Casing Coating

Fusion-bonded epoxy, minimum thickness 0.040 inches. Rated by coating manufacturer for continuous service for at least 25 years at temperatures of 230 degrees F and having a coefficient of expansion similar to that of steel. Coating shall be applied in accordance with the coating manufacturer's instructions. Factory-inspect for holidays and make repairs as necessary.

2.1.9 Coating of End Plates and conduit Sections Extending in Manholes

Zinc-rich coating that conforms to AASHTO M 300, Type IA except that volatile organic compounds shall not exceed 2.8 pounds per gallon. The zinc rich coating shall be applied in accordance with the coating manufacturer's requirements including surface preparation. No additional top coat shall be applied.

2.1.10 Carrier Pipe Guides

Maximum spacing 10 feet on centers, no more than 5 feet from pipe ends, minimum of three guides per elbow section. Guides shall be designed to allow thermal expansion without damage, provide proper pipe guiding, and to allow horizontal movement in two directions as required at expansion loops and bends. Design of supports shall permit flow of water and air vapor through the support. Pipe insulation shall extend thru the pipe guides and be protected by steel sleeves. Design of guides shall be such that no metal to metal contact exists between the casing and the carrier pipe. Insulation or non-metallic material used to ensure no metal to metal contact shall be designed to not be compressed by the weight of the carrier pipe when full of water.

2.1.11 Anchor Plates

Anchor plate shall be ASTM A36/A36M steel, welded to carrier pipe and casing, 0.5 inches minimum thickness and shall include, passages for air flow and water drainage through the annular air space in the system. Exterior surface of the anchor plate shall be coated with the same coating material as the casing.

2.1.12 Field Connection of Casing Sections

Steel section conforming to casing specification, welded to casing sections, coated on all surfaces with UHDS manufacturer's coating field repair compound, and covered with a 0.05 inch minimum thickness polyethylene shrink sleeve designed for a service temperature exceeding 500 degrees F.

2.1.13 Manufacturer's Identification

Provide embossed brass or stainless steel tag hung by brass or stainless steel chain at each end of each conduit or insulated piping in the manholes and buildings. The tag shall identify UHDS manufacturer's name, date of installation, Government contract, and manufacturer's project number.

2.2 FACTORY FABRICATED, DIRECT-BURIED, WATER-SPREAD-LIMITING (WSL) SYSTEM

2.2.1 Steam/High Temperature Hot Water Carrier Pipes

Refer to Paragraph, HEAT DISTRIBUTION PIPING for pipe material requirements. The pipe shall be steel with the ends machined and metallized to provide a satisfactory sealing surface for the sealing rings. The metallizing shall be a high nickel alloy applied to an excess thickness and then machined to the required OD.

2.2.2 Condensate Carrier Pipes

Carrier piping for condensate return systems shall be steel, Schedule 80. Refer to paragraph entitled "HEAT DISTRIBUTION PIPING" for pipe requirements. Condensate piping shall not be located in casings which contain steam piping or any other piping.

2.2.3 Casing for Steam and Condensate

The casing shall be reinforced thermosetting resin plastic pipe (RTRP) manufactured by the filament winding process. The casing pipe shall be wound to meet ASTM D2310 classification RTRP and ASTM D2996. The resin shall be a polyester isothalic resin. The outer surface shall be coated with a pigmented, protected resin containing a paraffinated wax and ultraviolet inhibitors. Casing thickness shall be as follows:

Carrier Pipe Size, inches	Casing Thickness, inches
2	0.185
3	0.185
4	0.185
6	0.250
8	0.250
10	0.250
12	0.250

2.2.4 Pipe Coupling, Steam

Coupling shall be of a multi-stage seal designed to accommodate the expansion and contraction of the system in the coupling. Couplings shall be of corrosion resistant materials capable of handling the design characteristics of the system listed in paragraph entitled "Rated Characteristics". The annular seals and carrier pipe ends shall be specifically designed to protect the seals and resist abrasion due to lateral loads in the system.

2.2.5 Pipe Coupling, Condensate

Coupling shall be a single stage seal design to accommodate the expansion and contraction of the adjacent pipes. Coupling shall be of corrosion resistance materials capable of handling the design characteristics of the system listed in paragraph entitled "Rated Characteristics." The annular seals and carrier pipe ends shall be specifically designed to protect the seals and resist abrasion due to lateral loads in the system.

2.2.6 Carrier Pipe Insulation

Conform to minimum thicknesses and type of insulation listed for WSL systems in Tables 1 and 2 as required for temperature in carrier pipe. Insulation shall consist of an inner layer of high temperature calcium silicate and an outer layer of polyurethane foam.

2.2.6.1 Calcium Silicate Insulation for Steam Systems

The calcium silicate insulation shall be a hydrous material satisfactory for temperatures to 1200 degrees F. Calcium Silicate insulation shall conform to ASTM C533. The physical properties shall be as follows:

Density (dry) 13 lbs./cu. ft. (minimum)
Compressive Strength to produce 5 percent compression: 250 psi (For 1.5 inch thick sample)

Maximum Linear shrinkage after 24 hour soaking period at 1200 degrees F: 1.1 percent

Maximum Thermal Conductivity k k = BTU-IN/HR-FT2-DEG.F). Where k varies with temperature as shown:

Mean Temp	100	200	300	400
k	0.38	0.41	0.44	0.48
k(metric	0.04	0.04	0.04	0.04

2.2.6.2 Polyurethane Foam Insulation for Steam and Condensate Systems

Polyurethane foam shall be in accordance with ASTM C591. The polyurethane foam shall completely fill the annular space between the calcium silicate insulation and the casing for the steam pipe and between the carrier pipe and the casing for condensate return system.

Polyurethane foam insulation shall also meet the following requirements:

a. Type: Two component urethane.

b. Compressive Strength: 25 psi parallel to rise (minimum at 50 percent compression).

c. Shrinkage: None at 30 to 70 degrees F.

d. Free Rise Density: 2 lbs/cubic foot.

e. Maximum aged k (90 degrees F/90 percent RH for 72 hours):

0.14 (BTU-IN/HR FT-2-DEG. F) at 75 degrees F, when tested in accordance with ASTM C518.

f. Minimum Closed Cell Content: 90 percent

2.2.6.3 Insulation Concentricity

Carrier pipe shall be concentric in relation to the casing pipe. The allowable maximum deviation from center line of the carrier pipe shall be plus or minus 0.25 inch at the casing center point and plus or minus 0.06

inch at the end seals.

2.2.6.4 Insulated Fittings

Fittings shall be pre-insulated by manufacturer using the same insulation thickness and casing as the straight sections.

2.2.6.5 Coupling Insulation for Steam Systems

The material which locks the bronze coupling in the casing shall be composed of refractory composite. The approximate minimum conductivity of this material shall be 1.6 (BTU/HR/F/IN DEG.F) at a mean temperature of 2300degrees F.

2.2.6.6 Coupling Insulation for Condensate Systems

The coupling shall be insulated with polyurethane foam per requirements herein. The insulation thickness shall be equal to the carrier pipe insulation. The coupling shall be encased in the same casing as the pipe.

2.2.7 Manufacturer's Identification

Provide an embossed brass or stainless steel tag hung by a brass or stainless steel chain at each end of each casing or insulated piping in the manholes and buildings. The tags shall identify UHDS manufacturer's name and date of installation.

2.2.8 End Seals

2.2.8.1 General

Each preinsulated section of piping shall completely seal the insulation providing a permanent water and vapor seal at each end of the preinsulated section of piping. Preinsulated factory fabricated sections of piping modified in the field shall be provided with an end seal which is equivalent to the end seals furnished with the preinsulated section of piping. Tests shall be conducted by the UHDS manufacturer to demonstrate that casings, couplings and end seals are capable of resisting penetration of water into the casing and insulation under rated conditions. The WSL System Tests shall be performed on each type of pre-fabricated system to be furnished, and the test results shall be verified by an independent testing laboratory. The steam system shall be tested and certified in accordance with paragraph entitled Assembly Testing of WSL systems for Steam Service. The Condensate Return system shall be tested and certified in accordance with paragraph entitled "Assembly ASSM Testing of WSL systems for Condensate Return Service". Test reports in booklet form showing all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system.

2.2.8.2 End Seals for Steam Service

End seals shall be elastomer-ring type designed and dimensioned to fit in the annular space between the casing and the carrier pipe. Tape used for covering field repair joints shall be multi polymer alloy film type and shall be compatible with synthetic elastomeric tape, suitable for cold application.

2.2.8.3 End Seals for Condensate Return Service Types

End seals provided shall be one of the following types:

a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Sufficient surface bonding area shall be provided between the casing and the carrier pipe.

b. Using specially designed molded caps made of polyethylene or rubber of standard manufactured thickness. A minimum 1 1/2 inch surface bonding area shall be provided between the cap and both the casing and carrier pipe.

c. Using elastomer-ring end seals designed and dimensioned to fit in the annular space between the casing and the carrier pipe.

d. Using a waterproof mastic seal vapor barrier over the exposed insulation ends.

e. Shrink sleeves.

2.2.9 Assembly Testing of WSL Systems for Steam Service

The tests shall demonstrate that the WSL system will operate successfully for 25 years under typical operating conditions. The tests shall be conducted in both a dry and wet environment. The WSL system shall be as described in the manufacturer's brochure. The testing program described below shall be conducted at the expense of the WSL system manufacturer. Tests shall be witnessed and verified by an independent testing laboratory. The entire pre-insulated test section shall be hydrostatically tested, with water, to 375 psig (1/5 times the rated pressure) before and after temperature cycling. The tests shall be conducted in a dry environment which followed by a test in a wet environment for 60 cycles which demonstrates resistance to ground water infiltration. All tests shall be conducted on one test section and all testing shall be completed in 1 time period (approximately 6 weeks) and the 120 testing cycles shall be continuous except for weekend time periods.

2.2.9.1 Apparatus

A curved bottom test tank at least 12 feet long, 32 inches wide, 32 inches deep shall be used. The tank shall be fitted with a gasketed and bolted cover to pressurize the tank to 8.67 psig. The tank shall have a drain at the lowest point and a vent at the highest point. Manhole entrance sleeves (i.e. wall sleeves through the ends of the tank to simulate manhole entries in actual field conditions) shall be centrally located on each end of the tank. Auxiliary equipment shall include: Steam supply with sufficient capacity to satisfy testing requirements, makeup water tank and pump, and a means for continuously recording temperatures and pressures at needed locations. Thermocouples shall be used to record temperatures at the following points:

a. Carrier pipe at tank inlet (in thermowell).

b. Casing at mid-point in pipe length (on casing).

c. Casing at anchor point (above FRRP overwrap on plate).

d. Casing at field joint (repair, on casing).

e. Casing at coupling mid-point (on casing).

f. End seal flange at coupling (on elastomer).

g. Outer edge of new end plate (at steel plate and FRP wrap).

h. Carrier pipe at specimen outlet end (in thermowell).

i. Interface of calcium-silicate and polyurethane insulations.

j. Carrier pipe internal pressure, at inlet to test specimen.

Surface thermocouples shall be epoxied to the surface of the casing. The calibration of the thermocouples shall be checked and recorded prior to installation and the recorder shall record within 0.1 degrees F resolution. A pressure transmitter shall be used to record pressure in the test tank.

2.2.9.2 Test Section

A 4 inch steel carrier pipe test section consisting of 27 feet of pre-insulated pipe meeting specified materials and design requirements shall be provided. Approximately 12 feet of the test section shall be encased within the tank as described below. The test section within the tank shall consist of an expansion coupling, field repair joint, anchor plate, anchor block and end seals. The test section shall be installed (as directed) on at least 11 inches of firmly tamped sand. Sand shall not be any lower than 4 inches from the top of the tank. The test section shall be anchored to the tank wall at one end and the building floor at the other end on the portion of the pipe external to the tank. The expansion coupling shall be misaligned by 1.5 degrees in the horizontal plane. Sand (4 fluid oz.) shall be introduced into the carrier pipe and disbursed throughout the test loop at startup.

2.2.9.3 Resistance to Water Damage and Joint Leakage

This test shall simulate the operation of the WSL system to assure the system will provide successful service life through its expected life span. The system shall be tested in steam service by cycling for an extended period of time, as described below. System performance shall be deemed successful if there is no joint leakage, deformation of the casing, deterioration of the end seals, or any other deleterious effects.

a. The piping system shall be subjected to 60 cycles of admitting steam into the system while at an ambient temperature of less than 100 degrees F, heating the system up to a temperature of 406 degrees F (as measured at the core pipe at the tank inlet and tank outlet), stopping the steam admission and allowing the system to cool back to ambient temperature. The system shall be held at 406 degrees F minimum for a minimum of 30 minutes, each cycle. This cycling shall continue for 60 cycles in dry sand followed by 60 cycles in a saturated environment. The reduction in temperature to less than 100 degrees F shall occur naturally with no artificial means of cooling used.

b. Results shall conform to paragraph Criteria for Satisfactory Results and Reporting.

2.2.9.4 Resistance to Mechanical or Structural Damage

This test shall simulate loads induced by truck traffic over pipe, which may occur under actual operating conditions. This test shall be conducted commencing with the 18th cycle of the Resistance to Water Damage and Joint Leakage test and continue through the 60th cycle. Other aspects of the Resistance to Water Damage and Joint Leakage test shall continue simultaneously with this test.

a. Apparatus: Same as for apparatus used in Resistance to water damage and joint leakage test loading device, with the addition of a 2000 psf. A hydraulic jack shall be used to apply the test pressure against a 18 by 18 inch plate bearing on the sand directly over the coupling in the tank.

b. Procedure: A steady and constant vertical load of 2000 psf shall be applied to the plate for 14 days during the test. The test section shall be installed as in the Resistance to water damage and joint leakage test. During the 14 day loading period, steam shall be circulated through the carrier pipe alternately at ambient and 406 degrees F as in earlier test.

c. Results: Requirements shall be in accordance with paragraph Criteria for Satisfactory Results and Reporting.

2.2.9.5 Resistance to Ground Water Infiltration

This test shall be the wet environment test conducted during the second 3 weeks (61st to 120th cycles) of the test period to show that the WSL system will resist the penetration of ground water into the system.

a. Apparatus: Same as for basic apparatus used in Resistance to Water Damage and Joint Leakage phase test, plus the following:

(1) One 50 gallon water reservoir with a 0 to 30 psig pressure gauge and compressed air connection.

(2) Provisions to introduce pressurized red dye into the curved bottom test tank. The water/dye solution shall be mixed to a concentration in accordance with the dye manufacturer's recommendation for maximum detectability.

(3) One pressure tank with 0 to 30 psig static pressure gauge.

b. Procedure: This phase shall start on the 61st cycle and continue until the 120th cycle. The test section of pipe shall be the same test segment used in the previous tests. The tank cover shall be bolted in place and the Resistance to Ground Water Infiltration test shall begin. The water/dye source shall be attached to the fill fitting and a surge tank shall be attached to the vent with a tee fitting. The pressure tank shall have 0 to 30 psig static pressure gauge attached. The other branch of the tee fitting shall employ a shut-off valve. With the shut-off valve open, the water/dye mixture shall be admitted into the tank through the fill fitting until the tank is full and water/dye runs freely from the open valve. The valve shall be closed and the filling shall continue until the pressure reaches 8.67 psig. The tank pressure shall be maintained throughout the test period. Steam shall be circulated through the carrier pipe and cycled from ambient to 406 degrees F as in the previous test. At the end of the test, the pressure shall be relieved by opening the vent valve and the water/dye shall be drained from the tank through the drain fitting.

c. Results: Requirements shall be in accordance with paragraph criteria for Satisfactory Results and Reporting.

2.2.9.6 Criteria for Satisfactory Results and Reporting

a. Reporting: Logs of times and temperature shall be recorded to assure compliance with test requirements and procedures. Complete photographic documentation of the construction and operation of the test facility, as well as the piping system components before and after testing, shall be produced. Data shall be analyzed to assure complete compliance with test objectives.

b. Drawing: A drawing showing details of the test apparatus and test specimen shall be provided.

c. For the Resistance to Water Damage and Joint Leakage test: Joints and end seals shall be removed for examination, immediately upon completion of all test cycles. Successful results shall show that steam has not leaked out of the carrier pipe and that the components show no signs of deterioration.

d. For the Resistance to Mechanical or Structural Damage test: The loading shall not have been sufficient to cause the casing to be damaged or deformed enough to impair functioning of the system. The casing shall not be ruptured or deformed more than one inch in any direction. Casing sections with pipe anchors shall not fail.

e. For the Resistance to Ground Water Infiltration test: Determine whether or not the water/dye solution has entered the insulation. This shall be observed by removing and inspecting all joints and seals for dye penetration at the end of the test. Results will be deemed successful if no dye solution is evident in the insulation.

f. Evidence of Test Results: After completion of all tests, the test apparatus shall be dismantled for visual inspection of all critical components subjected to the heat cycling, water infiltration and loading tests. All parts will be examined thoroughly for any detrimental affects. Examinations specified shall be conducted. Log sheets, test data and color photographs shall be kept on file and made available as required to document and substantiate compliance to the test requirements.

g. Report: A report from the independent testing agency shall be submitted. The report shall include the laboratory analysis of the condition of the test section and shall attest that the testing conditions were followed.

2.2.10 Assembly Test of WSL Systems for Condensate Return Service

Testing and certification procedures by an independent testing laboratory shall demonstrate that casings and end seals are capable of resisting penetration of ground water or condensate into the casing and insulation. The test shall be performed on the type of prefabricated system to be furnished. If more than 1 type of prefabricated system is to be used, the tests shall be performed on each type. The test shall consist of hot and cold cycle testing followed by immersion in a water filled chamber with a head pressure. The hot and cold cycle testing shall consist of a minimum of 120 cycles, of temperature cycling. A fluid with a temperature of 40 degrees F shall circulate through the carrier pipe alternating every 3 hours with a fluid with a temperature of 250 degrees F circulating through the carrier pipe. While the hot and cold cycle test is being performed, the test sample shall be either buried or encased in dry bedding sand with a minimum of 12 inches of sand all around the test sample. The carrier pipe size of the test sample shall be 3 inches in diameter and shall be restrained during the test period. The insulation thickness shall not exceed the maximum thickness provided for the piping in the project. Transition time for temperature cycle testing shall not exceed 15 minutes in going from cold to hot and 30 minutes in going from hot to cold. The fluid in the carrier pipe shall be water, or steam. Following the hot and cold cycling test, the test sample shall be immersed in a water filled chamber. The pressure on the highest point of the test sample shall not be less than 20 feet of water head pressure subjected over the entire length of the 8 foot test sample of prefabricated pipe. The water shall contain a dye penetrant, which shall be used to check for end seal leakage. The pressure in the chamber shall be held for not less than 48 hours. Upon completion of this pressure test, the test sample shall be cut open. With the use of a light that will readily show the presence of the dye that was in the water, the test sample shall be inspected. Evidence of the dye inside the test sample shall indicate that the end seal is not acceptable and cannot be certified.

2.3 PIPE INSULATION FOR DIRECT BURIED HEAT DISTRIBUTION SYSTEMS

Materials containing asbestos are not permitted.

2.3.1 Insulation Thickness

The minimum thickness of insulation for the heat distribution system shall be in accordance with Tables 1 and 2 in which the insulations listed have passed the 96 hour boiling water test.

TABLE 1 - MINIMUM PIPE INSULATION THICKNESS (inches)					
For Steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F).					
INSULATIONS For Drainable/Dryable Systems				INSULATIONS For other Pre-Engineered Systems	
Nominal Pipe Diameter (inches)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	WSL	
				Calcium Silicate	Polyurethane
1.0	2.0	2.5	4.0	N/A	N/A
1.5	2.0	2.5	4.0	N/A	N/A
2.0	2.5	3.5	4.5	N/A	N/A
2.5	2.5	3.5	4.5	N/A	N/A
3.0	3.0	4.0	5.0	1.0	+1.23

TABLE 1 - MINIMUM PIPE INSULATION THICKNESS (inches)					
For Steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F).					
INSULATIONS For Drainable/Dryable Systems				INSULATIONS For other Pre-Engineered Systems	
Nominal Pipe Diameter (inches)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	WSL	
				Calcium Silicate	Polyurethane
4.0	3.0	4.0	5.0	1.0	+1.22
5.0	3.0	4.0	5.0	N/A	N/A
6.0	3.5	4.5	5.5	1.5	+1.34
8.0	3.5	4.5	5.5	2.0	+1.21
10.0	4.0	5.0	6.0	2.5	+1.31
12.0	4.0	5.0	6.0	2.0	+1.29
14.0	4.0	5.0	6.0	N/A	N/A
16.0	4.0	5.0	6.0	N/A	N/A
18.0	4.0	5.0	6.0	N/A	N/A

TABLE 2 - MINIMUM PIPE INSULATION THICKNESS (inches) CONDENSATE RETURN HIGH TEMPERATURE HOT WATER RETURN SYSTEM				
Nominal Pipe Diameter (inches)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	Polyurethane
1.0	1.5	2.0	3.0	N/A
1.5	1.5	2.0	3.0	N/A
2.0	1.5	2.0	3.0	0.77
2.5	1.5	2.0	3.0	N/A
3.0	2.0	2.5	3.5	1.05
4.0	2.0	2.5	3.5	1.05
5.0	2.0	2.5	3.5	N/A

TABLE 2 - MINIMUM PIPE INSULATION THICKNESS (inches) CONDENSATE RETURN HIGH TEMPERATURE HOT WATER RETURN SYSTEM				
Nominal Pipe Diameter (inches)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	Polyurethane
1.0	1.5	2.0	3.0	N/A
1.5	1.5	2.0	3.0	N/A
6.0	2.5	3.0	4.5	1.32
8.0	2.5	3.0	4.5	N/A
10.0	3.0	4.0	5.0	N/A
12.0	3.0	4.0	5.0	N/A
14.0	3.0	4.0	5.0	N/A
16.0	3.0	4.0	5.0	N/A
18.0	3.0	4.0	5.0	N/A

2.4 HEAT DISTRIBUTION PIPING

2.4.1 Steam and High Temperature Hot Water Pipe

Pipe material shall be steel; seamless, ASTM A53/A53M, Grade B or ASTM A106/A106M, Grade B; or electric resistance welded ASTM A53/A53M, Grade B; Schedule 40. Standard weight permitted for pipe sizes 12 inches and above. ASTM A53/A53M, Type F furnace butt welded pipe is not allowed. No joints shall be allowed in the factory fabricated straight section of the carrier pipe. Factory fabricated piping sections as part of an expansion loop or bend shall have all welded joints 100 percent radiographed inspected in accordance with ASME B31.1. Radiographs shall be reviewed and interpreted by a Certified American Society for Nondestructive Testing (ASNT) Level III radiographer, employed by the testing firm, who shall sign the reading report.

2.4.1.1 Condensate Pipe

Steel; seamless, ASTM A53/A53M, Grade B or ASTM A106/A106M, Grade B, schedule 80; electric resistance welded ASTM A53/A53M, Grade B; Schedule 80. ASTM A53/A53M, Type F furnace butt welded pipe is not allowed. No joints shall be allowed in the factory fabricated straight section of the carrier pipe. Factory fabricated piping sections as part of an expansion loop or bend shall have all welded joints 100 percent radiographed inspected in accordance with ASME B31.1. Radiographs shall be reviewed and interpreted by an ASNT Certified Level II radiographer, employed by the testing firm, who shall sign the reading report.

2.4.1.2 Joints

Joints shall be butt-weld except socket-weld joints are permitted for pipe sizes 2 inches and smaller. Dye penetrant inspection may be used in place of 100 percent radiographic inspection for pipe sizes 2 inches and below. Indicate location and elevation of all field joints on detailed design layout drawings. Split-ring welding rings may be used.

2.4.2 Fittings

All welds in factory fittings shall be 100 percent radiographic inspected. All radiographs shall be reviewed and interpreted by a Certified ASNT Level III radiographer, employed by the testing firm, who shall sign the reading report. The Contracting Officer reserves the right to review all inspection records, and if any welds inspected are found unacceptable in accordance with ASME B31.1, the fitting shall be removed, replaced, and radiographically reexamined at no cost to the government.

2.4.2.1 Butt-Welded

Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe. All elbows shall be long radius unless otherwise indicated. Tees shall be full size or reducing as required, having interior surfaces smoothly contoured. Split-ring welding rings may be used.

2.4.2.2 Socket-Welded

Forged steel, ASME B16.11, 2000 pound class will be used for pipe sizes 2 inch and below. Dye penetrant inspection may be used in place of 100 percent radiographic inspection of welded fittings for pipe sizes 2 inch and below.

2.5 EXPANSION JOINTS, LOOPS AND BENDS

Stresses shall be less than the maximum allowable stress from the Power Piping Code (ASME B31.1). Submit detailed design layout drawings and stress and anchor force calculations for all loops and bends. Show locations of all anchors, guides and supports. Base the calculations on rated characteristics (pressures and temperatures), specified herein, for both the supply and return lines.

PART 3 EXECUTION

3.1 GENERAL

3.1.1 UHDS Design

The UHDS manufacturer is responsible for the complete design of the UHDS, the product to be supplied, fabrication, witnessing installation and testing of the system within the design parameters established by the contract drawings and specifications and in compliance with the detailed design. The complete design of the UHDS shall be prepared, signed, and sealed by a Professional Engineer in the employ of the UHDS manufacturer.

3.1.2 Installation, Inspection, and Testing

The pre-engineered system shall be installed, inspected, and tested in accordance with the contract drawings and specifications, the UHDS manufacturer's standard procedures, detailed design layout drawings and any directions given by the UHDS manufacturer's representative. All work described in paragraph "UHDS Manufacturer's Representative's Responsibilities" shall be performed in the presence of the UHDS manufacturer's representative.

3.1.3 [Job Conditions

Phasing of [demolition and construction] [construction] shall be in accordance with the provisions of Section 01 11 00 SUMMARY OF WORK, and as shown on contract drawings.

]3.1.4 Interruption of Existing Service

The contractor shall arrange, phase and perform work and provide temporary facilities, materials, equipment, and connections to utilities, to assure adequate heat distribution service for existing installations at all times. Only such absolutely necessary interruptions as may be required for making connections shall be permitted, and only at such times when approval is obtained from the Contracting Officer. Interruptions to heat distribution service shall be only with prior approval, and be the minimum possible duration. All interruptions shall be [between the hours of [_____] thru [_____]] [as scheduled under paragraph "PHASING" of Section 01 11 00 SUMMARY OF WORK] [as approved by the Contracting Officer].

3.1.5 Connecting to Existing Work

Connect new work to existing work in a neat and workmanlike manner. Connection shall be made only in manholes. Where an existing structure must be cut or existing utilities interfere, such obstruction shall be bypassed, removed, replaced or relocated, restored and repaired. Any changes required to the UHDS design as a result of interferences or conflicts must be approve by the UHDS designer and the Contracting Officer. Work disturbed or damaged shall be replaced to its prior condition, as required by Section 01 11 00 SUMMARY OF WORK.

3.1.6 Coordination

Coordinate the location of all items of equipment and work of all trades. Maintain operability and maintainability of the equipment and systems. Any relocation of equipment or systems to comply with the requirement of operability and maintainability shall be performed by the contractor at his cost.

3.1.7 Grading

Unless otherwise shown on the contract drawings or the detailed design layout drawings, steam/condensate and high temperature hot water supply/return lines shall be graded uniformly downward not less than 5.0 inches in 100 feet to the lower point of entry between manholes and/or building entries.

3.1.8 Variations

Any variations from the approved detailed design layout drawings must be submitted to the Contracting Officer for approval. Variations must be signed and sealed by the UHDS manufacturers' professional engineer responsible for the complete design of the UHDS.

3.1.9 Storage and Handling

Equipment and material placed on the job shall remain in the custody of the Contractor until final acceptance whether or not the Contractor has been reimbursed for the equipment and material by the Government.

The Contractor is solely responsible for the protection of the equipment and material against damage from any source. Protect all materials against entry of water and mud by installing watertight protection on open ends at all times. Sections of the casing or carrier piping found to have been subjected to full or partial submergence in water (which would allow the insulation to become wet) shall be immediately replaced. Protect materials at all times while stored or during installation from damage from UV light. Materials awaiting installation shall be completely covered to protect from UV degradation.

Place all damaged items in new operating condition or replace damaged items as determined and directed by the Contracting Officer, at no additional cost to the Government.

3.2 DEMOLITION

Perform work in accordance with requirements for phasing. Completely remove all pipe, valves, fittings, insulation, and all hangers including the connection to the structure and any fastenings. Seal all openings in manhole or building walls after removal of piping. All material and equipment removed shall become the property of the Contractor and shall be removed from Government property within one week and shall not be stored in operating areas. All flame cutting shall be performed with adequate fire protection facilities available as required by safety codes and Contracting Officer.

3.2.1 Asbestos Removal

Conform to Section 02 82 00 ASBESTOS REMEDIATION.

3.3 PIPE, PIPING JOINTS AND FITTINGS

3.3.1 Welded Joints

Clean pipe and fittings inside and outside before and after assembly. Remove all dirt, scale, and other foreign matter from inside the piping by use of a pipe swab or pipe pig before connecting pipe sections, valves, equipment or fittings. Use eccentric connectors as necessary between casing sections to provide drainage of casing section between manholes and between manholes and buildings.

3.3.2 Fittings

All changes in direction shall be made with factory-built reinforced fittings. Field-fabricated fittings and miters are not permitted.

3.4 WELDING

The Contractor is entirely responsible for the quality of the welding and shall:

a. Conduct tests of the welding procedures used by his organization, determine the suitability of the procedures used, determine that the welds made shall meet the required tests, and also determine that the welding operators have the ability to make sound welds under standard conditions.

b. Comply with ASME B31.1.

c. Perform all welding operations required for construction and installation of the heat distribution system.

3.4.1 Qualification of Welders

Rules of procedure for qualification of all welders and general requirements for fusion welding shall conform with the applicable portions of ASME B31.1 and also as outlined below.

3.4.2 Examining Welders

The contractor shall examine each welder to determine the ability of the welder to meet the qualifications required. Test welders for piping for all positions, including welds with the axis horizontal (not rolled) and with the axis vertical. Each welder shall:

a. Weld only in positions in which he/she has qualified.

b. Identify welds with the specific code marking signifying name and number assigned.

3.4.3 Examination Results

Provide the Contracting Officer with a list of names and corresponding code markings. Retest welders which fail to meet the prescribed welding qualifications. Disqualify welders who fail the second test, for work on the project.

3.4.4 Beveling

Field bevels and shop bevels shall be done by mechanical means or by flame cutting. Where beveling is done by flame cutting, surfaces shall be thoroughly cleaned of scale and oxidation just prior to welding. Conform to specified standards.

3.4.5 Alignment

Utilize split welding rings for field joints on all carrier pipes above two inches to assure proper alignment, complete weld penetration, and prevention of weld spatter reaching the interior of the pipe. Make field joints two inches and smaller with welding sockets.

3.4.6 Erection

Piping shall not be split, bent, flattened, or otherwise damaged either before, during, or after installation. Where the pipe temperature falls to 32 degrees F or lower, the pipe shall be heated to approximately 100 degrees F for a distance of one foot on each side of the weld before welding, and the weld shall be finished before the pipe cools to 32 degrees F.

3.4.7 Defective Welds

Replace and reinspect defective welds in accordance with ASME B31.1. Repairing defective welds by adding weld material over the defect or by peening shall not be permitted. Welders responsible for defective welds must be requalified.

3.4.8 Electrodes

Electrodes shall be stored in a dry heated area, and be kept free of moisture and dampness during fabrication operations. Discard electrodes that have lost part of their coating.

3.4.9 Radiographic Testing

An approved independent testing firm regularly engaged in radiographic testing shall perform radiographic examination of 100 percent of the field welds in the carrier piping of direct-buried systems in accordance with ASME B31.1. Furnish a set of films showing each weld inspected, a reading report evaluating the quality of each weld, and a location plan showing the physical location where each weld is to be found in the completed project, prior to installing casing field joints, backfilling and hydrostatic testing. All radiographs shall be reviewed and interpreted by a Certified American Society for Nondestructive Testing Level III radiographer, employed by the testing firm, who shall sign the reading report. The Contracting Officer reserves the right to review all inspection records, and if any welds inspected are found unacceptable they shall be removed, rewelded, and radiographically reexamined at no cost to the Government.

3.5 HEAT DISTRIBUTION SYSTEM INSTALLATION

The UHDS manufacturer's representative shall oversee the delivery, storage, and witness the installation and testing of the system. All work shall be in strict accordance with the requirements specified herein and with the printed instructions of the manufacturer. These specifications shall take precedence over the printed instructions, if conflicts arise. Printed instructions shall be submitted to the Contracting Officer prior to system installation.

3.5.1 Verification of Final Elevations

Prior to covering the top of the casing with backfill material, but after all temporary supports have been removed and initial backfilling of the conduit system has been accomplished, the Contractor shall measure and record the elevation of the top of the casing in the trench. Elevations shall be taken at every completed field joint, 1/3 points along each pipe section and top of elbows. This measurement shall be checked against the contract drawings. These measurements shall confirm that the conduit system has been installed to the elevations shown on the contract drawings. Slope shall be uniform to within 0.1 percent. These measurements shall be recorded by the Contractor, included in the UHDS manufacturer's representative daily report, and given to the Contracting Officer prior to covering the casing with backfill material.

3.5.2 Excavation, Trenching, and Backfilling

Perform all excavation, trenching, and backfilling as required by the UHDS manufacturer's design and as specified in Section 31 00 00 EARTHWORK. Pipe shall lay on a 12 inch minimum sand bed and backfilled with sand on all sides to a minimum of 6 inches as measured from outside of casing. Foundation for system must be firm and stable. Foundation and backfill must be free from rocks or substances which could damage the system coating. Concrete anchor and thrust blocks must be installed in undisturbed earth. Backfilling must not commence until system has been satisfactorily pressure tested (both hydrostatic test of carrier and, for

DDT systems, pneumatic test of casing. Minimum depth of burial to the top of the casing is 24 inches. Maximum depth of burial to the top of the casing is 10 feet.

3.5.3 UHDS Manufacturer's Representative Responsibilities

This shall be a person who regularly performs the duties listed below, is certified in writing by the UHDS manufacturer to be technically qualified and experienced in the installation of the system, and shall be authorized by the manufacturer to make and sign the daily reports specified herein. The UHDS Manufacturer's representative shall be present at the job site and witness when the following types of work are being performed:

a. Inspection and unloading.

b. Inspection of trench prior to commencing installation of system.

c. Inspection of concrete anchors and thrust blocks.

d. Hydrostatic testing of carrier piping.

e. Field joint closure work.

f. Pneumatic testing of DDT system casing.

g. Holiday test of conduit coating.

h. Repair of any coating.

i. Installation of cathodic protection system.

j. Initial backfill up to 10 inches above the top of the casing.

k. Verification of final elevations. Elevation readings shall be witnessed and recorded.

l. Testing of cathodic protection system.

m. Operational tests

The UHDS manufacturer's representative is to notify the contractor immediately of any problems. If necessary, the UHDS manufacturer's representative will notify the Contracting Officer of problems requiring immediate action, otherwise the daily reports will note any problems encountered and indicate the corrective actions taken.

3.5.4 UHDS Manufacturer Representative's Reports

The UHDS manufacturer representative shall prepare and sign a written daily report. Present the original daily report to the Contracting Officer no later than one working day after it is prepared, and forward one copy to the manufacturer's main office. The report shall state whether or not the condition and quality of the materials used and the delivery, storage, installation and testing of the system are in accordance with the plans, specifications, and manufacturer's printed instructions and is satisfactory in all respects. When any work connected with the installation is unsatisfactory, the report shall state what corrective action has been taken or shall contain the UHDS manufacturer's recommendations for corrective action. The report shall identify any conditions that could result in an unsatisfactory installation, including such items as open conduit ends left in the trench overnight and improper manhole entries. The daily reports are to be reviewed, signed and sealed, on a weekly basis, by the registered engineer responsible for the system design. Signed and sealed copies of the daily reports shall be submitted with the payment request. Requests for payment shall be denied if the weekly review is not accomplished.

Upon completion of the work and before final acceptance, deliver to the Contracting Officer a notarized Certificate of Compliance signed by a principal officer of both the manufacturing and the contracting firm, stating that the installation is satisfactory and in accordance with plans, specifications, and manufacturer's instructions.

The UHDS manufacturer will retain a copy of all daily reports and the Certificate of Compliance for 5 years after final acceptance of the system by the government.

3.5.5 Protection

Protect casing coating from damage during unloading, storage, rigging and installation. Protect casing and carrier pipe ends from water intrusion during unloading, storage, rigging and installation. Protect piping and all accessories from damage due to exposure to UV light.

3.5.6 Defective Material

The UHDS Manufacturer's Representative shall take prompt action to remove from the site all damaged or defective material, subject to rejection in accordance with the quality assurance provisions included in the manufacturer's submittals and printed instructions, and shall order prompt replacement of such material.

3.5.7 Cathodic Protection

Provide cathodic protection for all steel casing systems and all buried exposed metal. Assume that 25 percent of the exterior of the UHDS is exposed metal. Cathodic protection systems shall have a minimum design life of 25 years and shall conform to [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM][Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM]. Provide dielectric pipe flanges and unions and isolation devices at all points necessary. Provide test stations at grade on each section of the piping system. Isolation flanges and unions shall be rated for the service temperature and pressure.

3.6 TESTS

Demonstrate leak-tightness of all piping systems by performing pressure tests (hydrostatic, pneumatic) and operational tests. Pressure test heat distribution system in conformance with requirements stated in this specification and in printed instructions for the system supplied. Tests shall include carrier piping and casing. The carrier pipe shall be hydrostatically tested. Casings of DDT systems shall be pneumatically tested. Casing and end seals of WSL system will be tested for intrusion of water into the casing and insulation.

3.6.1 Holiday Testing of Direct-Buried System Steel Casings

Test entire exterior surface of the casing including the bottom exterior surface of the casing for faults in coating after installation in trench prior to backfilling. Use test method and voltage recommended by coating manufacturer. Repair any holidays found and retest. System shall not be backfilled until all holidays are eliminated.

3.6.2 Pneumatic, Hydrostatic and Operational Tests

Before conducting heat distribution system tests, flush lines with high pressure water until discharge shows no foreign matter and are deemed clean to the satisfaction of the Contracting Officer.

3.6.2.1 Pneumatic Test

The casing of DDT systems shall be pneumatically tested after welding and before field coating using air as the test medium. The test pressure shall be 15 psig. Persons not working on the test operations shall be kept out of the testing area while testing is proceeding. The test shall be made on the system as a whole or on sections that can be isolated. Joints in sections shall be tested prior to backfilling when trenches must be backfilled before the completion of other pipeline sections. The test shall continue for 24 hours from the time of the initial readings to the final readings of pressure and temperature. The initial test readings of the instrument shall not be made for at least 1 hour after the casing has been subjected to the full test pressure, and neither the initial nor final readings shall be made at times of rapid changes in atmospheric conditions. There shall be no indication of reduction of pressure during the test after corrections have been made for changes in atmospheric conditions in conformity with the relationship T(1)P(2)=T(2)P(1), in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial (1) and final (2) readings. Pressure shall be measured with a mercury manometer, inclined manometer(slope gauge), or an equivalent device so calibrated as to be read in increments of not greater than 0.1 psi. [Pressure shall be measured with a pressure gauge conforming to ASME B40.100. A throttling type needle valve or a pulsation dampener and shutoff valve may be included. The diameter of the face shall be at least 4.5 inches with a measurable range of 0 to 15 psig and graduations of not greater than 0.1 psig.] During the test, the entire system shall be completely isolated from all compressors and other sources of air pressure. Each joint shall be tested while under test pressure by means of soap and water or an equivalent nonflammable solution prior to backfilling or concealing any work. The testing instruments shall be approved by the Contracting Officer. All labor, materials and equipment for conducting the tests shall be furnished by the Contractor and shall be subject to inspection at all times during the tests. The Contractor shall maintain proper safety precautions for air pressure testing at all times during the tests.

3.6.2.2 Hydrostatic Test

Carrier piping shall be tested hydrostatically before insulation is applied at field joints and shall be proved tight at a pressure 1.5 times the heat distribution supply pressure of [_____] psig for 2 hours. There shall be no indication of reduction of pressure during the test. Pressure shall be measured with a device calibrated as to be read in increments of not greater than 5.0 psi.

3.6.2.3 Operational Test

Prior to acceptance of the installation, Contractor shall subject system to operating tests simulating actual operating conditions to demonstrate satisfactory functional and operating efficiency. These operating tests shall cover a period of not less than six hours for each portion of system tested. Conduct tests at times as the Contracting Officer may direct.

a. The contractor shall provide calibrated instruments, equipment, facilities and labor, at no additional cost to the Government.

b. When failures occur, repair problems then repeat test.

3.6.3 Deficiencies

Deficiencies discovered shall be corrected at the Contractor's expense, to the satisfaction of the Contracting Officer. Major deficiencies or failure to correct deficiencies, to the satisfaction of the Contracting Officer, may be considered cause for rejecting the entire installation.

3.7 VALVE MANHOLES

Valve manholes, piping, and equipment in valve manholes shall be in accordance with the contract drawings and Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES.

3.8 BURIED UTILITY WARNING AND IDENTIFICATION

3.8.1 Plastic Marking Tape

Polyethylene plastic tape manufactured specifically for warning and identifying buried utility lines shall be supplied and installed. Tape shall be buried above the pipe during the trench backfilling operation and shall be buried approximately 12 inches below grade. Tape shall be [0.004 inch thick polyethylene] [polyethylene with a metallic core]. Tape shall be acid and alkali-resistant and shall have a minimum strength of 1750 psi lengthwise and 1500 psi crosswise with an elongation factor of 350 percent. [The tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 3 feet deep. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion.] The tape shall be of a type specifically manufactured for marking and locating metallic underground utilities. Tape shall be 6 inches wide and printed with a caution and identification of the piping system over the entire tape length. Tape shall be yellow with bold black letters. Tape color and lettering shall be unaffected by moisture and other substances contained in the backfill material.

3.8.2 Markers for Underground Piping

Markers for underground piping shall be located along the distribution and service lines. Markers shall be placed as indicated approximately 2 feet to the right of the distribution system when facing in direction of flow in the supply line. The marker shall be concrete 6 inch square or round section [2] [3] feet long. The top edge of the marker shall have a minimum 1/2 inch chamfer all around. The letters [STEAM] [HTHW] [CONDENSATE] shall be impressed or cast on the top, and on one side of the markers to indicate the type of system that is being identified. Each letter shall be formed with a V-shaped groove and shall have a width of stroke at least 1/4 inch at the top and depth of 1/4 inch. The top of the marker shall protrude not more than [1] [2] [3] [4] inch(es) above finished grade.

3.9 THERMAL PERFORMANCE TESTING

The purpose of this section is to provide a basis for assuring the thermal performance of a heat distribution system procured under this specification. The equipment and procedures specified herein shall assure acceptable thermal performance upon installation. All materials and procedures described for this test shall be included as deliverables of the construction contract for the system unless otherwise noted. The methods used for the prescribed thermal performance measurements have been verified by several successful field studies. This work has clearly demonstrated that methods based on temperature measurements at the soil/casing interface are accurate, reliable, and repeatable.

3.9.1 Equipment

3.9.1.1 Casing Temperature Measurement

Before backfilling, temperature sensors shall be installed by adhesion with epoxy (epoxy used to adhere to exterior of casing shall be suitable to 500 degrees F) to the exterior of every other field closure after welding, once the field coating has been applied and cured. A sensor shall be adhered with epoxy to the coated casing at the midpoint of every other pipe section between field joints, but no closer than 5 feet to any guide on the interior of the casing. After the sensors have been adhered to the casing, two complete wraps of duct tape shall be used to secure and protect the sensor. In all cases the radial position of the sensor shall be at 45 degrees from the top of the conduit at either the 1:30 or 10:30 position. The position chosen shall be the position facing away from the adjacent heat distribution system pipe, if present. All sensors shall be type T thermocouples in accordance with ISA MC96.1, copper constantan 20 gauge thermocouples, made from special limits grade thermocouple wire (accuracy plus or minus 0.75 degrees F), with each conductor insulated and an overall jacket on all conductors. Insulation on the thermocouple wires shall be suitable for service at temperature of carrier pipe. No splicing or other connections will be allowed in the thermocouple wire between sensor location and termination point. Each sensor shall be shown with a special symbol on the detailed design layout drawings and shall be identified by a number and/or letter code, starting from the upstream manhole.

3.9.1.2 Carrier Pipe Temperature Measurement

Carrier pipe temperature shall be measured within the manhole where the terminal equipment will be located. Carrier pipe temperature shall be measured by a sensor adhered with epoxy, suitable to 500 degrees F directly to the exterior of the carrier pipe. Sensors shall be type T thermocouples in accordance with ISA MC96.1, copper constantan 20 gauge thermocouples, made from special limits grade thermocouple wire (accuracy plus or minus 0.75 degrees F), with each conductor insulated and an overall jacket on all conductors. Insulation on the thermocouple wires shall be suitable for service at temperature of carrier pipe. No splicing or other connections will be allowed in the thermocouple wire between sensor location and termination point. The location of this sensor shall be at either the 1:30 or 10:30 position. At the location of the sensor the carrier pipe shall be insulated with an approved calcium silicate insulation of 5 inches minimum thickness. This insulation shall extend at least 6 inches on each side of the actual sensor location and shall be clad with an aluminum jacket.

3.9.1.3 Terminals

The wires from each casing or carrier pipe temperature sensor shall be extended into the nearest manhole and terminated in a NEMA ICS 4 type 4 waterproof enclosure, of suitable size, mounted near the top of the manhole at a location near the manhole entrance so as to be accessible without entrance into the manhole, where possible. The termination of the sensor wires shall be with a connector type OMEGA Miniature Jack Panel (MJP-*-*-T) or exact equal. The thermocouple jack panel shall be mounted to the back plate of the NEMA ICS 4 type 4 enclosure. The temperature sensors shall be labeled at their termination within the NEMA ICS 4 type 4 enclosure; a drawing showing the location of each temperature sensor shall be laminated and attached to the inside of the NEMA ICS 4 type 4 enclosure. The manufacturer's operating casing temperature factors for each temperature sensor location shall be laminated to a card attached to the inside of the NEMA ICS 4 type 4 enclosure. All temperature sensors shall be verified as operational by an independent laboratory, hired by the Contractor, after backfilling is complete but before the system is accepted.

3.9.2 Initial Thermal Performance Test

After the system construction is complete, including all backfilling, and the system has reached operating condition for not less than 48 hours nor more than 168 hours, all of the temperature sensors shall be read by an independent laboratory with experience and equipment appropriate for the sensors used. For each temperature sensor location the initial casing temperature shall be recorded. All of the temperature values of the temperature sensors shall be tabulated and submitted in accordance with requirements herein.

3.9.3 Warranty Thermal Performance Test

After not less than 9 months nor more than 11 months of continuous operation, all of the temperature values of the temperature sensors shall be read by an independent laboratory with experience and equipment appropriate for the sensors used. The temperature shall be tabulated and submitted in accordance with requirements herein.

3.9.4 System Failure

System shall be deemed a failure when the conduit surface temperature exceeds values in Table 3, that portion shall be repaired and temperatures again measured and recorded.

TABLE 3

Carrier pipe Temperature TP (degrees F)	Acceptable Casing Temperature TC (degrees F)
250	110
275	116
300	123
325	129

TABLE 3	
Carrier pipe Temperature TP (degrees F)	Acceptable Casing Temperature TC (degrees F)
350	136
400	149
425	155
450	162

The following equations were used to calculate the above values:

TC, </=[(0.261) X (TP) + 44.3]

-- End of Section --

SECTION 33 63 13.19

CONCRETE TRENCH HYDRONIC AND STEAM ENERGY DISTRIBUTION
02/16

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B650	(1995; R 2018) Standard Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C547	(2019) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2022) Standard Specification for Cellular Glass Thermal Insulation
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1056	(2020) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM F1139	(1988; R 2019) Steam Traps and Drains

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2015) (10th Ed) EJMA Standards

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-45	(2020) Bypass and Drain Connections
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 10/NACE No. 2	(2015) Near-White Blast Cleaning

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heat Distribution System

SD-03 Product Data

Spare Parts

Support of the Equipment

SD-04 Samples

Insulation

SD-05 Design Data

Expansion Loop Insulation Method; G[, [____]]

SD-06 Test Reports

Tests

SD-07 Certificates

Flange Gasket Kits

SD-10 Operation and Maintenance Data

Maintenance; G[, [____]]

1.3 DELIVERY, STORAGE, AND HANDLING

Store all materials and equipment delivered and placed in storage with protection from the weather; excessive humidity and excessive temperature variation; and dirt, dust, or other contaminants.

1.4 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the related submittals and not later than the start of the field tests. Include in the data a complete list of parts and supplies and source of supply.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

Equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.1.2 Nameplates

Ensure each major item of equipment such as sump pumps, motors, steam traps, and pressure reducing valves is provided with the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Asbestos Prohibition

Asbestos and asbestos-containing products are not allowed.

2.1.4 Electrical Work

Provide motors, manual or automatic motor control equipment, and protective or signal devices required for the operation specified under this section in accordance with NFPA 70 and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2 PIPING AND FITTINGS

Unless otherwise specified, provide all pipe, fittings, valves, and piping accessories conforming to the requirements of ASME B31.1, and be the proper type, class, and grade for pressure and temperature of the heating medium.

2.2.1 Steel Pipe

Provide steel pipe 2 inches in diameter and larger that are seamless or electric-resistance welded conforming to ASTM A53/A53M, Grade B, Type E or S; or to ASTM A106/A106M, Grade B. Provide steel pipe 1-1/2 inches in diameter and smaller that are seamless conforming to ASTM A106/A106M, Grade B. Provide condensate piping, gauge piping, and piping 0.75 inch in diameter and smaller that are extra strong. Provide all other pipe that are standard weight.

2.2.1.1 Nipples

Provide nipples conforming to ASTM A733 as required to match adjacent piping.

2.2.1.2 Steel Flanges

Provide steel flanges conforming to ASME B16.5 Class [150] [and] [or] [300] and matching valves or flanged fittings on which used. Ensure flanges have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.2.1.3 Pipe Threads

Provide pipe threads conforming to ASME B1.20.1. Pipe threads may be used only on pipe 0.75 inch or smaller.

2.2.2 Fittings

Provide fittings, valves, flanges and unions that have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.2.2.1 Welded Fittings

Provide welded fittings conforming to ASTM A234/A234M, buttwelded or socket welded, standard weight or extra strong, as required to match connecting piping. Provide buttwelded fittings conforming to ASME B16.9, and socket welded fittings conforming to ASME B16.11.

2.2.2.2 Malleable Iron Fittings

Provide fittings conforming to ASME B16.3, ASTM A47/A47M, class as required to match connecting piping.

2.2.2.3 Unions

Provide unions conforming to ASME B16.39 as required to match adjacent piping.

2.2.3 Insulating Flanges and Dielectric Waterways

Submit certificate from the material supplier of the electrically insulating flange gasket kits stating that the supplied material meets specified requirements and that provides evidence that satisfactory operating requirements have been met, before the materials are delivered. Certificate must be signed by an official authorized to certify in behalf of material supplier or product manufacturer and must identify quantity and date or dates of shipment or delivery to which the certificates apply. Install insulating flanges or flange gasket kits at every pipe connection from the trench system to an underground system and at dissimilar metals. Provide a kit consisting of a flange gasket, bolt sleeves, and one insulating washer and one steel washer for both ends of each bolt. Ensure the gasket kits are capable of electrically isolating the pipe at the pressure and temperature of the heating medium at the point of application. Material of the type being used must have been installed in an installation which has been satisfactorily operating for not less than 2 years. Ensure that these kits are provided and properly installed according to manufacturer published instructions as indicated. Provide dielectric waterways with temperature and pressure rating equal to or greater than that specified for the connecting piping used for joining dissimilar metals, 0.75 inch and smaller threaded pipe. Ensure waterways have metal connections on both ends suited to match connecting piping. Provide dielectric waterways internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Ensure dielectric flanges meet the performance requirements described herein for dielectric waterways.

2.3 VALVES

Unless otherwise specified, provide valves that comply with the material, fabrication, and operating requirements of ASME B31.1. Provide valves suitable for the temperature and pressure requirements of the system on which used. Provide valves for [steam] [hot water] conforming to ASME B31.1 Class [150] [and] [or] [300], as suitable for the application. [Provide valves for condensate services conforming to ASME B31.1 Class 150.] Provide valves 6 inches and larger with a 1 inch minimum gate or globe [integral] bypass valve sized in conformance with MSS SP-45. Provide valves that have the manufacturer's trademark.

2.3.1 Steel Valves

Provide globe, gate, angle, and check valves conforming to the requirements of ASME B16.34 and ASME B31.1 for the temperature and pressure requirements of the system. Provide gate valves 2-1/2 inches and smaller with a rising stem. Provide gate valves 3 inches and larger with an outside screw and yoke.

2.3.2 Bronze Valves

2.3.2.1 Globe, Gate, and Angle Valves

Provide globe, gate, and angle valves conforming to requirements of MSS SP-80.

2.3.2.2 Check Valves

Provide check valves conforming to the requirements of MSS SP-80.

2.3.3 Packing

Provide valves with packing that does not contain asbestos. Provide valve stem packing that is die-formed, ring type specifically designated as suitable for the temperature and pressure of the service and compatible with the fluid in the system. Provide packing rings that are polytetrafluoroethylene with minimum 50 percent graphite filament top and bottom rings. Provide valves 1-1/2 inches and smaller that have four or five packing rings. Provide valves 2 inches and larger with at least six packing rings. Spiral or continuous packing will not be acceptable. Provide a metal insert having proper clearance around the valve stem at the bottom of the stuffing box and acting as a base for the packing material. Provide packing glands furnished with a liner of noncorrosive material and one piece construction with provisions for not less than two bolts for packing adjustment.

2.4 STEAM TRAPS

Provide class of trap bodies suitable for a working pressure of not less than 1.5 times the steam supply pressure, but not less than 200 psi, and traps capable of operation under a steam-supply pressure as indicated with trap capacities as shown when operating under the specified working conditions. Provide traps that fail open.

2.4.1 Bucket Traps

Provide inverted-bucket type bucket traps with automatic air discharge conforming to ASTM F1139.

2.4.2 Thermostatic Traps

Provide thermostatic type thermostatic traps with bimetallic element automatic air discharge conforming to ASTM F1139.

2.5 STRAINERS

Provide basket or Y-type strainers with connections the same size as the pipe lines in which the connections are installed. Provide heavy and durable strainer bodies of cast steel with bottoms drilled and plugged suitable for service temperatures and pressures utilized with arrows clearly cast on the sides to indicate the direction of flow. Each strainer is equipped with an easily removable cover and sediment basket with the body or bottom opening equipped with nipple and gate valve for blowdown. Provide 0.025 inch thick stainless steel, Monel or sheet brass strainer basket with small perforations of sufficient number to provide a net free area at least 2.5 times the area of the entering pipe. Provide cast steel bodies and stainless or Monel baskets for high temperature hot water systems.

2.6 PRESSURE GAUGES

Provide pressure gauges conforming to ASME B40.100 with a minimum dial size of 4-1/4 inches, a throttling type needle valve or a pulsation dampener, and shut-off valve.

2.7 THERMOMETERS

Do not provide thermometers containing mercury.

2.7.1 Liquid in Glass

Provide liquid in glass type thermometer with well and separable corrosion-resistant steel socket. Provide thermometer on insulated pipe with an insulation stand-off provision. Provide thermometer with minimum scale length of 7 inches.

2.7.2 Dial

Provide a dial type thermometer with a dial size of 3.5 inches in diameter with stainless steel case, remote-type bulb or direct-type bulb as applicable, with an accuracy of plus or minus 2 degrees F and white face with black digits graduated in 2 degrees F increments.Provide thermometer wells of the separable socket type for each thermometer with direct-type bulb.

2.8 INSULATION AND JACKETING

2.8.1 Insulation for Piping in Concrete Trenches

Provide molded calcium silicate insulation for all piping, fittings, and valves conforming to ASTM C533, Type I, or molded mineral fiber insulation conforming to ASTM C547, Class 2, or cellular glass insulation conforming to ASTM C552. Provide factory or field applied insulation. Other than FOAMGLAS, do not use laminated construction in thicknesses less than 4 inches. Provide insulation on piping in concrete trenches covered with aluminum or nonmetallic jacket.

2.8.2 Aluminum Jacket

Provide smooth sheet jacket, 0.016 inch nominal thickness; ASTM B209, Type 3003, 3105, or 5005. Use aluminum jacket over calcium silicate insulation.

2.8.3 Nonmetallic Jacket

Provide nonmetallic jacket consisting of a 6 ounces per square yard fiberglass fabric impregnated with chlorosulfanated polyethylene (Hypalon) and a 1.5 mils polyvinyl fluoride film (Tedlar) bonded to it. Ensure overall thickness of the composite is 0.010 inch and weigh approximately 10.5 ounces per square yard. Jacket may be either field or factory applied to the insulation. Do not use the jacket with any calcium silicate insulation. Use nonmetallic jacket with molded mineral fiber insulation.

2.8.4 Bands

Provide bands for aluminum jackets that are .38 inch wide and 32 gauge thickness made of aluminum or annealed stainless steel. Provide bands for insulation that are 0.5 inch wide and 32 gauge thickness made of annealed stainless steel.

2.8.5 Insulation for Flanges, Unions, Valves, and Fittings

Provide flanges, unions, valves, and fittings insulated with premolded prefabricated, or field fabricated segments of removable and reusable insulation of the same material and thickness as the manhole pipe insulation with the same thermal characteristics and thickness as the adjoining piping.

2.9 CONCRETE WORK

2.9.1 Concrete

2.9.1.1 Cast-in-Place Concrete

Provide as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.9.1.2 Precast Concrete Products

Provide as specified in [Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION][Section 03 41 16.08 PRECAST CONCRETE SLABS (MAX. SPAN 8 FEET O.C.)].

2.9.2 Concrete Joint Sealants

Provide concrete joint sealants conforming to ASTM C920, Type M (multicomponent), Class 25, grade NS (nonsag) for vertical surfaces or grade P (pourable self-leveling).

2.9.3 Gasket Material

Provide gasket material used between concrete trench covers and trench wall tops that is 0.25 inch thick neoprene pad with a minimum width of 2 inches conforming to ASTM D1056.

2.9.4 Concrete Expansion Joints, Contraction Joints, and Waterstops

Provide concrete expansion joints, contraction joints, and waterstops as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.10 BITUMINOUS PAVING

Provice bituminous course and tack coat used at street crossings as specified in Section 32 12 16.16 ROAD-MIX ASPHALT PAVING and Section 32 12 13 BITUMINOUS TACK AND PRIME COATS.

2.11 MISCELLANEOUS METAL

Provide miscellaneous metal not otherwise specified conforming to Section 08 31 00 ACCESS DOORS AND PANELS. Provide miscellaneous metal bolted together, shop welded, or assembled in the field, and pipe supports including structural cross support members and anchors that is hot-dip galvanized in accordance with Section 08 31 00 ACCESS DOORS AND PANELS.

2.12 INSPECTION PORTS AND ACCESS COVERS

Provide inspection ports and access covers in concrete tops that are standard cast iron frame and cover. Provide inspection ports that are 12 inch nominal diameter and access covers that are 24 inch nominal diameter unless otherwise indicated.

2.13 BELLOWS TYPE JOINTS

Select bellows type or slip-type to satisfy specific design conditions. Provide joints that are flexible, guided expansion joints. Ensure the expansion element is stainless steel. Provide bellows type expansion joints that are in accordance with the applicable requirements of EJMA Stds and ASME B31.1 with internal liners.

2.14 EXPANSION JOINTS

Provide expansion joints for either single or double slip of connected pipes, as required or indicated, and for not less than the traverse indicated. Provide joints designed for hot water working pressure and are in accordance with applicable requirements of EJMA Stds and ASME B31.1. Provide joints designed for packing injection under full line pressure. Provide end connections flanged or beveled for welding as indicated. Provide joints with anchor base where required or indicated. Where adjoining pipe is carbon steel, the sliding slip must be seamless steel plated with a minimum of 2 mils of hard chrome in accordance with ASTM B650. Provide joint components fabricated from material equivalent to that of the pipeline. Ensure initial setting are made in accordance with the manufacturer's recommendations to compensate for ambient temperature at time of installation. Install pipe alignment guides as recommended by the joint manufacturer, but in any case not be more than 5 feet from expansion joint except for lines 4 inches or smaller; guides must be installed not more than 2 feet from the joint. Provide service outlets where indicated.

2.15 FLEXIBLE BALL JOINTS

Provide flexible ball joints constructed of alloys as appropriate for the service intended. Where so indicated, the ball joint must be designed for packing injection under full line pressure to contain leakage. Provide joint ends threaded to 2 inches only, grooved, flanged or beveled for welding as indicated or required, and be capable of absorbing a minimum of 15 degrees angular flex and 360 degrees rotation. Provide balls and sockets of equivalent material as the adjoining pipeline. Exterior spherical surface of carbon steel balls must be plated with 2 mils of hard chrome in accordance with ASTM B650. Provide ball type joints designed and constructed in accordance with ASME B31.1 and ASME BPVC SEC VIII D1, where applicable. Provide flanges conforming to ASME B16.5. Provide gaskets and compression seals compatible with the service intended.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 SITEWORK

3.2.1 Excavation, Trenching, and Backfilling

Provide excavation, trenching, and backfilling of concrete trench systems, [and relocation of interferences and modifications to existing facilities] in accordance with Section 31 00 00 EARTHWORK.

3.2.2 Removal, Replacement, or Relocation of Interferences

Remove, replace, or relocate interferences indicated or found during construction. Removal, replacement, or relocation must be as shown, or as approved by the Contracting Officer. Examples of interferences include:

a. Storm and sanitary sewers and manholes.

b. Water lines, gas lines, fire hydrants, and lawn sprinkler systems.

c. Power and communication lines, conduits, poles, and guys.

d. Fences, sidewalks, and signs.

e. Grass, shrubs, trees, and rocks.

3.2.3 Modifications to Existing Facilities

Modifications to existing facilities must be made as indicated. Examples of modifications include:

a. Removal and replacement of street or parking area pavements.

b. Removal and replacement of curbs, gutters, and sidewalks.

c. Reconstruction of existing valve manholes.

d. New heat distribution piping entrances to buildings, valve manholes, or trenches.

3.2.4 Electric Work

Provide any wiring required for the operation of the equipment specified, but not shown on the electrical drawings, in this section in accordance with Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION, and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.5 Painting

Clean the heat affected zone of field welded galvanized surfaces and other galvanized surfaces damaged during installation in compliance with SSPC SP 10/NACE No. 2 and painted in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.3 PIPING

3.3.1 General Piping Requirements

Accurately cut pipe to measurements established at the site and worked into place without springing or forcing. Ensure pipe is clear of all openings and equipment. Excessive cutting or other weakening of structural members to facilitate piping installation will not be permitted. Remove burrs from ends of pipe by reaming. Ensure installation permits free expansion and contraction without damage to joints or hangers. Install piping in accordance with ASME B31.1. Weld joints for piping in concrete trenches [, except joints at traps, strainers, and at valves 0.75 inch and smaller in steam, condensate, and drip lines, which may use unions or may be threaded]. Do not attach supports, anchors, or stays where either expansion or the weight of the pipe will cause damage to permanent construction. Provide noninsulated ferrous parts of the piping, piping support system, or equipment that are hot-dip galvanized after fabrication in conformance with ASTM A123/A123M.

a. Ensure expansion of piping provide for by changes in the direction of the run of pipe or by expansion loops as shown.

b. Changes in direction may be made by bending the pipe, provided that a hydraulic pipe bender is used. Pipe to be bent must be steel conforming to ASTM A53/A53M or ASTM A106/A106M type and grade for bending, and class required to match adjoining pipe. Bent pipe showing kinks, wrinkles, or malformations will not be acceptable.

c. Pitch all piping, unless otherwise indicated, with a grade of not less than 1 inch in 20 feet toward drain points with slope maintained throughout the system, including through each leg of each expansion loop.

d. Properly cap or plug open ends of pipe lines and equipment during installation to keep dirt and other foreign matter out of the system.

3.3.2 Welded Joints

Weld joints between sections of pipe and between pipe and fittings in accordance to the requirements specified in paragraph WELDING. Branch connections may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings where used, must be forged and must be no larger than two nominal pipe sizes smaller than the main run. Branch outlet fittings must be flared for improved flow where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength.

3.3.3 Flanged and Threaded Joints

3.3.3.1 Flanged Joints

Provide true faced joints with gaskets, square and tight. Provide electrically isolated flange joints at all connections to building underground systems and between dissimilar metals.

3.3.3.2 Threaded Joints

Provide joints with graphite or inert filler and oil, graphite compound, or polytetrafluoroethylene tape applied to the male threads only. Provide dielectric unions at connections of dissimilar metals in 0.75 inch and smaller piping.

3.3.4 Reducing Fittings

3.3.4.1 Horizontal Water Heating Lines

In horizontal hot water heating lines, provide eccentric type reducing fittings to maintain the tops of adjoining pipes at the same level.

3.3.4.2 Horizontal Steam Lines

In horizontal steam lines, provide eccentric type reducing fittings to maintain the bottom of adjoining pipes at the same level.

3.3.5 Branch Connections

Ensure branches from mains branch off top of mains as indicated or as approved. Ensure connections allow unrestricted circulation, elimination of air pockets, and permit the complete drainage of the system.

3.3.6 Pipe Supports Exposed in Concrete Trenches

Securely support horizontal and vertical runs of pipe in concrete trenches . Provide adjustable pipe hangers having bolted hinged loops and turnbuckles or by other approved devices as shown on the drawings, and all conforming to MSS SP-58 for suspended pipe. Chain or flat steel strap hangers or single point supports will not be acceptable. Provide all pipe supports including the structural cross support member in accordance with Section 08 31 00 ACCESS DOORS AND PANELS.

3.4 WELDING

Perform welding and radiographic examination of all steel carrier pipe welds in accordance with Section 40 05 13.96 WELDING PROCESS PIPING. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

3.5 RADIOGRAPHIC TESTING

Submit detail drawings for steam traps, valves, sump pumps, pressure gauges, thermometers and insulation, including a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Show on the drawings complete wiring and schematic diagrams, pipe stress calculations for any revised expansion loops, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show on the drawings proposed system layout, provisions for expansion, pipe anchors and guides, and layout and anchorage of equipment and appurtenances in valve manholes, and equipment relationship to other parts of the work including clearances for maintenance and operation.

a. Provide radiographic examination of all field welds in the steel carrier piping of the heat distribution system in accordance with ASME B31.1 performed as specified in Section 40 05 13.96 WELDING PROCESS PIPING. Provide an approved independent testing firm or firms regularly engaged in radiographic testing to perform a radiographic examination of all field welds in accordance with ASME B31.1.

b. Furnish a set of films showing each weld inspected, a reading report evaluating the quality of each weld, and a location plan showing the physical location where each weld is to be found in the completed project, prior to backfilling and hydrostatic testing. Provide a report that is reviewed and interpreted by a Certified Level III Radiographer employed by the testing firm with signature of reviewer/interpreter on the report readings for all radiographs.

c. The Contracting Officer reserves the right to review all inspection records, and if any welds inspected are found unacceptable they will be removed, rewelded, and radiographically examined at no cost to the Government.

3.6 INSULATION

Submit display sample sections for insulation of pipe, elbow, tee, valve, support point, and terminating points. After approval of material and prior to insulation of piping, prepare a display of insulated sections showing compliance with specifications, including fastening, sealing, jacketing, straps, waterproofing, supports, hangers, anchors, and saddles. Keep sample sections on display at the jobsite during the construction period until no longer needed. Install insulation so that it is not damaged by pipe expansion or contraction. Groove insulation installed over welds to assure a snug fit. Hold insulation in place with stainless steel straps. Install a minimum of 2 bands on each individual length of insulation with maximum spacing not exceeding 18 inch centers. Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate on each test report the final position of controls and valves.

3.6.1 Installation

Install material in accordance with published installation instructions of the manufacturer. Apply insulation materials only after piping tests are satisfied completed.

3.6.1.1 Preparation

Prior to application, thoroughly clean surfaces of moisture, grease, dirt, rust, and scale, and paint where required.

3.6.1.2 Thickness

Provide the minimum thickness of insulation for [the heat distribution system] [and] [condensate return system] [each section of pipe] in accordance with Tables 1 and 2.

TABLE 1
Minimum Pipe Insulation Thickness (inches)

For steam up to 16 psig to 250 psig and high temperature hot water supply and return piping up to 450 degrees F

Nominal Pipe Diameter (inches)	Insulation Thermal Conductivity (k)		
	k less than 0.29	k from 0.29 to 0.40	k greater than 0.40
1.0	2.0	2.5	4.0
1.5	2.0	2.5	4.0
2.0	2.5	3.5	4.5
2.5	2.5	3.5	4.5
3.0	3.0	4.0	5.0
4.0	3.0	4.0	5.0
5.0	3.0	4.0	5.0
6.0	3.5	4.5	5.5
8.0	3.5	4.5	5.5
10.0	4.0	5.0	6.0
12.0	4.0	5.0	6.0
14.0	4.0	5.0	6.0
16.0	4.0	5.0	6.0
18.0	4.0	5.0	6.0

NOTE: Insulation thermal conductivity (k-value) is in units of Btu-inches/hour-square-feet-degrees F at 200 degrees F mean temperature.

TABLE 2 Minimum Pipe Insulation Thickness (inches)			
For Low Pressure Steam (less than 16 psig), Condensate Return and Low Temperature Hot Water (less than 250 degrees F) supply and return piping.			
Nominal Pipe Diameter (inches)	Insulation Thermal Conductivity (k)		
	k less than 0.29	k from 0.29 to 0.40	k greater than 0.40
1.0	1.5	2.0	3.0
1.5	1.5	2.0	3.0
2.0	1.5	2.0	3.0
2.5	1.5	2.0	3.0
3.0	2.0	2.5	3.5
4.0	2.0	2.5	3.5
5.0	2.0	2.5	3.5
6.0	2.5	3.0	4.5
8.0	2.5	3.0	4.5
10.0	3.0	4.0	5.0
12.0	3.0	4.0	5.0
14.0	3.0	4.0	5.0
16.0	3.0	4.0	5.0
18.0	3.0	4.0	5.0
NOTE: Insulation thermal conductivity (k-value) is in units of Btu-inches/hour-square-feet-degrees F at 200 degrees F mean temperature.			

3.6.2 Insulation on Pipes Passing Through Sleeves

Install insulation continuously through sleeves. Provide aluminum jackets over the insulation. When penetrating building walls, extend aluminum jackets not less than 2 inches beyond the sleeve on each side of the wall and be secured with an aluminum band on each side of the wall. Where flashing is provided, secure the jacket with one band not more than 1 inch from the end of the jacket.

3.6.3 Covering of Insulation in Concrete Trenches

Provide aluminum jackets for pipe insulation, flanges, valves, and fittings.

3.7 CONCRETE TRENCH SYSTEM

Provide and install a concrete cast-in-place trench system with a removable top as shown on the drawings.

3.7.1 Concrete

Provide materials and methods for mixing and placing of concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.7.2 Joint Sealants

Seal concrete joints as indicated. Provide type II sealant (non-sagging) for vertical joints. Provide type I sealant for trench top butt joints. For all other joints, seal with Type I or Type II sealant. Provice trench bottom sealant finish flush with floor.

3.7.3 Concrete Trench Tops

Provide precast or cast-in-place concrete trench tops. Provide concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Ensure tops are flat and true and lay flat at all locations where contact on trench wall is to be made. Tolerances must be true planes within 0.012 inch in 8 feet as determined by 8 foot straight edge placed diagonally on top. Deviation from square or designated skew (difference in length of the two diagonal measurements) must be 0.012 inch in 6 feet or 0.25 inch total, whichever is greater. Maximum permissible warpage of one corner out of the plane of the other three must be 0.06 inch per foot distance from the nearest adjacent corner. Do not install concrete trench tops with defects which affect the strength of the cover unit, or which are warped, honeycombed, contain visible air pockets, exposed aggregate, or other surface defects such as spalled, chipped, or broken edges, . Place neoprene gasket material on the top of concrete trench walls so as to provide a seal between the wall and the concrete trench covers. Surfaces of joints to be in contact with gasket material must be dry and free of oil, grease, dirt, loose concrete particles, or other foreign substances. Place gasket material in a continuous length along the wall as much as practical. Butt gasket ends tightly together at splices. Construct concrete trench tops in maximum lengths of 8 feet and minimum lengths of 4 feet and must be a minimum of 4 inches thick, unless otherwise indicated. Provide each top section with means to accept a lifting device for removal of slab, as indicated on the drawings.

3.7.4 Concrete Trench Construction

Ensure inside edge and top of walls has smooth and even surfaces to accommodate trench tops.

3.7.5 Final Elevations

Slope the concrete trench floor continuously and drain toward valve manholes. Construct the concrete trench at the elevation shown on the drawings and grade the adjacent areas. Grade any cut or fill areas adjacent to the concrete trench back to the existing grade at a 1 to 10 slope, or as indicated. Take care to avoid forming pockets adjacent to the concrete trench; thereby, preventing surface drainage. Install the concrete trench floor and pipe parallel and maintain constant slope toward the drain points indicated.

3.7.6 Coordination with Existing Utilities

Before beginning work in a given area, all utility information must be field verified by surface markings made by the affected utility Owner's Representative. Notify the Contracting Officer in advance, and receive prior approval before excavating in any areas. The actual concrete trench routing may be offset or changed if approved by the Contracting Officer in order to reduce conflicts, interruptions, expedite the work, or for any other reason to the mutual benefit of the Contractor and the Government. Utility conflicts may be cast into the floor of the trench providing they do not interfere with concrete trench drainage and are approved by the Contracting Officer. [After the new heat distribution system is cut-in, the existing system can be [removed.] [abandoned in place if not in conflict with the new construction and not shown to be removed on the drawings.]]

3.7.7 Piping Support System

Do not install pipes, pipe supports, or other related items on the floor of the concrete trench system. Pipe support members spanning traversely across the tunnel must allow a minimum of 4 inches clearance between structural member and concrete trench floor. Additional minimum clearances required from the pipe insulation surface must be as follows: 8 inches to concrete trench floor, 6 inches to side walls, 6 inches to trench cover, and 6 inches between adjoining pipes.

3.7.8 Pipe Expansion

Expansion must be accommodated by loops and bends as indicated on the drawings and specified. Pipe in the loops and bends must accommodate expansion while maintaining required insulation clearance from floors, walls, tops, and other pipes to avoid crushing or breaking of insulation. Expansion loops may be designed around obstacles such as utility manholes, structures, or trees to avoid construction conflicts. Maintain slopes of pipe and trench bottoms Contractor must have the option to adjust the loop dimensions around obstacles based on final field measurements, if approved by the Contracting Officer. Submit pipe stress calculations for each revised expansion loop or bend based on the final actual measured lengths, or must submit dimensions to the Contracting Officer for verification of loop and bend sizes before proceeding with that segment of work. Ensure allowable pipe stresses are in accordance with ASME B31.1. Submit final expansion loop insulation method for approval to the Contracting Officer.

3.7.9 Concrete Trench Inspection Ports

3.7.10 Road/Drive Crossings

Install handicap ramp style curb cuts at all street and drive crossings as indicated.

3.7.11 Railroad Crossings

Restore tracks to their original condition as approved by the Contracting Officer after construction is complete.

3.8 TESTS

Conduct tests before, during, and after the installation of the system. Provide all instruments, equipment, facilities, and labor required to properly conduct the tests. Test pressure gauges for a specific test must be approved by the Contracting Officer and must have dials indicating not less than 1.5 times, nor more than 3 times the test pressure.

3.8.1 Cleaning of Piping

Prior to the hydrostatic and operating tests, flush the interior of the piping with clean water until the piping is free of all foreign materials. Flushing and cleaning out of system pipe, equipment, and components must not be considered completed until witnessed and accepted by the Contracting Officer. After flushing the system is completed, drain and fill the system with clean water. Provide temporary bypasses or temporary strainers around equipment and control valves to prevent clogging.

3.8.2 Field Tests

Conduct the following field tests when applicable to the system involved. If any failures occur, ensure adjustments or replacements as directed by the Contracting Officer and repeat the tests until satisfactory tests are completed.

3.8.2.1 Hydrostatic Tests of Service Piping

Hydrostaically test service piping before insulation is applied at field joints, and be proved tight at a pressure 1.5 times the working pressure of [_____] psig or at 200 psig, whichever is greater. Hydrostatic test pressure must not exceed 500 psig. Hydrostatic test pressures must be held for a minimum of 4 hours. If the hydrostatic test pressure cannot be held, make necessary adjustments or replacements and repeat the tests until satisfactory results are achieved.

3.8.2.2 Equipment Tests

Operate all pumps, valves, traps, alarms, controls, and any other operable item of equipment to verify proper operation and compliance with the specifications. Record and submit pump voltage, current, and discharge readings for approval in accordance with SUBMITTALS paragraph (SD-06).

3.8.2.3 Insulating Flange Test

Test insulating flanges for electrical isolation in accordance with the insulating flange manufacturer's standard test. This test must be witnessed and approved by the Contracting Officer.

3.8.2.4 Operational Tests

After installation of the concrete trench system, or testable portion thereof, conduct operational tests. Do not place trench covers prior to completion of operational tests. Operational tests must consist of operating the system at the pressure and temperature expected for the system when in normal service, and must demonstrate satisfactory operating effectiveness. Ensure the test on each system, or portion thereof, last a minimum of 24 hours.

3.8.2.5 Trench Water Removal Tests

After the above tests are completed, and before concrete trench and valve manhole covers are placed, clean the concrete trenches, sumps, and valve manholes of dirt and debris. Test concrete trench system to ensure gravity drainage of water is maintained in trench bottom from high points to drained low points. Verify water does not pond between high and low points, and that drained low points are operational either by use of sump pumps or by gravity drainage to storm drains, as indicated. Test must not be considered completed until witnessed and accepted by the Contracting Officer. Place trench tops and sealed immediately after approval by the Contracting Officer.

3.9 MAINTENANCE

Provide [six] [_____] [hard] [optical disc] copies of operation and [six] [_____] copies of maintenance manuals for the equipment furnished. Provide one complete set prior to performance testing, and the remainder upon acceptance. Detail in the operation manuals the step-by-step procedures required for system startup, operation, and shutdown and include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides and include piping and equipment layout and simplified wiring and control diagrams indicating location of electrical components with terminals designated for wiring, as installed. Operation and maintenance manuals must be approved prior to performance testing.

-- End of Section --

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SECTION 33 63 14

EXTERIOR BURIED PUMPED CONDENSATE RETURN
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon

	Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM D1330	(2004; R 2010) Rubber Sheet Gaskets

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

1.2 SYSTEM DESCRIPTION

Design and provide [new and modify existing] exterior buried factory-prefabricated preinsulated pumped condensate (hot water) return piping system complete and ready for operation. Provide identical buried factory-prefabricated insulated piping material up to the first flanged connection in manholes and aboveground. Design pressure and temperature ratings of system components shall be for working pressure of 125 psig condensate at 250 degrees F.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Cooling tanks

Manholes

Federal Agency buried piping system

Show design and layout of piping system. Drawings shall have Professional Engineer Seal.

SD-03 Product Data

Pipe and fittings

Valves

Strainers

Pipe hangers and supports

Traps

Gages

Federal Agency Approved Brochure for plastic carrier piping

Thermometers

SD-05 Design Data

Federal Agency buried piping system

Submit calculations of system design. Calculations must have Professional Engineer Seal.

SD-07 Certificates

Certification of welder's qualifications

1.4 QUALITY ASSURANCE

1.4.1 Certification of Welder's Qualifications

Submit prior to site welding. Certifications shall not be more than one year old.

PART 2 PRODUCTS

2.1 PLASTIC CARRIER PIPING

2.1.1 Plastic Carrier Pipe and Fittings

Provide plastic carrier piping conforming to the Federal Agency Approved Brochure. Pipe, fittings, and adhesive shall be supplied by the same manufacturer. Pipe, fittings, flanges, and couplings shall have end connections of the adhesive bell and spigot type. Threaded piping, including pipe, fittings, flanges, and couplings, will not be permitted.

2.1.2 Flanged Connections

Provide flat face type flanged connections between plastic piping and metal piping. Plastic flanges shall be for connecting to ASME B16.5, Class 150 flanges.

2.1.3 Gaskets, Bolts, Nuts, and Washers

a. Gaskets: ASTM D1330, except the Shore A durometer hardness shall be 55 to 65, 0.125 inch thick ethylene propylene, full face of flange. Provide one piece factory cut gaskets.

b. Bolts: ASTM A193/A193M, Grade B7. Extend a minimum of two full threads beyond the nut with the bolts tightened to the torque recommended by plastic pipe manufacturer.

c. Nuts: ASTM A194/A194M, Grade 7, with Teflon coated threads.

d. Washers: Provide steel flat circular washers under bolt heads and nuts.

2.2 STEEL PIPING

Provide steel piping in manholes and aboveground. Steam piping includes piping upstream of steam traps. Condensate piping includes piping downstream of steam traps.

2.2.1 Steam Pipe

a. ASTM A53/A53M: Type E (electric-resistance welded, Grade A or B) or Type S (seamless, Grade A or B), black steel. Provide Weight Class STD (Standard) for welding end connections. Provide Weight Class XS (Extra Strong) for threaded end connections.

b. ASTM A106/A106M: Grade A or B, black steel, Schedule No. 40 for pipe sizes through 10 inches, and minimum pipe wall thickness of 0.375 inch for pipe sizes 12 inches and larger for welding end connections. Provide Schedule 80 for threaded end connections.

2.2.2 Condensate Pipe

Provide steel piping for other than exterior buried factory-prefabricated insulated pumped condensate return piping.

a. ASTM A53/A53M: Type E (electric-resistance welded, Grade A or B) or Type S (seamless, Grade A or B); black steel, Weight Class XS (Extra Strong).

b. ASTM A106/A106M: Grade A or B, black steel, Schedule No. 80.

2.2.3 Buried Steel Piping to Cooling Well or Drain

Provide direct buried steel condensate pipe and fittings with exterior coal tar epoxy painting system.

2.2.4 Threaded Fittings

ASME B16.11, or ASME B16.3, Class 150 for steam, Class 300 for condensate.

2.2.5 Socket Welding Fittings

ASME B16.11.

2.2.6 Buttwelding Fittings

ASME B16.9. Provide the same material and weight as the piping in which fittings are installed. Provide backing rings conforming to ASME B31.1 and be compatible with materials being welded.

2.2.7 Eccentric Reducing Fittings

ASME B16.9. Provide the same material and weight as the piping in which fittings are installed. Provide for changes in horizontal steam piping sizes.

2.2.8 Flanges and Unions

Provide flanges at connections to plastic piping.

2.2.8.1 Flanges

ASME B16.5, Class 150. Provide flat face flanged connections between plastic piping and metal piping.

2.2.8.2 Unions

ASME B16.39, Class 150 for steam, Class 250 for condensate.

2.2.9 Gaskets, Bolts, Nuts, and Washers

a. Gaskets: Provide ASME B16.21, composition ring 0.0625 inch thick for steam and gravity condensate (steam) piping. Provide ASTM D1330, except the Shore A durometer hardness shall be 55 to 65, 0.125 inch thick, full face of flange for pumped condensate (hot water) piping. Provide one piece factory cut gaskets.

b. Bolts: ASTM A193/A193M, Grade B7. Extend a minimum of two full threads beyond the nut with the bolts tightened to the required torque.

c. Nuts: ASTM A194/A194M, Grade 7, with Teflon coated threads.

d. Washers: Provide steel flat circular washers under bolt heads and nuts.

2.3 VALVES

Provide with stems in the horizontal position or not greater than 45 degrees above the horizontal position. Valves shall have flanged end connections, except sizes smaller than 2.5 inches in steel piping may have union end connections, or threaded end connections with a union on one side of the valve.

2.3.1 Valves for Condensate Service

Valves downstream of steam traps shall be for minimum working pressures of ASME Class 125.

2.3.1.1 Gate Valves

MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-70.

2.3.1.2 Globe and Angle Valves

MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-85.

2.3.1.3 Check Valves

MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-71. Provide swing check valves.

2.3.2 Valves for Steam Service

Valves upstream of steam traps shall be steel body for minimum working pressures of ASME Class 150.

2.3.2.1 Gate, Globe, and Angle Valves

ASME B16.34.

2.3.2.2 Check Valves

ASME B16.34, swing check.

2.4 PIPING ACCESSORIES

2.4.1 Pipe Hangers and Supports

Provide MSS SP-58 and MSS SP-69, of the adjustable type, except as specified or indicated otherwise. Tack-weld Type 39 pipe covering protection saddles to steel pipe for insulated piping. Provide steel support rods. The finish of rods, nuts, bolts, washers, hangers, and supports shall be hot-dip galvanized after fabrication. Rollers, bases, and saddles may be painted with two coats of aluminum or light gray paint rated for use on hot metal surfaces up to 450 degrees F in lieu of hot-dip galvanized. Provide stainless steel axles for rollers. Miscellaneous metal shall conform to ASTM A36/A36M, hot-dip galvanized after fabrication.

2.4.2 Strainers

Steel body in accordance with ASME B16.5 for minimum of ASME Class 150. Provide stainless steel strainer element with minimum diameter perforations of 0.016 inch for steam, 0.031 inch for steam mixed with condensate, and 0.047 inch for condensate (hot water). Provide blow-off outlet with pipe nipple, gate valve, and discharge pipe nipple.

2.4.3 Traps

Steel body, internals of stainless steel, minimum of ASME Class 150, and of the types indicated.

2.4.4 Pipe Sleeves

Provide where piping passes entirely through walls and floors. Provide sleeves of sufficient length to pass through entire thickness of walls and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation or conduit and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

a. Sleeves in Masonry and Concrete Walls and Floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron sleeves. Core drilling of masonry and concrete may be provided in lieu of sleeves when cavities in the core-drilled hole are grouted smooth.

b. Sleeves in Other Than Masonry and Concrete Walls and Floors: Provide 26 gage galvanized steel sheet.

2.4.5 Escutcheon Plates

Provide split hinge type metal plates for piping entering walls and floors in exposed spaces. Provide polished stainless steel plates or chromium-plated copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.4.6 Cooling Tanks

Construct of steel for minimum working pressure of ASME Class 150.

a. Thermometers: Provide bimetal dial-type thermometers with stainless steel case, stem, and fixed thread connection; 5 inch diameter dial with glass face gasketed within the case; accuracy within one percent of scale range. Provide scale range for the intended service.

b. Gages: Provide single style pressure gage for steam with 4.5 inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubbers, and syphon. Provide scale range for the intended service.

c. Self-Powered Cooling Valve: Provide Spirax Sarco T-44 or Ogontz 3\4-AFR-255-CRB self-powered cooling valve with special factory setting to automatically open at 250 degrees F. Notwithstanding any other provision of this contract, no other product will be acceptable.

2.4.7 Couplings

Provide special couplings for joining plastic condensate return pipe to ASTM A106/A106M steel pipe. Couplings shall be for working pressure of 125 psig hot water at 250 degrees F. Couplings shall include carbon steel sleeve flared at each end, two Viton gaskets, two steel follower rings, and set of steel track bolts to properly compress the gaskets. Tighten bolts to torque recommended by coupling manufacturer. Provide 7 inch long carbon steel sleeves for use with each nominal pipe size with minimum wall thickness as follows:

MINIMUM WALL THICKNESS (inches)						
Nominal Pipe Sizes (inches)	2	3	4	6	8	10
Wall Thickness	0.15	0.20	0.20	0.25	0.25	0.25
NOTE: Rockwell 411 couplings for steel pipe with Viton gaskets and Dresser 38 couplings for steel pipe with Viton gaskets will meet this specification.						

2.5 BURIED PIPING SYSTEM

Design and provide exterior buried factory-prefabricated preinsulated pumped condensate return piping in a conduit for which a Federal Agency Approved Brochure has been issued. In case of differences between the Approved Brochure and the project specification and drawings, the project specifications and drawings shall govern. Design, equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, testing, and repair requirements shall be in accordance with the Approved Brochure.

2.5.1 System Design

Design the underground piping system including trench bed and pipe anchors in accordance with the Approved Brochure. Pipe expansion loops will not be permitted. Expansion design having lateral movement through manholes will not be permitted. Design shall include buried prefabricated preinsulated piping system including concrete pipe anchors exterior of manholes, interface with each manhole, and the watershed to aboveground piping. Provide manholes, piping within manholes, piping aboveground, and piping not in approved conduit systems as indicated; redesign will not be permitted. Earth horizontal resistant loading is 2000 psf.

2.5.2 System Requirements

Provide system approved for Class A [or Class B] ground water conditions. Minimum depth of burial shall be [36 inches] [_____] from center of carrier pipe to final ground surface. Provide insulation, completely filling the space between the carrier pipe and the conduit in accordance with the Approved Brochure.

2.5.3 Buried Warning and Identification Tape

Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inches minimum width, color coded for the utility involved with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall read CAUTION BURIED STEAM PIPING BELOW or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material. Bury tape with the printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of exterior buried pumped condensate return piping system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.1, except as modified herein. Field assembly shall be in accordance with the Federal Agency Approved Brochure. Install piping straight and true to bear evenly on sand bedding material. Install valves with stems horizontal or above. Provide flanges and unions at valves, traps, strainers, connections to equipment, and as indicated.

3.1.1 Cleaning of Piping

Keep the interior and ends of new piping and existing piping affected by the Contractor's operations, cleaned of water and foreign matter during installation by using plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.

3.1.2 Demolition

Remove materials so as not to damage materials which are to remain. Replace existing work damaged by the Contractor's operations with new work of the same construction.

3.2 PLASTIC CARRIER PIPING

Exterior buried factory-prefabricated insulated pumped condensate (hot water) return piping system, including field joints, bedding, and initial backfill shall be in accordance with the Approved Brochure, except as modified herein.

3.2.1 Connections to Metal Pipe

Connections between plastic carrier pipe and metal pipe shall be flanged, with metal pipe anchored within 5 feet of the connection. Expansion and load forces of metal piping shall not be transmitted to the plastic carrier pipe or conduit. Do not bury flanged pipe connections. Provide flat circular steel washers under bolt heads and nuts on flanges; tighten bolts to the torque recommended by the plastic pipe manufacturer.

3.2.2 Field Joints

3.2.2.1 Plastic Carrier Piping Joints Without Concrete Anchor

Pressure test and approve piping joints. Provide with polyurethane or polyisocyanate insulation of the same type and thickness as the insulation on the carrier piping. Provide waterproof shrink sleeves to cover the insulation and overlap not less than 6 inches of each end of conduit section.

3.2.2.2 Plastic Carrier Piping Joints With Concrete Anchor

Pressure test and approve piping joints. Provide concrete anchors (thrust blocks) for each elbow and tee. Provide waterproof end seals between the carrier piping and the conduit adjacent to each carrier pipe fitting. Encase the carrier pipe fitting and at least 2 inches of each end of the conduit with a minimum of 6 inches of concrete.

3.2.3 Concrete Thrust Blocks

Cast thrust blocks after completion of hydrostatic testing. Encase each elbow and tee of the carrier pipe in a concrete thrust block with a minimum of 3 square feet of thrust-bearing surface cast against undisturbed soil, a minimum pipe-to-bearing surface single dimension of 10 inches perpendicular to the bearing surface, and a minimum volume of 9 cubic feet, except as indicated otherwise. Disturbed soil under and around thrust blocks shall be compacted. Provide concrete thrust blocks under this section as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE except the concrete shall be of 4000 psi minimum 28 day compressive strength, air entrained admixture (3.6 ounces per cubic yard), with water-reducing admixture (22 ounces per cubic yard).

3.3 STEEL PIPING

Test, inspect, and approve piping before burying, covering, or concealing. Provide fittings for changes in direction of piping and for connections. Stab type connections will not be permitted. Make changes in piping sizes through tapered reducing fittings; bushings will not be permitted. Jointing compound for pipe threads shall be Teflon pipe thread paste. Pipe nipples 6 inches long and shorter shall be Schedule 80 steel pipe. Condensate piping shall include drip, vent, relief, and gage connecting piping.

3.3.1 Fittings and End Connections

For sizes less than one inch provide threaded fittings and end connections. For sizes 1 to 2 inches provide threaded or socket-welding or buttwelding fittings and end connections; provide threaded connections for threaded valves, traps, strainers, and threaded connections to equipment. For sizes 2.5 inches and larger provide buttwelding fittings and end connections; provide flanged connections for flanged valves, traps, strainers, and flanged connections to equipment.

3.3.2 Welding

ASME B31.1, metallic arc process, including qualification of welders.

3.3.3 Pipe Hangers and Supports

Provide additional hangers and supports for concentrated loads in piping between hangers and supports, such as for valves.

3.4 NAMEPLATES

Provide laminated plastic nameplates for equipment, gages, thermometers, and valves. Nameplates shall be melamine plastic, 0.125 inch thick, black with white center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the white core. Minimum size of nameplates shall be 1 by 2.5 inches. Lettering shall be minimum of 0.25 inch high normal block style. Key the nameplates to a chart and schedule for each system. Frame charts and schedules under glass, and locate where directed near each system. Furnish two copies of each chart and schedule.

3.5 FIELD QUALITY CONTROL

Before final acceptance of the work, test each system to demonstrate compliance with contract requirements. Flush and clean piping before placing in operation. Flush piping at a minimum velocity of 8 fps. Correct defects in work provided by Contractor and repeat tests until work is in compliance with contract requirements. Furnish potable water, electricity, instruments, connecting devices, and personnel for the tests.

3.5.1 Field Inspections

Prior to initial operation, inspect piping system for compliance with drawings, specifications, and manufacturer's submittals.

3.5.2 Field Tests of Carrier Piping

Do not cover the carrier piping joints with insulation or concrete anchors (thrust blocks), until the carrier piping joints have passed all field tests and testing requirements in the Approved Brochure for exterior buried factory-prefabricated insulated condensate return piping system.

3.5.3 Field Repairs of Plastic Carrier Pipe and Joints

Repair leaking and porous sections of pipe or joints by removing and replacing with new materials. Do not overwrap the fault with any type of patch or other material. If a joint is damaged during laying operation, cut off the joint, bond a coupling to the severed end, and lay in the piping as a normal pipe. If damage occurs to a new pipe section after pipe has been laid, cut out damaged section and replace with a new pipe section in accordance with manufacturer's instructions.

3.6 FIELD PAINTING

After completion of field inspections and tests, clean and paint metal surfaces exposed to the weather and in manholes, including valves, strainers, traps, flow meters, pipe flanges, bolts, nuts, washers, pipe hangers and supports, expansion joints, and miscellaneous metal. Do not paint piping prior to the application of field-applied insulation. Do not paint stainless steel or aluminum jackets. Apply paint to clean dry surfaces. Clean surfaces to remove dust, dirt, rust, oil, and grease. Provide surfaces with two coats of enamel paint applied to a total minimum dry film thickness of 2 mils. Apply the second coat of paint after the preceding coat is thoroughly dry. Color of finish coat shall be aluminum or light gray. Paint shall be rated for use on hot metal surfaces up to 450 degrees F and for use on surfaces exposed to the weather.

3.7 CONNECTIONS TO EXISTING SYSTEMS

Notify the Contracting Officer in writing at least 15 days prior to the date the connections are required; receive approval before interrupting service. Provide materials required to make connections into existing systems and perform excavating, backfilling, and other incidental labor as required.

-- End of Section --

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SECTION 33 63 16

EXTERIOR SHALLOW TRENCH STEAM DISTRIBUTION
07/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.20	(2017) Metallic Gaskets for Pipe Flanges
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel

	Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A615/A615M	(2020) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D229	(2019) Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

1.2 SYSTEM DESCRIPTION

Provide [new and modify existing] exterior [steam and condensate] [hot water] piping system of shallow concrete trench type, complete and ready for operation. [Provide piping to and including main steam pressure regulating valves, bypass valves, safety-relief valves, and high pressure traps within each building.] Design pressure and temperature ratings of system components shall be for [working pressure of 150 psig steam at 366 degrees F and 125 psig condensate at 250 degrees F] [hot water at 450 degrees F].

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Piping system; G[, [_____]]

Pipe hangers and supports; G[, [_____]]

Manholes; G[, [_____]]

Shallow concrete trench; G[, [_____]]

SD-03 Product Data

Pipe

Valves; G[, [_____]]

Strainers; G[, [_____]]

Pipe hangers and supports

Traps

Gages

Steam flow meters; G[, [_____]]

Expansion joints; G[, [_____]]

Manhole drainers; G[, [_____]]

Sealant

SD-07 Certificates

Certification of welder's qualifications

SD-10 Operation and Maintenance Data

Manhole drainers, Data Package 2; ; G[, [_____]]

Steam flow meters, Data Package 2; ; G[, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.4 QUALITY ASSURANCE

1.4.1 Certification of Welder's Qualifications

Submit prior to site welding. Certification shall not be more than one year old.

PART 2 PRODUCTS

2.1 PIPE

[Steam piping includes piping upstream of steam traps. Condensate piping includes piping downstream of steam traps.]

2.1.1 [Steam] [Hot Water] Pipe

a. ASTM A53/A53M: Type E (electric-resistance welded, Grade A or B) or Type S (seamless, Grade A or B), black steel. Provide Weight Class STD (Standard) for welding end connections. Provide Weight Class XS (Extra Strong) for threaded end connections.

b. ASTM A106/A106M: Grade A or B, black steel, Schedule No. 40 for pipe sizes through 10 inches, and minimum pipe wall thickness of 0.375 inch for pipe sizes 12 inches and larger for welding end connections. Provide Schedule No. 80 for threaded end connections.

2.1.2 Condensate Pipe

a. ASTM A53/A53M: Type E (electric-resistance welded, Grade A or B) or Type S (seamless, Grade A or B); black steel, Weight Class XS (Extra Strong).

b. ASTM A106/A106M: Grade A or B, black steel, Schedule No. 80.

2.1.3 Buried Steel Piping to Cooling Well or Drain

Provide direct buried steel condensate pipe and fittings with exterior coal tar epoxy painting system.

2.2 FITTINGS

2.2.1 Threaded Fittings

ASME B16.11, or ASME B16.3, Class [150 for steam, Class 300 for condensate] [300 for hot water].

2.2.2 Socket-Welding Fittings

ASME B16.11.

2.2.3 Buttwelding Fittings

ASME B16.9. Provide same material and weight as piping in which fittings are installed. Backing rings shall conform to ASME B31.1 and be compatible with materials being welded.

2.2.4 Eccentric Reducing Fittings

ASME B16.9. Provide same material and weight as piping in which fittings are installed.

2.2.5 Flanges and Unions

a. Flanges: ASME B16.5, Class [150 or Class 300 as required] [300 for hot water].

b. Unions: ASME B16.39, Class [150 for steam, Class 250 for condensate] [300 for hot water].

2.2.6 Gaskets, Bolts, Nuts, and Washers

a. Gaskets: Provide gaskets suitable for the intended service. Provide spiral wound, non-asbestos gasket with centering ring per ASME B16.20.

b. Bolts: ASTM A193/A193M, Grade B7. Extend a minimum of two full threads beyond the nut with the bolts tightened to the required torque.

c. Nuts: ASTM A194/A194M, Grade 7, with Teflon coated threads.

d. Washers: Provide steel flat circular washers under bolt heads and nuts.

e. Electrically Isolating (Insulating) Gaskets for Flanges: Provide ASTM D229 electrical insulating material of 1000 ohms minimum resistance. Provide one piece factory cut insulating gaskets between flanges. Provide silicon-coated fiberglass insulating sleeves between bolts and holes in flanges; bolts may have reduced shanks of a diameter not less than diameter at root of threads. Provide 0.125 inch thick high-strength insulating washers next to flanges and provide stainless steel flat circular washers over insulating washers and under bolt heads and nuts. Provide bolts 0.5 inch longer than standard length to compensate for thicker insulating gaskets and washers under bolt heads and nuts.

2.3 VALVES

Provide with stems in the horizontal position or not greater than 45 degrees above the horizontal position. Valves shall have flanged end connections, except sizes smaller than 2.5 inches may have union end connections, or threaded end connections with a union on one side of valve.

2.3.1 Valves for [Steam] [Hot Water] Service

Valves [upstream of steam traps] shall be steel body for minimum working pressure of ASME Class [150] [300 for hot water].

a. Gate Valves, Globe Valves, Angle Valves, and Check Valves: ASME B16.34, steel body, minimum of ASME Class [150] [300 for hot water]. Provide swing check valves.

b. Steam Pressure Regulating Valves: Steel body, minimum of ASME Class 150, except as modified herein. Valve seats and disc shall be of replaceable heat-treated stainless steel. Valves shall be single seated; seat tight under dead end conditions, and move to the closed position in the event of pressure failure of the operating (controlling) medium. Provide strainer in inlet from external operating (controlling) medium. Valves shall be controlled by pilot valve with strainer at inlet from external pressure sensing piping. Valves shall be internally or externally steam traced for freeze protection. Valves shall be piston operated type or spring loaded diaphragm operated type with stainless steel springs.

c. Safety-Relief Valve: Minimum of ASME Class [150] [300 for hot water], with test lever. Valves shall have steel [or copper alloy] body with flanged inlet and outlet connections or threaded connections attached to threaded ASME Class [150] [300 for hot water] flanges. Valves shall be ASME rated for capacity indicated.

2.3.2 Valves for Condensate Service

Valves downstream of steam traps shall be for minimum working pressures of ASME Class 125.

a. Gate Valves: MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-70.

b. Globe and Angle Valves: MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-85.

c. Check Valves: MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-71. Provide swing check valves.

2.4 PIPING ACCESSORIES

2.4.1 Pipe Hangers and Supports

Provide MSS SP-58 and MSS SP-69, Type 46, of the adjustable type, except as specified or indicated otherwise. Tack-welded Type 39 pipe covering protection saddles to steel pipe for insulated piping. Provide steel support rods. Finish of rods, nuts, bolts, washers, hangers, and supports shall be hot-dip galvanized after fabrication. Rollers, bases, and saddles may be painted with two coats of aluminum or light gray paint rated for use on hot metal surfaces up to 450 degrees F in lieu of hot-dip galvanized. Axles for rollers shall be stainless steel. Miscellaneous metal shall conform to ASTM A36/A36M, hot-dip galvanized after fabrication.

2.4.2 Strainers

Construct of steel in accordance with ASME B16.5 for minimum of ASME Class [150] [300 for hot water]. Provide stainless steel strainer element with perforations of [0.016 inch for steam, 0.031 inch for steam mixed with condensate, and] 0.047 inch for [condensate (hot water)] [hot water]. Provide blow-off outlet with pipe nipple, gate valve, and discharge pipe nipple.

2.4.3 Traps

Steel body, internals of stainless steel, minimum of ASME Class 150, and of the types indicated.

2.4.4 Gages

Provide single style pressure gage with 4.5 inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubbers, and syphon. Provide scale range for the intended service.

2.4.5 Pipe Sleeves

Provide where piping passes entirely through walls and floors. Provide sleeves of sufficient length to pass through entire thickness of walls and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

a. Sleeves in Masonry and Concrete Walls and Floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron sleeves. Core drilling of masonry and concrete may be provided in lieu of sleeves when cavities in the core-drilled hole are completely grouted smooth.

b. Sleeves in Other Than Masonry and Concrete Walls and Floors: Provide 26 gage galvanized steel sheet.

2.4.6 Escutcheon Plates

Provide split hinge type metal plates for piping entering walls and floors in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.4.7 Electronic Steam Flow Meters

Meter shall be for minimum working pressure of ASME Class [150] [300]. Meter shall include an orifice plate, pressure transmitter, indicator, and totalizer. Provide meter for measuring steam flow in pounds per hour. Meter shall be for installation and operation in horizontal position.

a. Orifice Plate: Provide differential producing type orifice plate with circular hole for insertion into steam piping between two ASME B16.5 Class 300 welding neck orifice flanges. Orifice plate shall be Type 304 stainless steel. Furnish a dimensional report and flow versus differential curve with accuracy of plus or minus one percent over a 5 to 1 flow range. Orifice flanges shall have at least two radially-drilled and tapered holes for metering and two jack screws.

b. Pressure Transmitter: Provide solid state electronic type differential pressure transmitter. Transmitter shall utilize Type 316 stainless steel dual opposed rupture-proof bellows converted to produce a 4 to 20 mA dc output. Transmitter shall have a flow range of 0 to 3000 pounds per hour of steam flow with accuracy of plus or minus 2 percent of full scale over a 5 to 1 flow range. House transmitter in a weatherproof enclosure designed for wall mounting. Bellows body shall be rated for not less than 1000 psig. Power requirements are 120 volts ac. Provide transmitter complete with condensate reservoirs, steel three-valve manifold for isolation and nulling, and blowdown valves.

c. Indicator: Provide electric indicator to continuously indicate steam flow by means of a 4 to 20 mA dc electrical input signal. Indicator shall have pivot and jewel suspension and a mirrored scale with uniform graduations over a steam flow range of 0 to 3000 pounds per hour.

d. Totalizer: Provide totalizer that linearizes a 4 to 20 mA dc electrical input signal into digital signal scaled in pounds of steam flow, displays totalized steam flow on a six-digit nonresettable counter, and transmits each totalizer count to the output.

e. Output: An isolated, 500 volt minimum, ac or dc switch closure rated at 50 volts dc or 40 volts RMS ac, one ampere minimum capacity. Duration of closure shall be not less than 0.04 second or more than 0.06 second.

2.4.8 Steam Flow Meters

Meter shall be for minimum working pressure of ASME Class [150] [300] with steel pressure chambers [or ASME Class 250 with cast-iron pressure chambers]. Provide meter in horizontal pipe between two ASME B16.5 welding neck flanges. Provide rotary type meter for flow integration. Working parts shall be stainless steel or brass. Steam flow shall cause rotation of a rotor assembly at a speed directly proportional to rate of steam flow, as controlled by a damping liquid. Rotational speed of rotor assembly shall be reduced by gearing in damping liquid chamber. Final drive to exterior counter shall be by driving magnets; stuffing box shall not be allowed. Counter shall be enclosed in dust-tight cast-aluminum housing attached to, but easily removable from, meter. For steam pipe main sizes 4 inches and smaller, provide meter directly in steam piping. For steam pipe main sizes larger than 4 inches, provide meter in shunt bypass piping with two ASME B16.5 Class 300 welding neck orifice flanges in steam pipe main. In shunt bypass piping, provide two flanged gate valves calibrated by meter manufacturer. In steam pipe main, provide 0.125 inch thick stainless steel orifice plate sized to suit meter capacity between two ASME B16.5 Class 300 welding neck orifice flanges. [Provide six-dial counter with electrical contactor to transmit signal to data terminal cabinet (DTC) for indicating steam flow in pounds.] [Provide pressure compensated six-dial counter to automatically and continuously correct steam flow meter readings for steam pressure variations.] [Provide remote totalizer for recording steam flow in pounds.]

2.4.9 Guided Slip Tube Expansion Joints

Internally-externally guided type, injected semiplastic type packing, with service outlets. Joints shall be for minimum working pressure of ASME Class [150] [300]. Provide single or double slip tube type as indicated. Provide flanged or buttwelding end connections as indicated.

2.4.10 Flexible Ball Expansion Joints

Provide chromium plated steel balls capable of 360 degree rotation plus 15-degree angular flex movement. Provide pressure molded composition gaskets for continuous operation temperature of 525 degrees F. Joints shall be designed for minimum working pressure of ASME Class [150] [300]. Provide flanged or buttwelding end connections as indicated.

2.4.11 Bellows Expansion Joints

Type 304 stainless steel corrugated bellows, reinforced with rings, internal sleeves, and external protective covers or externally pressurized joints. Provide limit stops to limit total movement in both directions. Cold set joints to compensate for temperature at time of installation. Joints shall withstand 10,000 cycles over a 20 year period. Joints shall be for minimum working pressure of ASME Class [150] [300]. Provide single or double bellows expansion joint as indicated. Provide first pipe alignment guide no more than four pipe diameters from expansion joints; provide second pipe alignment guide no more than 14 pipe diameters from the first guide. Provide flanged or buttwelding end connections as indicated.

2.5 MANHOLE DRAINERS (EJECTORS)

Provide automatic type drainers to operate on 125 psig steam supply. Drainer shall operate when water level rises sufficiently in the sump and shall pump water from the sump. When water level is lowered by pumping action, pumping action shall stop until water again gathers in sump. Provide each drainer with controls to accomplish above sequence of operation. Drainer shall be constructed of stainless steel or corrosion-resistant copper and bronze. Piping from manhole drainers shall be ASTM A53/A53M, Weight Class XS (Extra Strong), hot-dip galvanized steel pipe with ASME B16.11 or ASME B16.3 Class 300, hot-dip galvanized threaded fittings. Provide steam pressure regulating valve assembly for manhole drainers for operation on steam system above 125 psig.

2.6 CONCRETE MANHOLES

Provide under this section as specified in Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION, except as modified herein. Concrete shall be of 4000 psi minimum 28 day compressive strength, air-entrained admixture (3.6 ounces per cubic yard), with water-reducing admixture (22 ounces per cubic yard), reinforced with deformed steel bars. Construct manhole sides by one monolithic pour. Cast-iron steps with non-slip surfaces and spaces 12 to 16 inches apart on centers shall be firmly embedded in concrete walls for access to bottom of manholes. Provide top of manhole as indicated.

2.7 NAMEPLATES

Provide laminated plastic nameplates for equipment, gages, thermometers, and valves. Nameplates shall be melamine plastic, 0.125 inch thick, black with white center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the white core. Minimum size of nameplates shall be 1 by 2.5 inches. Lettering shall be minimum of 0.25 inch high normal block style. Key the nameplates to a chart and schedule for each system to identify its function. Frame charts and schedules under glass, and locate where directed near each system. Furnish two copies of each chart and schedule.

2.8 SHALLOW CONCRETE TRENCH

a. Cast-in-Place Concrete: Provide concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE, except as modified herein. Concrete shall be 4000 psi minimum 28 day compressive strength, air entrained admixture (3.6 ounces per cubic yard), with water-reducing admixture (22 ounces per cubic yard), reinforced with ASTM A615/A615M deformed steel bars.

b. Precast Concrete: Provide as specified in Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION, except as modified herein. Concrete shall be 4000 psi minimum 28 day compressive strength, air-entrained.

c. Gasket Material: Provide neoprene pad, not less than 2 inch wide by 0.25 inch thick, between concrete trench covers and concrete trench wall tops.

d. Backing Rods: Provide compressible, nonshrinkable, nonreactive with joint sealant and nonabsorptive type such as upholstery cord, cotton, jute, or plastic rod, all free of oils or bitumens.

e. Separating Tape: Provide polyethylene or polyester tape, 3 mil minimum thickness or masking tape, rubber tape, or other barrier sheet, nonreactive, nonabsorptive, adhesive-back tape, 0.12 inch wider than normal width of the joint.

f. Dowel Bars: Provide ASTM A615/A615M including supplementary requirements (S1), Grade 40 or 60 for plain billet-steel concrete reinforcement bars. Coat sliding portion of each bar with lacquer resisting primer. Remove burrs and projections from the bars. Fit the outer end of the sliding portion of each dowel with a tight-fitting metal sleeve which conforms to manufacturer's recommendation for the dowel bars.

g. Exterior Sealant: ASTM C920, Type S or Type M, Class 25. Provide Grade NS, Use NT, sealant for joints in vertical surfaces. Provide Grade P, Use T, sealant for joints in horizontal surfaces.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of exterior heat distribution system including equipment, materials, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.1, except as modified herein. Install piping straight and true to bear evenly on supports and sand bedding material. Install valves with stems horizontal or above centerline of pipe. Provide flanges or unions at valves, traps, strainers, connections to equipment, and as indicated.

a. Cleaning of Piping: Keep the interior and ends of new piping and existing piping affected by the Contractor's operations, cleaned of water and foreign matter during installation by using plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.

b. Demolition: Remove materials so as not to damage materials which are to remain. Replace existing work damaged by the Contractor's operations with new work of the same construction.

3.2 PIPING

Test, inspect, and approve piping before burying, covering, or concealing. Provide fittings for changes in direction of piping and for connections. Reducing branch connections in steel piping may be made with forged branch outlet reducing fittings for branches two or more pipe sizes smaller than mains. Branch outlet fittings shall be forged, flared for improved flow where attached to pipe, reinforced against external strains, and designed to withstand full pipe bursting strength. Stab type connections will not be permitted. Jointing compound for pipe threads shall be Teflon pipe thread paste. Pipe nipples 6 inches long and shorter shall be Schedule 80 steel pipe. Make changes in piping sizes through tapered reducing fittings; bushings will not be permitted.

a. Fittings and End Connections: For sizes less than 1 inch provide threaded fittings and end connections. For sizes 1 to 2 inches provide threaded or socket-welding or buttwelding fittings and end connections; provide threaded connections for threaded valves, traps, strainers, and threaded connections to equipment. For sizes 2.5 inches and larger provide buttwelding fittings and end connections; provide flanged connections for flanged valves, traps, strainers, and flanged connections to equipment.

b. Welding: ASME B31.1, metallic arc process, including qualification of welders.

c. Pipe Hangers and Supports: Provide additional hangers and supports for concentrated loads in piping between hangers and supports, such as for valves. Support steel piping as follows:

MAXIMUM SPACING (FEET)									
Pipe Size (inches)	one and under	1.5	2	3	4	6	8	10	12
Steel Piping	9	12	13	15	17	21	24	26	30

3.3 FIELD QUALITY CONTROL

3.3.1 Inspections

Prior to initial operation, inspect piping system for compliance with drawings, specifications, and manufacturer's submittals.

3.3.2 Piping Tests

Before final acceptance of the work, test each system as in service to demonstrate compliance with contract requirements. Before insulation is applied, hydrostatically test each piping system at not less than [225] [500] psig in accordance with ASME B31.1, with no leakage or reduction in gage pressure for 2 hours. Flush and clean piping before placing in operation. Flush piping at a minimum velocity of 8 fps. Correct defects in work provided by Contractor and repeat tests until work is compliance with contract requirements. Furnish potable water, electricity, instruments, connecting devices, and personnel for tests.

3.4 FIELD PAINTING

After completion of field inspections and tests, clean and paint metal surfaces exposed to weather and in manholes, including valves, strainers, traps, flow meters, pipe flanges, bolts, nuts, washers, pipe hangers, support, expansion joints, manhole drainers, and miscellaneous metal. Do not paint piping prior to the application of field-applied insulation. Do not paint stainless steel or aluminum jackets. Apply paint to clean dry surfaces. Clean surfaces to remove dust, dirt, rust, oil, and grease. Provide surfaces with two coats of enamel paint applied to a total minimum dry film thickness of 2 mils. Apply the second coat of paint after the preceding coat is thoroughly dry. Color of finish coat shall be aluminum or light gray. Paint shall be rated for use on hot metal surfaces up to 450 degrees F and for use on surfaces exposed to weather.

3.5 CONNECTIONS TO EXISTING SYSTEMS

Notify Contracting Officer in writing at least 15 days prior to date the connections are required. Obtain approval before interrupting service. Provide materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required.

-- End of Section --

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SECTION 33 63 23

EXTERIOR ABOVEGROUND STEAM DISTRIBUTION
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.20	(2017) Metallic Gaskets for Pipe Flanges
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A475	(2022) Standard Specification for Metallic-Coated Steel Wire Strand
ASTM D229	(2019) Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

1.2 SYSTEM DESCRIPTION

Provide [new and modify existing] exterior aboveground steam and condensate piping system complete and ready for operation. Provide piping to and including the main steam pressure regulating valves, bypass valves, safety-relief valves, and high pressure traps within each building. Design pressure and temperature ratings of system components shall be for working pressure of 150 psig steam at 366 degrees F and 125 psig condensate at 250 degrees F. [Provide [new and modify existing] exterior buried factory-prefabricated preinsulated steam and condensate piping under roads as specified in paragraph entitled "Buried Piping Under Roads."]

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S"

classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Piping

Valves

Strainers

Pipe hangers and supports

Traps

Gages

Steam flow meters

Expansion joints

Manhole drainers

SD-07 Certificates

Certification of welder's qualifications

SD-10 Operation and Maintenance Data

Manhole drainers, Data Package 2; G[, [_____]]

Steam flow meters, Data Package 2; G[, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.4 QUALITY ASSURANCE

1.4.1 Certification of Welder's Qualifications

Submit prior to site welding. Certifications shall not be more than one year old.

PART 2 PRODUCTS

2.1 PIPING

Steam piping includes piping upstream of steam traps. Condensate piping includes piping downstream of steam traps.

2.1.1 Steam Pipe

a. ASTM A53/A53M, Type E (electric-resistance welded, Grade A or B) or Type S (seamless, Grade A or B); black steel. Provide Weight STD (Standard) for welding end connections. Provide Weight Class XS (Extra Strong) for threaded end connections.

b. ASTM A106/A106M, Grade A or B, black steel, Schedule No. 40 for pipe sizes through 10 inches, and minimum pipe wall thickness of 0.375 inch for pipe sizes 12 inches and larger for welding end connections. Provide Schedule 80 for threaded end connections.

2.1.2 Condensate Pipe

a. ASTM A53/A53M, Type E (electric-resistance welded, Grade A or B) or Type S (seamless, Grade A or B); black steel, Weight Class XS (Extra Strong).

b. ASTM A106/A106M, Grade A or B, black steel, Schedule No. 80.

2.1.3 Buried Steel Piping to Cooling Well or Drain

Provide direct buried steel condensate pipe and fittings with exterior coal tar epoxy painting system.

2.2 FITTINGS

2.2.1 Threaded Fittings

ASME B16.11, or ASME B16.3, Class 150 for steam, Class 300 for condensate.

2.2.2 Socket Welding Fittings

ASME B16.11.

2.2.3 Buttwelding Fittings

ASME B16.9. Provide the same material and weight as the piping in which fittings are installed. Backing rings shall conform to ASME B31.1 and be compatible with materials being welded.

2.2.4 Eccentric Reducing Fittings

ASME B16.9. Provide the same material and weight as the piping in which fittings are installed. Provide for changes in horizontal steam piping sizes.

2.2.5 Flanges and Unions

2.2.5.1 Flanges

ASME B16.5, Class 150 or 300 as required.

2.2.5.2 Unions

ASME B16.39, Class 150 for steam, Class 250 for condensate.

2.2.6 Gaskets, Bolts, Nuts, and Washers

a. Gaskets: Provide spiral wound, non-asbestos gasket with centering ring per ASME B16.20. [ASME B16.21, composition ring 0.0625 inch thick. Provide one piece factory cut ring gaskets for raised-face flanged joints, and full-face gaskets for flat-face flanged joints.]

b. Bolts: ASTM A193/A193M, Grade B7. Extend a minimum of two full threads beyond the nut with the bolts tightened to the required torque.

c. Nuts: ASTM A194/A194M, Grade 7, with Teflon coated threads.

d. Washers: Provide steel flat circular washers under bolt heads and nuts.

e. Electrically isolating (insulating) gaskets for flanges: Provide ASTM D229 electrical insulating material of 1000 ohms minimum resistance. Provide one piece factory cut insulating gaskets between flanges. Provide silicon-coated fiberglass insulating sleeves between the bolts and the holes in flanges; bolts may have reduced shanks of a diameter not less than the diameter at the root of threads. Provide 0.125 inch thick high-strength insulating washers next to flanges and provide stainless steel flat circular washers over insulating washers and under bolt heads and nuts. Provide bolts 0.5 inch longer than standard length to compensate for the thicker insulating gaskets and the washers under bolt heads and nuts in the horizontal position or not greater than 45 degrees above the horizontal position.

2.3 VALVES

Provide with stems in the horizontal position or not greater than 45 degrees above the horizontal position. Valves shall have flanged end connections, except sizes smaller than 2.5 inches may have union end connections, or threaded end connections with a union on one side of the valve.

2.3.1 Valves for Steam Service

Valves upstream of steam traps shall be steel body for minimum working pressure of ASME Class 150.

2.3.1.1 Gate Valves, Globe Valves, Angle Valves, and Check Valves

ASME B16.34, steel body, minimum of ASME Class 150. Provide swing check valves.

2.3.1.2 Steam Pressure Regulating Valves

Steel body, minimum of ASME Class 150, except as modified herein. Valve seats and disc shall be of replaceable heat-treated stainless steel. Valves shall be single seated, seat tight under dead end conditions, and move to the closed position in the event of pressure failure of the operating (controlling) medium. Provide strainer in inlet from external operating (controlling) medium. Valves shall be controlled by pilot valve with strainer at inlet from external pressure sensing piping. Valves shall be internally or externally steam traced for freeze protection. Valves shall be piston operated type or spring loaded diaphragm operated type with stainless steel springs.

2.3.1.3 Safety-Relief Valves

Minimum of ASME Class 150, with test lever. Valves shall have steel or copper alloy body. Valves shall have flanged inlet and outlet connections or threaded connections attached to threaded ASME Class 150 flanges. Valves shall be ASME rated for capacity indicated.

2.3.2 Valves for Condensate Service

Valves downstream of steam traps shall be for minimum working pressures of ASME Class 125.

2.3.2.1 Gate Valves

MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-70.

2.3.2.2 Globe and Angle Valves

MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-85.

2.3.2.3 Check Valves

MSS SP-80, except sizes 2.5 inches and larger shall conform to MSS SP-71. Provide swing check valves.

2.4 PIPING ACCESSORIES

2.4.1 Pipe Hangers and Supports

Provide MSS SP-58 and MSS SP-69, Type 43, of the adjustable type, except as specified or indicated otherwise. Tack-weld Type 39 pipe covering protection saddles to steel pipe for insulated piping. Provide steel support rods. The finish of rods, nuts, bolts, washers, hangers, and supports shall be hot-dip galvanized after fabrication. Rollers, bases, and saddles may be painted with two coats of aluminum or light gray paint rated for use on hot metal surfaces up to 450 degrees F in lieu of hot-dip galvanized. Provide stainless steel axles for rollers. Miscellaneous metal shall conform to ASTM A36/A36M, hot-dip galvanized after fabrication.

2.4.2 Strainers

Construct of steel in accordance with ASME B16.5 for minimum of ASME Class 150. Provide stainless steel strainer element with perforations of 0.016 inch for steam, 0.031 inch for steam mixed with condensate, and 0.047 inch for condensate (hot water). Provide blow-off outlet with pipe nipple, gate valve, and discharge pipe nipple.

2.4.3 Traps

Steel body, internals of stainless steel, minimum of ASME Class 150, and of the types indicated.

2.4.4 Gages

Provide single style pressure gage for steam with 4.5 inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubbers, and syphon. Provide scale range for the intended service.

2.4.5 Pipe Sleeves

Provide where piping passes entirely through walls and floors. Provide sleeves of sufficient length to pass through entire thickness of walls and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

a. Sleeves in Masonry and Concrete Walls and Floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron sleeves. Core drilling of masonry and concrete may be provided in lieu of sleeves when cavities in the core-drilled hole are grouted smooth.

b. Sleeves in Other Than Masonry and Concrete Walls and Floors: Provide 26 gage galvanized steel sheet.

2.4.6 Escutcheon Plates

Provide split hinge type metal plates for piping entering walls and floors in exposed spaces. Provide polished stainless steel plates or chromium-plated copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.4.7 Electronic Steam Flow Meter

Meter shall be for minimum working pressure of ASME Class 150. Meter shall include an orifice plate, pressure transmitter, indicator, and totalizer. Provide meter for measuring steam flow in pounds per hour. Meter shall be for installation and operation in horizontal position.

2.4.7.1 Orifice Plate

Provide differential producing type orifice plate with circular hole for insertion into the steam piping between two ASME B16.5 Class 300 welding neck orifice flanges. Orifice plate shall be Type 304 stainless steel. Furnish a dimensional report and flow versus differential curve with accuracy of plus or minus one percent over a 5 to 1 flow range. Orifice flanges shall have at least two radially-drilled and tapped holes for metering and two jack screws.

2.4.7.2 Pressure Transmitter

Provide solid state electronic type differential pressure transmitter. Transmitter shall utilize Type 316 stainless steel dual opposed rupture-proof bellows converted to produce a 4 to 20 mA dc output. Transmitter shall have a flow range of zero to 3000 pounds per hour of steam flow with accuracy of plus or minus 2 percent of the full scale over a 5 to 1 flow range. House transmitter in a weatherproof enclosure designed for wall mounting. Bellows body shall be rated for not less than 1000 psig. Power requirements are 120 volts ac. Provide transmitter complete with condensate reservoirs, steel three-valve manifold for isolation and nulling, and blowdown valves.

2.4.7.3 Indicator

Provide electric indicator to continuously indicate steam flow by means of a 4 to 20 mA dc electrical input signal. Indicator shall have pivot and jewel suspension and a mirrored scale with uniform graduations over a steam flow range of zero to 3000 pounds per hour.

2.4.7.4 Totalizer

Provide totalizer that linearizes a 4 to 20 mA dc electrical input signal into a digital signal scaled in pounds of steam flow, displays totalized steam flow on a six-digit nonresettable counter, and transmits each totalizer count to the output.

2.4.7.5 Output

An isolated (500 volts minimum) ac or dc switch closure rated at 50 volts dc or 40 volts RMS ac, one ampere minimum capacity. Duration of closure shall be not less than 0.04 second or more than 0.06 second.

2.4.7.6 Adjustments

Upon completion of the work, furnish the services of a competent technician regularly employed by the manufacturer of the flow meter to make the necessary adjustments to place the steam flow meter in operation and to conduct performance tests which demonstrate that the flow measuring equipment is functioning. Install the steam flow meter in accordance with manufacturer's recommendations.

2.4.8 Steam Flow Meters

Meter shall be for minimum working pressure of ASME Class 150 with steel pressure chambers or ASME Class 250 with cast-iron pressure chambers. Provide meter in horizontal pipe between two ASME B16.5 welding neck flanges. Provide rotary type meter for flow integration. Working parts shall be stainless steel. Steam flow shall cause rotation of a rotor assembly at a speed directly proportional to the rate of steam flow, as controlled by a damping liquid. The rotational speed of the rotor assembly shall be reduced by gearing in the damping liquid chamber. Final drive to the exterior counter shall be by driving magnets; stuffing box shall not be allowed. Counter shall be enclosed in a dust-tight cast-aluminum housing attached to, but easily removable from the meter. For steam pipe main sizes 4 inches and smaller, provide meter directly in the steam piping. For steam pipe main sizes larger than 4 inches, provide meter in shunt bypass piping with two ASME B16.5 Class 300 welding neck orifice flanges in the steam pipe main. In the shunt bypass piping, provide two flanged gate valves calibrated by the meter manufacturer. In the steam pipe main, provide 0.125 inch thick stainless steel orifice plate sized to suit meter capacity between two ASME B16.5 Class 300 welding neck orifice flanges. [Provide six-dial counter with an electrical contactor to transmit signal to data terminal cabinet (DTC) for indicating steam flow in pounds.] [Provide remote totalizer for recording steam flow in pounds.] [Provide pressure compensated six-dial counter to automatically and continuously correct steam flow meter readings for steam pressure variations.]

2.4.9 Steam Meter-Strain Gage Target Flow Type

a. Operation: The steam meter shall have four interconnected strain gages attached to the sensing tube, two in the forward side of flow, two on the reverse side of the flow, producing a four-active arm, bridge circuit. At zero flow, the bridge circuit is balanced and produces zero output. Forces from the fluid are transferred from the target to the sensing tube producing strain on the sensing tube. The bridge circuit becomes unbalanced producing an output to a microprocessor sending unit. A mass flow computer is connected to the sending unit for visual display.

b. Valve Body: ANSI Class 150; Inline type body with flanged ends - 303/304 stainless steel.

c. Sensing Element: 316 Stainless Steel.

d. Seals: Teflon, Vitron, Buna-N, Grafoil.

e. Sending Unit: Microprocessor design with 24-bit speed and accuracy, 4-20 mA output, programmable cutoff, two programmable open collector output hi/lo set points, RS-232 communications, open collector 0-1000hz square wave output.

Accuracy: 0.02 percent of rate.
Repeatability: 0.01 percent of rate.
Power: 16-30vdc, 24vdc at 100mA maximum with current loop connected at 4.00maDC.
Temperature: 32-140 degrees F
Enclosure: Explosion proof type watertight housing.

f. Mass Flow Computer: Wall mounted. The mass flow computer indicates mass rate, mass totalization, flow rate, temperature, pressure and density.

Flow: Square wave digital pulse with plus or minus 0.057 percent accuracy.

Temperature: 4-wire RTD: 100 ohm platinum to European alpha 3850 curve;

Current loop; 4-20 mA; Accuracy: plus or minus 0.1 percent at 77 degrees F.

Pressure: Current Loop: 4-20mA; Accuracy: plus or minus 0.1 percent at 77 degrees F.

Power: 120/240vac plus 10 percent to 15 percent. 50/60 Hz at .2amps.
Temperature: 32-131 degrees F.

2.4.10 Guided Slip Tube Expansion Joints

Internally-externally guided type, injected semiplastic type packing, with service outlets. Joints shall be for minimum working pressure of ASME Class 150. Provide single or double slip tube type as indicated. Provide flanged or buttwelding end connections as indicated.

2.4.11 Flexible Ball Expansion Joints

Provide chromium plated steel balls capable of 360-degree rotation plus 15-degree angular flex movement. Provide pressure molded composition gaskets designed for continuous operation temperature of 525 degrees F. Joints shall be for minimum working pressure of ASME Class 150. Provide flanged or buttwelding end connections as indicated.

2.4.12 Bellows Expansion Joints

Type 304 stainless steel corrugated bellows, reinforced with rings, internal sleeves, and external protective covers. Provide limit stops to limit total movement in both directions. Cold set the joints to compensate for temperature at time of installation. Joints shall withstand 10,000 cycles over a 20 year period. Joints shall be for minimum working pressure of ASME Class 150. Provide single or double bellows expansion joint as indicated. Provide first pipe alignment guide no more than four pipe diameters from the expansion joint; provide second pipe alignment guide no more than 14 pipe diameters from the first guide. Provide flanged or buttwelding end connections as indicated.

2.5 POLES SUPPORTING ABOVEGROUND PIPING

2.5.1 Concrete Poles

Provide under this section as specified in Section 03 45 33 PRECAST[PRESTRESSED] STRUCTURAL CONCRETE. Accurately set the top fittings to grade by means of adjusting screws, and grout in place. Provide high-strength grout consisting of one part portland cement and two parts clean, sharp sand with minimal water to make a workable grout. Wet tops of poles before placing the grout. Prevent grout leaks around the bottom of the fittings which streak or disfigure the concrete. Discoloration or disfiguring of concrete will not be permitted.

2.5.2 Steel Pipe Poles

a. ASTM A53/A53M: Type E (electric-resistance welded, Grade A or B) or Type S (seamless, Grade A or B; hot-dip galvanized, Weight Class STD (Standard).

b. ASTM A106/A106M: Grade A or B, hot-dip galvanized, Schedule No. 40 for pipe sizes through 10 inches, and minimum pipe wall thickness of 0.375 inch for pipe sizes 12 inches and larger.

2.5.3 Guy Wires, Fittings, and Hardware

a. Guy Wires: ASTM A475, high strength grade, extra galvanized, stranded with seven wires in each strand. Wire shall be a minimum of 3/8 inch diameter. Provide thimbles at each end of guy wire. Prestress guy wires until taut.

b. Anchor Rods and Anchors: Provide thimble-eye, 1.25 inch diameter steel rod with 10 inch diameter screw anchor, hot-dip galvanized.

c. Turnbuckles: Provide open turnbuckles, forged steel body, with jaw and jaw end pulls, 0.375 inch size, hot-dip galvanized.

d. Clamps: Provide hot-dip galvanized forged high carbon steel clamps capable of developing full strength of guy wire, and fitted with galvanized heat-treated bolts. Provide two clamps at each connection of guy wire.

2.5.4 Miscellaneous Metal

ASTM A36/A36M, standard mill finished structural shapes, hot-dip galvanized after fabrication.

2.5.5 Fastenings

Provide steel bolts and oversized nuts conforming to ASTM A307. Galvanize in accordance with ASTM A153/A153M. Provide nuts with an approved means for locking to ensure nuts remain tight under severe service, including vibrations. Drive bolts to a tight fit without injury to the threads. Bolts with injured threads will not be permitted. Drill holes 1/16 inch larger than bolts; burning of holes will not be permitted. Tighten bolts to the required torque.

2.6 MANHOLE DRAINERS (EJECTORS)

Provide automatic type drainers to operate on 125 psig steam supply. The drainer shall operate when the water level rises sufficiently in the sump, the float shall rise and open the steam control valve to admit steam to the drainer, which in turn shall pump the water from the sump. When the water level is lowered by the pumping action, the float shall lower and close the steam valve to stop the pumping action until water again gathers in the sump. Provide each drainer with controls to accomplish the above sequence of operation. The automatic float-operated steam valve shall be designed to prevent dead centering under field conditions and to lengthen the life of the valve seat. The valve shall have a high grade, renewable composition disc and a stainless steel or hard, noncorrosive bronze renewable seat inserted in the valve body. The drainer shall be constructed of corrosion-resistant copper and bronze. Piping from manhole drainers shall be ASTM A53/A53M, Weight Class XS (Extra Strong), hot-dip galvanized steel pipe with ASME B16.11 or ASME B16.3, Class 300, hot-dip galvanized threaded fittings. Provide a steam pressure regulating valve assembly for manhole drainers for operation on steam system above 125 psig.

2.7 CONCRETE MANHOLES

Provide under this section as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE, except as modified herein. Concrete shall be of 4000 psi minimum 28 day compressive strength, air entrained admixture (3.6 ounces per cubic yard), with water-reducing admixture (22 ounces per cubic yard), reinforced with deformed steel bars. Construct manhole sides by one monolithic pour. Cast-iron steps with nonslip surfaces, and spaced 12 to 16 inches apart on centers shall be firmly embedded in concrete walls for access to bottom of manholes. Provide top of manhole as indicated. [Steel grating covers for manholes shall be welded parallel bearing bars, with right angle cross members, zinc coated after fabrication; size as indicated.]

2.8 BURIED PIPING UNDER ROADS

Provide [new and modify existing] buried factory-prefabricated preinsulated steam and condensate piping in accordance with Section 33 63 13 EXTERIOR UNDERGROUND STEAM DISTRIBUTION SYSTEM.

2.8.1 Carrier Piping

2.8.1.1 Steam Piping

Provide steel piping.

2.8.1.2 Condensate Piping

Provide steel piping.

2.8.2 Piping Insulation for Carrier Piping

Products containing asbestos will not be permitted.

2.8.2.1 Insulation for Steam Piping

Nominal Pipe Sizes (inches)	Calcium Silicate Insulation Cellular Glass Insulation (inches)	Mineral Fiber Insulation (inches)
less than 3	3.0	2.5
3 thru 4	3.5	3.0
5 thru 6	4.0	3.5
8 and larger	5.0	4.5

2.8.2.2 Insulation for Steam Condensate Carrier Piping

Nominal Pipe Sizes (inches)	Calcium Silicate Insulation Cellular Glass Insulation (inches)	Mineral Fiber Insulation (inches)
less than 3	2.0	1.5
3 thru 4	2.5	2.0
5 and larger	3.0	2.5

2.8.3 Cathodic Protection

Provide sacrificial anode type cathodic protection system for metal conduits.

2.8.4 Buried Warning and Identification Tape

Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inches minimum width, color coded for the utility involved, with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall read CAUTION BURIED STEAM PIPING BELOW OR similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of exterior steam distribution system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.1, except as modified herein. Install piping straight and true to bear evenly on supports and sand bedding material. Install valves with stems horizontal or above. Provide flanges or unions at valves, traps, strainers, connections to equipment, and as indicated.

3.1.1 Cleaning of Piping

Keep the interior and ends of new piping and existing piping affected by the Contractor's operations, cleaned of water and foreign matter during installation by using plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.

3.1.2 Demolition

Remove materials so as not to damage materials which are to remain. Replace existing work damaged by the Contractor's operations with new work of the same construction.

3.2 PIPING

Test, inspect, and approve piping before burying, covering, or concealing. Provide fittings for changes in direction of piping and for connections. Reducing branch connections in steel piping may be made with forged branch outlet reducing fittings for branches two or more pipe sizes smaller than mains. Branch outlet fittings shall be forged, flared for improved flow where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Stab type connections will not be permitted. Jointing compound for pipe threads shall be Teflon pipe thread paste. Pipe nipples 6 inches long and shorter shall be Schedule 80 steel pipe. Make changes in piping sizes through tapered reducing fittings; bushings will not be permitted. Condensate piping shall include drip, vent, relief, and gage connecting piping.

3.2.1 Fittings and End Connections

For sizes less than one inch provide threaded fittings and end connections. For sizes one to 2 inches provide threaded or socket-welding or buttwelding fittings and end connections; provide threaded connections for threaded valves, traps, strainers, and threaded connections to equipment. For sizes 2.5 inches and larger provide buttwelding fittings and end connections; provide flanged connections for flanged valves, traps, strainers, and flanged connections to equipment.

3.2.2 Welding

ASME B31.1, metallic arc process, including qualification of welders.

3.2.3 Pipe Hangers and Supports

Provide additional hangers and supports for concentrated loads in piping between hangers and supports, such as for valves. Support steel piping as follows:

MAXIMUM SPACING (FEET)									
Pipe Size (inches)	one and under	1.5	2	3	4	6	8	10	12
Steel Piping	9	12	13	15	17	21	24	26	30

3.2.4 Buried Piping Under Roads

Installation including field joints, bedding, and initial backfill shall be in accordance with the Approved Brochure.

3.3 NAMEPLATES

Provide laminated plastic nameplates for equipment, gages, thermometers, and valves. Nameplates shall be melamine plastic, 0.125 inch thick, black with white center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the white core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be minimum of 0.25 inch high normal block style. Key the nameplates to a chart and schedule for each system. Frame charts and schedules under glass, and locate where directed near each system. Furnish two copies of each chart and schedule.

3.4 FIELD QUALITY CONTROL

3.4.1 Inspections

Prior to initial operation, inspect piping system for compliance with drawings, specifications, and manufacturer's submittals.

3.4.2 Piping Tests

Before final acceptance of the work, test each system as in service to demonstrate compliance with contract requirements. Before insulation is applied, hydrostatically test each piping system at not less than 225 psig in accordance with ASME B31.1, with no leakage or reduction in gage pressure for 2 hours. Flush and clean piping before placing in operation. Flush piping at a minimum velocity of 8 fps. Correct defects in work provided by Contractor and repeat tests until work is in compliance with contract requirements. Furnish potable water, electricity, instruments, connecting devices, and personnel for the tests.

3.4.3 Buried Piping Under Roads

Installation including field joints, bedding, and initial backfill shall be in accordance with the Section 33 63 13 EXTERIOR UNDERGROUND STEAM DISTRIBUTION SYSTEM. Bury tape with the printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

3.4.3.1 Conduit Coating

Test conduit coating of buried piping under roads prior to backfill in accordance with the approved brochure.

3.4.3.2 Cathodic Protection

Test cathodic protection of buried piping under roads to prove continuity of electrical connections prior to backfill.

3.5 FIELD PAINTING

After completion of field inspections and tests, clean and paint metal surfaces exposed to the weather and in manholes, including valves, strainers, traps, flow meters, pipe flanges, bolts, nuts, washers, pipe hangers, supports, expansion joints, and miscellaneous metal. Do not paint piping prior to the application of field-applied insulation. Do not paint stainless steel or aluminum jackets. Apply paint to clean dry surfaces. Clean surfaces to remove dust, dirt, rust, oil, and grease. Provide surfaces with two coats of enamel paint applied to a total minimum dry film thickness of 2 mils. Apply the second coat of paint after the preceding coat is thoroughly dry. Color of finish coat shall be aluminum or light gray. Paint shall be rated for use on hot metal surfaces up to 450 degrees F and for use on surfaces exposed to the weather.

3.6 CONNECTIONS TO EXISTING SYSTEMS

Notify the Contracting Officer in writing at least 15 days prior to the date the connections are required. Obtain approval before interrupting service. Provide materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required.

-- End of Section --

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SECTION 33 71 01

OVERHEAD TRANSMISSION AND DISTRIBUTION
05/19, CHG 1: 11/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS ANSI O5.1 (2017) Wood Poles -- Specifications & Dimensions

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.11 (2016) Forged Fittings, Socket-Welding and Threaded

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C1 (2003) All Timber Products - Preservative Treatment by Pressure Processes

AWPA C4 (2003) Poles - Preservative Treatment by Pressure Processes

AWPA C25 (2003) Sawn Crossarms - Preservative Treatment by Pressure Processes

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel

ASTM A53/A53M (2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A240/A240M (2020a) Standard Specification for Chromium and Chromium-Nickel Stainless

	Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A475	(2022) Standard Specification for Metallic-Coated Steel Wire Strand
ASTM A575	(2020) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM A576	(2017) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B2	(2013) Standard Specification for Medium-Hard-Drawn Copper Wire
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B230/B230M	(2007; R 2021) Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes
ASTM B231/B231M	(2016; R 2021) Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors
ASTM B232/B232M	(2017) Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)
ASTM B398/B398M	(2015; R 2021) Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes
ASTM B399/B399M	(2004; R 2021) Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors
ASTM B857	(2018) Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Alunimum Conductors, Coated-Steel Supported (ACSS/TW)
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products

ASTM D117	(2018) Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Liquids
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 18	(2012) Standard for Shunt Power Capacitors
IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.30.1	(2011)Standard Requirements for AC High-Voltage Air Switches Rated Above 1000 V
IEEE C37.41	(2016; Corr 2017) Design Tests for High-Voltage (>1000 V) Fuses and Accessories
IEEE C37.42	(2016) Specifications for High-Voltage (> 1000 V) Fuses and Accessories
IEEE C37.63	(2013) Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems
IEEE C57.12.00	(2021) General Requirements for

	Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.20	(2017) Overhead-Type Distribution Transformers, 500 KVA and Smaller: High Voltage, 34 500 Volts and Below; Low Voltage, 7970/13,800 Y V and Below
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.31	(2010; Corr 2014) Standard for Pole-Mounted Equipment - Enclosure Integrity
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.15	(2018) Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE C135.1	(1999) Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction
IEEE C135.2	(1999) Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for Overhead Line Construction
IEEE C135.22	(1988) Standard for Zinc-Coated Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 62271-111	(2019) High Voltage Switchgear And Controlgear - Part 111: Automatic Circuit Reclosers for Alternating Current Systems up to and including 38 kV

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7	(2014) Requirements for Watthour Meter Sockets
ANSI C29.2	(2020) American National Standard for Insulators - Wet-Process Porcelain and Toughened Glass - Distribution Suspension Type
ANSI C29.3	(1986; R 2012) American National Standard for Wet Process Porcelain Insulators - Spool Type
ANSI C29.4	(1989; R 2012) Standard for Wet-Process Porcelain Insulators - Strain Type
ANSI C29.5	(1984; R 2002) Wet-Process Porcelain Insulators (Low and Medium Voltage Pin Type)
ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA WC 70	(2021) Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard
NEMA/ANSI C29.7	(1996; 2002) American National Standard for Wet Process Porcelain Insulators - High-Voltage Line Post Type

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 202-1	(2004) List of Materials Acceptable for

	Use on Systems of RUS Electrification Borrowers
RUS Bull 1728H-701	(1993) Wood Crossarms (Solid and Laminated), Transmission Timbers and Pole Keys

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, must be as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Conductors; G[, [_____]]

Insulators; G[, [_____]]

Concrete Poles; G[, [_____]]

Steel Poles; G[, [_____]]

Wood Poles

Nameplates; G[, [_____]]

Pole Top Switch; G[, [_____]]

Recloser; G[, [_____]]

Sectionalizer; G[, [_____]]

Cutouts; G[, [_____]]

Transformer; G[, [_____]]

Metering Equipment; G[, [_____]]

Meters; G[, [_____]]

Surge Arresters; G[, [_____]]

Capacitors; G[, [_____]]

Voltage Regulator; G[, [_____]]

Guy Strand

Anchors

SD-05 Design Data

Concrete Poles; G[, [_____]]

Steel Poles; G[, [_____]]

Power-Installed Screw Foundations; G[, [_____]]

SD-06 Test Reports

Wood Crossarm Inspection Report

Field Test Plan; G[, [_____]]

Field Quality Control; G[, [_____]]

Ground Resistance Test Reports; G[, [_____]]

Medium-Voltage Preassembled Cable Test; G[, [_____]]

Sag and Tension Test; G[, [_____]]

Low-Voltage Cable Test; G[, [_____]]

Acceptance Checks and Tests; G[, [_____]]

SD-07 Certificates

Concrete Poles; G[, [_____]]

Steel Poles; G[, [_____]]

Wood Poles; G[, [_____]]

Wood Crossarms; G[, [_____]]

Transformer Efficiencies; G[, [_____]]

SD-09 Manufacturer's Field Reports

Operation and Maintenance Manuals; G[, [_____]]

Transformer Test Schedule; G[, [_____]]

Overhead-type Distribution Transformer Routine and Other Tests; G [, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals, Data Package 5; G[, [_____]]

[1.4.1 Government Submittal Review

[Code [C144][_____], NAVFAC [Atlantic] [_____] will review and approve transformer submittals.] As an exception to this paragraph, transformers manufactured by ABB in Athens, GA; by Cooper Power Systems in Lumberton, MS; by ERMCO in Dyersburg, TN; or by Howard Industries in Laurel, MS need not meet the submittal requirements of this contract. Instead, the following must be submitted.

a. A certification, from the manufacturer stating, that the manufacturer will meet the technical requirements of this specification.

b. Provide transformer test schedule and routine and other tests required by submittal item "SD-09 Manufacturer's Field Reports."

c. Provide Provide acceptance test reports received by submittal item "SD-06 Test Reports."

d. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data."

]1.5 QUALITY ASSURANCE

1.5.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory except of NFPA 70 when more stringent requirements are specified or indicated, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 and IEEE C2 unless more stringent requirements are specified or indicated.

1.5.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2-years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site must not be used, unless specified otherwise.

1.5.3 Ground Resistance Test Reports

Submit the measured ground resistance of grounding system. When testing grounding electrodes and grounding systems, identify each grounding electrode and each grounding system for testing. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

1.5.4 Wood Crossarm Inspection Report

Furnish an inspection report from an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with applicable AWPA and RUS standards. The RUS approved Quality Mark "WQC" on each crossarm will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

1.5.4.1 Field Test Plan

Provide a proposed field test plan [20] [30] [_____] days prior to testing the installed system. No field test must be performed until the test plan is approved. The test plan must consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

1.6 OPERATIONS AND MAINTENANCE DATA

Provide operation and maintenance manuals for systems in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provides basic data relating to the design, operation, and maintenance of the electrical distribution system.

1.6.1 Additions to Operations and Maintenance Data

In addition to requirements of Data Package 5, include the following in the operation and maintenance manuals provided:

a. Assembly and installation drawings

b. Prices for spare parts and supply list

c. Date of purchase

1.7 DELIVERY, STORAGE, AND HANDLING

Devices and equipment must be visually inspected by the Contractor when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Replace damaged items. Store oil filled transformers and switches in accordance with the manufacturer's requirements. Store wood poles held in storage for more than 2 weeks in accordance with ATIS ANSI O5.1. Handle wood poles in accordance with ATIS ANSI O5.1, except that pointed tools capable of producing indentations more than inch in depth must not be used. Nails and holes are not permitted in top of poles. Handle and store metal poles in accordance with the manufacturer's instructions.

1.8 WARRANTY

The equipment items must be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Consider materials specified herein or shown on contract drawings which are identical to materials listed in RUS 202-1 as conforming to requirements. Provide equipment and component items, not hot-dip galvanized or porcelain enamel finished, with corrosion-resistant finishes which must withstand [120] [480] hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16 inch from the test mark. Provide the described test mark and test evaluation in accordance with ASTM D1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Coat cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel with a zinc rich paint conforming to the manufacturer's standard.

2.2 POLES

Provide poles of lengths and [classes] [strengths] indicated.

2.2.1 Wood Poles

Wood poles machine trimmed by turning, [Douglas Fir] [Lodgepole Pine]

[Western Larch] [Southern Yellow Pine] [_____] conforming to ATIS ANSI O5.1. Gain, bore and roof poles before treatment. Should additional gains be required subsequent to treatment, metal gain plates must be provided. Pressure treat poles with [pentachlorophenol,] [ammoniacal copper arsenate (ACA),] [chromated copper arsenate (CCA)], except that Douglas Fir and Western Larch poles must not be treated with CCA in accordance with AWPA C1 and AWPA C4. Ensure the quality of each pole with "WQC" (wood quality control) brand on each piece, or by an approved inspection agency report.

2.2.2 Steel Poles

Design steel poles to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors, hot-dip galvanized in accordance with ASTM A123/A123M and not painted. Poles must have tapered tubular members, either round in cross-section or polygonal, and comply with strength calculations performed by a registered professional engineer. Submit calculations in accordance with the design data portion of paragraph SUBMITTALS. Provide certification, from the manufacturer, that the technical requirements of this specification must be met. Pole shafts must be one piece. Poles must be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings must be approximately 3 to 4 feet above grade and must include manufacturer, year of manufacture, top and bottom diameters, length, and a loading tree. Provide attachment requirements as indicated, including grounding provisions. Climbing facilities are not required. Bases must be of the anchor-bolt-mounted type.

2.2.3 Concrete Poles

Design concrete poles to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors. Poles must be reinforced or prestressed, either cast or spun. Spun poles must be manufactured by a centrifugal spinning process with concrete pumped into a polished round tapered metal mold. Concrete for spun poles must have a compressive strength of at least 5000 psi at 28 days; steel wire must have an ultimate tensile strength of at least 120,000 psi; and reinforcing bars must have an ultimate tensile strength of at least 40,000 psi. After the high speed spinning action is completed, a spun pole must be cured by a suitable wet steam process. Spun poles must have a water absorption of not greater than three percent to eliminate cracking and to prevent erosion. Concrete poles must have hollow shafts. Poles must have a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water and frost. Poles must not be installed for at least 15 days after manufacture. Provide fittings and brackets that conform to the concrete pole design. Poles must conform to strength calculations performed by a registered professional engineer and submitted in accordance with design data portion of paragraph SUBMITTALS. Provide certification, from the manufacturer, that the technical requirements of this specification must be met.

2.3 CROSSARMS AND BRACKETS

2.3.1 Wood Crossarms

Conform to RUS Bull 1728H-701. Pressure treat crossarms with pentachlorophenol, chromated copper arsenate (CCA), or ammoniacal copper arsenate (ACA). Treatment must conform to AWPA C25. Crossarms must be solid wood, distribution type, and a 1/4 inch 45 degree chamfer on all top edges. Cross-sectional area minimum dimensions must be 4-1/4 inches in height by 3-1/4 inches in depth in accordance with IEEE C2 for Grade B construction. Crossarms must be 8 feet in length, except that 10 foot crossarms must be used for crossarm-mounted banked single-phase transformers or elsewhere as indicated. Crossarms must be machined, chamfered, trimmed, and bored for stud and bolt holes before pressure treatment. Factory drilling must be provided for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Drilling must provide required climbing space and wire clearances. Crossarms must be straight and free of twists to within 1/10 inch per foot of length. Bend or twist must be in one direction only.

2.3.2 Crossarm Braces

Provide [flat steel][or][steel angle] as indicated. Provide braces with [38 inch span for 8 foot crossarms][and][60 inch span for 10 foot crossarms].

2.3.3 Armless Construction

Pole mounting brackets for line-post or pin insulators and eye bolts for suspension insulators must be as indicated. Brackets must be attached to poles with a minimum of two bolts. Brackets may be either provided integrally as part of an insulator or attached to an insulator with a suitable stud. Bracket mounting surface must be suitable for the shape of the pole. Brackets for wood poles must have wood gripping members. Horizontal offset brackets must have a 5-degree uplift angle. Pole top brackets must conform to IEEE C135.22, except for modifications necessary to provide support for a line-post insulator. Brackets must provide a strength exceeding that of the required insulator strength, but in no case less than a 2800 pound cantilever strength.

2.4 HARDWARE

Hardware must be hot-dip galvanized in accordance with ASTM A153/A153M and ASTM A123/A123M.

[Zinc-coated hardware must comply with IEEE C135.1, IEEE C135.2, IEEE C135.22. Steel hardware must comply with ASTM A575 and ASTM A576. Pole-line hardware must be hot-dip galvanized[steel.][steel, except anchor rods of the copper-molten welded-to-steel type with nonferrous corrosion-resistant fittings must be used.] Intall washers under boltheads and nuts on wood surfaces and elsewhere as required. Washers used on through-bolts and double-arming bolts must be approximately 2-1/4 inches square and 3/16 inch thick. The diameter of holes in washers must be the correct standard size for the bolt on which a washer is used. Washers for use under heads of carriage-bolts must be of the proper size to fit over square shanks of bolts. Use eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises wherever required to support and to protect poles, brackets, crossarms, guy wires, and insulators.

]2.5 INSULATORS

Provide wet-process porcelain insulators which are radio interference free.

[a. Line post type insulators: NEMA/ANSI C29.7, Class [_____].

][b. Suspension insulators: ANSI C29.2 [4/52-4 for 34.5 kV on NAVSTA

NORVA], Quantity per Phase, [_____], Class [_____].

][c. Spool insulators: ANSI C29.3, Class [_____].

][d. Guy strain insulators: ANSI C29.4, Class [_____], [except provide fiberglass type when used with underground terminal or when other interference problems exist].

][e. Pin insulators: ANSI C29.5, Class [_____].

]2.6 OVERHEAD CONDUCTORS, CONNECTORS AND SPLICES

Conductors of bare [copper] [aluminum (AAC)] [aluminum alloy (AAAC)] [aluminum conductor steel reinforced (ACSR)] [aluminum conductor steel supported (ACSS)] of sizes and types indicated.[Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL 486A-486B must be used.]

2.6.1 Solid Copper

ASTM B1, ASTM B2, and ASTM B3, hard-drawn, medium-hard-drawn, and soft-drawn, respectively. ASTM B8, stranded.

2.6.2 Aluminum (AAC)

ASTM B230/B230M and ASTM B231/B231M.

2.6.3 Aluminum Alloy (AAAC)

ASTM B398/B398M or ASTM B399/B399M.

2.6.4 Aluminum Conductor Steel Reinforced (ACSR)

ASTM B232/B232M, aluminum.

2.6.5 Aluminum Conductor Steel Supported (ACSS)

ASTM B857, aluminum.

2.6.6 Connectors and Splices

Connectors and splices must be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. Aluminum-composition, aluminum-composition to copper, and copper-to-copper must comply with UL 486A-486B.

2.7 NEUTRAL-SUPPORTED SECONDARY AND SERVICE DROP CABLES

[Service][Secondary] cables must be [aluminum] [copper], [triplex] [quadruplex] with cross-linked polyethylene insulation on the phase conductors. Neutral must be bare [ACSR] [ACSS] [aluminum alloy] [hard drawn copper] and must be the same size as the phase conductors unless otherwise indicated. Cables shall conform to [NEMA WC 70][and][ANSI/NEMA WC 71/ICEA S-96-659] [ASTM B857] for cross-linked polyethylene insulation.

2.8 GUY STRAND

[ASTM A475, [high-strength] [extra high-strength], Class A or B, galvanized strand steel cable][Class 30 [high-strength] [extra high-strength] copper-clad steel]. Guy strand must be [_____] inch in diameter with a minimum breaking strength of [_____] pounds. Provide guy terminations designed for use with the particular strand and developing at least the ultimate breaking strength of the strand.

2.9 ROUND GUY MARKERS

Vinyl or PVC material, [white] [yellow] colored, 8 feet long and shatter resistant at sub-zero temperatures.

2.9.1 Guy Attachment

Thimble eye guy attachment.

2.10 ANCHORS AND ANCHOR RODS

Anchors must present holding area indicated on drawings as a minimum. Anchor rods must be triple thimble-eye, [3/4] [one] inch diameter by 8 feet long. Anchors and anchor rods must be hot dip galvanized.

2.10.1 Screw Anchors

Screw type [swamp] anchors having a manufacturer's rating [of not less than [_____] pounds in loose to medium sand/clay soil, Class 6] [at least equal to rating indicated] and extra heavy pipe rods conforming to ASTM A53/A53M, Schedule 80, and couplings conforming to ASME B16.11, [fitting Class 6000.]

2.10.2 Plate Anchors

Minimum area of [_____] square inches and rated by manufacturer for [_____] pounds or more in soils classified as medium dense coarse sand and sandy gravels; firm to stiff clays and silts.

2.10.3 Rock Anchors

Rock anchors having a manufacturer's rating of [23,000][36,000] pounds.

2.11 GROUNDING AND BONDING

2.11.1 Driven Ground Rods

Provide cone pointed [copper-clad steel ground rods conforming to UL 467][zinc-coated steel ground rods conforming to IEEE C135.30][solid stainless steel ground rods] not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.11.2 Grounding Conductors

ASTM B3. Provide soft drawn copper wire ground conductors a minimum No. 4 AWG. Ground wire protectors must be PVC. Keep ground conductors straight and short. Minimize bends in all ground connections.

2.11.3 Grounding Connections

UL 467. Exothermic weld or compression connector.

2.12 SURGE ARRESTERS

IEEE C62.11, metal oxide, polymeric-housed, surge arresters arranged for [crossarm] [equipment] mounting. RMS voltage rating must be [3] [6] [9] [10] [12] [15] [27] [30] [36] kV. Arresters must be [Distribution] [Intermediate] [Station] class.

2.13 FUSED CUTOUTS

[Open][Enclosed] type fused cutouts rated [100] [200] amperes and [_____] amperes symmetrical interrupting current at [[7.8] [15] kV ungrounded] [8.3/15 kV gnd Y] [15/26 kV gnd Y] [27/34.5 kV gnd Y], conforming to IEEE C37.42. [IEEE C37.41 rated backup current limiting fuses in series with Type K expulsion fuses.]Type [K] [T] fuses conforming to IEEE C37.42 with ampere ratings [as indicated] [equal to 150 percent of the transformer full load rating]. Open link type fuse cutouts are not acceptable.[Provide heavy duty open drop-out type, rated 15 kV, 200 Amp, 7,100 Amp I.C. (Sym.).]

2.14 CONDUIT RISERS AND CONDUCTORS

The riser shield must be PVC containing a PVC back plate and PVC extension shield or a rigid galvanized steel conduit, as indicated, and conforming to UL 6. Provide conductors and terminations as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.15 TRANSFORMER (OVERHEAD-TYPE DISTRIBUTION)

a. IEEE C57.12.20.

b. Single phase, self-cooled, 65 degrees C. continuous temperature rise, two winding, 60 Hertz.

c. Insulating liquid:

[Mineral oil: ASTM D3487, Type II, tested in accordance with ASTM D117. Provide identification of transformer as "non-PCB" and "Type II mineral oil" on the nameplate.

][Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D877/D877M. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid on the nameplate.

The fluid must be a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable fluids. The fluid must meet the following fluid properties:

(1) Pour point: ASTM D97, less than -15 degrees C

(2) Aquatic biodegradation: EPA 712-C-98-075, 100 percent.

(3) Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass.

] d. Ratings:

(1) kVA: [_____].

(2) BIL: [95] [75] [60] kV.

(3) Primary voltage: [_____] kV.

(4) Secondary voltage: [_____] volts.

(5) Minimum Tested Impedance at 85 degrees C: [_____] percent.

[e. Single-phase connections:

(1) Connect primary: [Phase-to-phase] [Phase-to-ground].

(2) Provide transformer with [_____] high voltage bushing(s).

][f. Three-phase connections:

(1) Connect primary: [Grounded wye] [Ungrounded wye] [Delta].

(2) Connect secondary: [Grounded wye] [Delta], for [_____] volt, three phase, [_____] wire service.

(3) Provide transformer with [_____] high voltage bushings.

] g. Taps:

(1) Provide four 2-1/2 percent full capacity taps, 2 above and 2 below rated primary voltage. Tap changer must have external handle.

[h. Externally operated Series-Multiple Voltage-Changing Switch.

] i. Corrosion Protection:

[Transformer tanks and covers must be corrosion resistant and must be fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L.]Paint coating system must comply with IEEE C57.12.28 regardless of tank and cover material. Finish coat must be light gray, ANSI color No. 70.

j. Show transformer kVA capacity using 2 1/2 inch Arabic numerals placed near the low-voltage bushings.

2.15.1 Specified Transformer Efficiencies

Provide single phase transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer(s) prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "KVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K, for a liquid-immersed distribution transformer. Submit certification, including supporting calculations, from the manufacturer indicating conformance.

kVA Single	EFFICIENCY (percent)
10	98.70

kVA Single	EFFICIENCY (percent)
15	98.82
25	98.95
37.50	99.05
50	99.11
75	99.19

[2.16 GROUP-OPERATED LOAD INTERRUPTER SWITCHES

2.16.1 Manually Operated Type (Switch Handle Operated)

Manually operated (switch handle operated) load interrupter switches must comply with IEEE C37.30.1 and must be of the outdoor, manually-operated, three-pole, single-throw type with either tilting or rotating insulators. Switches must be equipped with interrupters capable of interrupting currents equal to the switch's continuous current rating. Each switch must be preassembled for the indicated configuration and mounting. Moving contacts must be of the high-pressure, limited-area type, designed to ensure continuous surface contact. Switches must be fused or non-fused as indicated. Switches must be complete with necessary operating mechanisms, handles, and other items required for manual operation from the ground. Switch operating handles must be located approximately 3 feet 6 inches above final grade. Insulation of switch operating mechanisms must include both insulated interphase rod sections and insulated vertical shafts. Provide each handle must be provided with a padlock arranged to lock the switch in both the open and the closed position.

[2.16.2 Remotely Operated Type (Stored-Energy Actuator)

Remotely-operated, [air-insulated] [SF6 insulated] load interrupter switches must be rated in accordance with and comply with the requirements of IEEE C37.30.1 and must be of the outdoor, three-pole, [pole-mounted] [crossarm-mounted] type. Interrupter devices must be [air-insulated] [SF6-insulated, puffer-type] switches capable of interrupting currents equal to the switch continuous current ratings indicated. Switches must utilize an electric motor-charged, stored-energy (spring-driven) operator to simultaneously trip all phases. A switch-control unit must be provided [for push-button operation from the ground] [for push-button operation from the ground and remote switch actuation via telemetry]. The switch-control unit must be pad-lockable, tamper-resistant, in a NEMA ICS 6, Type [3R] [4] [4X] [4X-SS] enclosure, which is connected to the switch actuator by a shielded control cable. Control power for closing and tripping must be provided by a battery mounted in the control unit enclosure. The switch control unit must be provided with a separate 120 volt ac circuit for the battery powered. Power for charging the operator mechanism may be 120 volt ac or battery powered. If operator mechanism charging power is from a battery, capacity must be provided for a minimum of [_____] [four] sequential opening and closing operation without battery charging. The switch control unit must be configured for supervisory, control, and data acquisition (SCADA) function, including local and remote operation. Provide voltage and current sensors, one set for each phase, for monitoring of both normal and fault conditions. Provide switches with visual indication of open switch contact for clearance and isolation purposes. Provide switch mechanisms with provisions for grounding of nonenergized metal parts. Provide the switch control unit with a switch operations.

]][2.17 RECLOSER

IEC 62271-111, IEEE C37.60. Operating temperature range of minus 40 degree C to 55 degree C. Paint the reclosure tank Munsell 5BG7.0/0.4 sky gray (ANSI 70), with paint coateing system compying with IEEE C57.12.31. The Munsell color notation is specified in ASTM D1535.

a. [Electronically] [Hydraulically] operated, in [air] [epoxy] [oil] insulating medium with [oil] [vacuum] interruption.

b. [Three-phase][Single-phase].

c. [15.5kV] [27kV] [38kV] maximum design voltage. [2.4kV] [4.8kV] [8.32kV] [14.4kV] [24.9kV] [34.5kV][_____] nominal operating voltage.

d. [100A] [200A] [400A] [600A] [800A] [1200A] [_____] continuous current.

e. [50] [60] hertz.

f. [8kA] [10kA] [12kA] [16kA] [20kA] [_____] interrupting rating, symmetrical.

g. [110] [125] [150] [170] kV BIL.

h. [Form 6][Form 4D] recloser control.

][2.18 SECTIONALIZER

IEEE C37.63. Operating temperature range of minus 40 degree C to 55 degree C. Paint the reclosure tank Munsell 5BG7.0/0.4 sky gray (ANSI 70), with paint coateing system compying with IEEE C57.12.31. The Munsell color notation is specified in ASTM D1535.

a. [Electronically][Hydraulically] operated, oil-insulated.

b. Three-phase.

c. [15.5 kV] [27 kV] [38 kV] maximum design voltage. [2.4 kV] [4.8 kV] [8.32 kV] [14.4 kV] [24.9 kV][_____] nominal operating voltage.

d. 200 A continuous current. 440 A interrupting loadbreak current.

e. [50] [60] Hertz.

f. 9 kV maximum momentary and making current, asymmetrical.

g. [110] [125] [150] kV BIL.

][2.19 METERING EQUIPMENT

Pole mounted metering equipment must include current transformers, potential transformers, watthour meter, [meter test switch block,] metering enclosure, wire, conduit and fittings.

2.19.1 Potential Transformers

Potential transformers must be rated for outdoor service fitted for crossarm mounting and secondary connection box for conduit connection.

Voltage rating must be [2.4] [4.16] [7.2] [12.0] [12.47] [_____] kV to 120 volts ac, 60 Hz. Transformers must conform to the requirements of IEEE C57.13 BIL [45] [60] [75] [95] kV and accuracy Class 0.3 (min.) of [75 VA] [burden Y].

2.19.2 Current Transformers

Current transformers must be rated for outdoor service with crossarm mounting and secondary connection box for conduit connection. Voltage rating must be [2.4] [4.16] [7.2] [12.47] [12.0] [_____] kV. Current rating must be [_____] to 5 amperes. Transformers must conform to requirements of IEEE C57.13, BIL [45] [60] [75] [95] kV and accuracy Class 0.3 at [B2.0] [50 VA].

2.19.3 Watthour Meter

Provide meter with provisions for future pulse initiation.

a. Meters: NEMA/ANSI C12.10 and ANSI C12.1; when providing meter with electronic time-of-use register.

    (1) Form: [5A] [5S] [6A] [6S].

    (2) Element: [2] [2 1/2] [3].

    (3) Voltage: 120 volts.

    (4) Current: 2 1/2 amperes.

    (5) Frequency: 60 hertz.

    (6) Kilowatt hour register: 5 dial or 5 digit type.

b. Demand register:

    (1) Solid state type.

    (2) Meter reading multiplier:

        (a) Indicate multiplier on the meter face.

        (b) Provide multiplier in even hundreds.

    (3) Demand interval length: must be programmed for [15] [30] [60] minutes with rolling demand up to six subintervals per interval.

c. Mounting:

    (1) Provide meter with [matching socket per ANSI C12.7 with [manual] [automatic] current short-circulating device.]["A" base type mounting].

[2.19.4 Meter Test Block

Provide meter test block with [T] [10] pole group of open knife type switches designed for the isolation of metering devices at meter location by opening each circuit individually. Current switches must short circuit current supply before opening meter circuit. Switch handles of potential switches must be black. Switch handles of current switches must be red.

]2.19.5 Metering Enclosure

Metering enclosure must be of galvanized steel, weatherproof construction with pole mounting bracket, and 3/4 inch exterior plywood, full size backboard and hinged door arranged for padlocking in closed position. Internal space must be adequate to house equipment and wiring but not smaller than 20 by 30 by 11 inches deep. Paint metal manufacturer's standard finish.

]2.20 CAPACITORS

IEEE 18. Operating temperature range of minus 40 degrees C to 46 degrees C. Provide capacitor tank fabricated of stainless steel conforming to ASTM A240/A240M, Type 409. Paint the capacitor tank Munsell 5BG7.0/0.4 sky gray (ANSI 70), with paint coating system complying with IEEE C57.12.31. The Munsell color notation is specified in ASTM D1535. Capacitor equipment must comply with IEEE 18 and must be of the three-phase, grounded-wye, outdoor type rated for continuous operation and automatically switched. Equipment must be suitable for mounting on a single pole. Polychlorinated biphenyl and tetrachloroethylene (perchloroethylene) must not be used as the dielectric. Equipment must be rated for the system voltage. The indicated kvars must be automatically switched by [single-step] [time switch] [voltage] [current] [kilovar] [control] [multiple-step] [voltage] [kilovar] [control providing the indicated number of steps and switching the indicated kvar]. Provide necessary transformers for sensing circuit variations and for low-voltage control. Provide oil-immersed switches for automatic switching of capacitors, and must be electrically separate from ungrounded capacitor enclosures and metal frames. Installations must include one primary fuse cutout and one surge arrester for each ungrounded phase conductor. Fuse link ratings must be in accordance with the manufacturer's recommendations. Capacitor equipment, except for low-voltage control and primary fuse cutouts, must be subassembled and coordinated by one manufacturer. Ship units, including metal pole-mounting supports and hardware, in complete sections ready for connection at the site. Low-voltage equipment must be socket or cabinet type, mounted on the pole approximately 4 feet above grade, must be connected with the necessary wiring in conduit to capacitor equipment, and must be provided with secondary arrester protection against switching surges when recommended by the manufacturer.

2.21 VOLTAGE REGULATOR

Voltage regulators must comply with IEEE C57.15 and must be of the outdoor, self-cooled, 55/65 degrees C temperature rise, single-phase type. Windings and the load-tap-changing mechanism must be mineral-oil-immersed. When operating under load, a regulator must provide plus and minus 10 percent automatic voltage regulation in approximately 5/8 percent steps, with 16 steps above and 16 steps below rated voltage. Automatic control equipment must provide Class 1 accuracy. Bypass surge arresters must be suitable for [a grounded] [an ungrounded] system and for the associated regulator voltage.[[Station][Intermediate] class surge arresters must be mounted next to each incoming line bushing on a regulator tank-mounted bracket and connected to a surge arrester ground pad-mounted on the regulator tank].

2.21.1 Ratings

Ratings at 60 Hz must be

Maximum voltage..[_____]

Basic Insulation Level (BIL)...........................[_____]

Current..[_____]

2.21.2 Bypass and Isolation Switches

Switches must be of the outdoor, stickhook-operated, single-pole, single-throw, vertical-break type suitable for the indicated mounting. Switches must be of a type designed to provide bypass of a single-phase regulator circuit by an integral sequence which always occurs when each switch is opened or closed. Each opening sequence must initially bypass the single-phase regulator circuit, then open the input and output circuits, and finally interrupt the exciting current. Opening any single-phase regulator circuit must not be possible until after the bypass circuit is closed. Ratings at 60 Hz must be in accordance with IEEE C37.41 and as follows:

Maximum voltage..[_____]

Nominal voltage class..................................[_____]

BIL..[_____]

Momentary asymmetrical current in the closed position.....[_____]

Momentary asymmetrical current in the bypass position.....[_____]

Continuous and interrupting current.....................[_____]

2.21.3 Miscellaneous

Standard accessories and components in accordance with IEEE C57.15 must be provided. Single-phase units must be provided with additional components and accessories required by IEEE C57.15 for three-phase units. Install regulator control approximately 5 feet from ground on field side of pole. Control cable must be properly shielded or installed in suitable conduit.

2.22 ELECTRICAL TAPES

Tapes must be UL listed for electrical insulation and other purposes in wire and cable splices. Terminations, repairs and miscellaneous purposes, electrical tapes must comply with UL 510.

2.23 CAULKING COMPOUND

Compound for sealing of conduit risers must be of a puttylike consistency workable with hands at temperatures as low as 35 degrees F, must not slump at a temperature of 300 degrees F, and must not harden materially when exposed to air. Compound must readily caulking or adhere to clean surfaces of the materials with which it is designed to be used. Compound must have no injurious effects upon the workmen or upon the materials.

2.24 NAMEPLATES

2.24.1 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. Equipment containing liquid-dielectrics must have the type of dielectric on the nameplate.

2.24.2 Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 0.125 inch thick, white with [black] [_____] center core. Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be one by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.25 SOURCE QUALITY CONTROL

2.25.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

(1) The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) The accuracy shall be directly traceable to the National Institute of Standards and Technology.

(3) Instrument calibration frequency schedule must not exceed 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels must be visible on all test equipment.

(5) Calibrating standard must be of higher accuracy than that of the instrument tested.

(6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.25.2 Routine and Other Tests

IEEE C57.12.00 and IEEE C57.12.90. Routine and other tests must be performed by the manufacturer on [each of] the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests must be as follows:

a. Polarity

b. Ratio

c. No-load losses (NLL) and excitation current

d. Load losses (LL) and impedance voltage

e. Dielectric

    (1) Impulse

    (2) Applied voltage

    (3) Induced voltage

f. Leak

PART 3 EXECUTION

3.1 INSTALLATION

Provide overhead pole line installation conforming to requirements of [_____] [IEEE C2] [CALPUC G.O. 95] for Grade [B] [C] construction of overhead lines in [light] [medium] [heavy] loading districts and NFPA 70 for overhead services. Provide material required to make connections into existing system and perform excavating, backfilling, and other incidental labor. Consider street, alleys, roads and drives "public." Pole configuration must be as indicated.

3.1.1 Overhead Service

Terminate overhead service conductors into buildings at service entrance fittings or weatherhead outside building. Installation and connection of service entrance equipment to overhead service conductor is included in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Nearby support bracket for overhead wires must be not less than [_____] feet above finished grade at building. Drip loops must be formed on conductors at entrances to buildings, cabinets, or conduits.

3.1.2 Tree Trimming

Where lines pass through trees, trees must be trimmed at least [15 feet] [_____] clear on both sides horizontally and below for medium-voltage lines, and [5 feet] [_____] clear on both sides horizontally and below for other lines. No branch must overhang horizontal clearances. Where trees are indicated to be removed to provide a clear right-of-way, clearing is specified in Section 31 11 00 CLEARING AND GRUBBING.

3.1.3 Wood Pole Installation

Provide pole holes at least as large at the top as at the bottom and large enough to provide 4 inch clearance between the pole and side of the hole.[Provide a 6 inch band of soil around and down to the base of the pole treated with [_____] gallons of a termiticide solution. Treatment requirements are specified in Section 31 31 16.13 Chemical Termite Control.]

3.1.3.1 Setting Depth of Pole

Pole setting depths must be as follows:

Length of Pole (feet)	Setting in Soil (feet)	Setting in Solid Rock (feet)
20	5.0	3.0
25	5.5	3.5
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.5	5.0
60	8.0	5.0
65	8.5	5.5
70	9.0	5.5
75	9.5	6.0
80	10.0	6.0
85	10.5	6.5
90	11.0	6.5
95	11.5	7.0
100	12.5	7.5

3.1.3.2 Setting in Soil, Sand, and Gravel

"Setting in Soil" depths, as specified in paragraph entitled "Setting Depth of Pole," apply where the following occurs:

a. Where pole holes are in soil, sand, or gravel or any combination of these;

b. Where soil layer over solid rock is more than 2 feet deep;

c. Where hole in solid rock is not substantially vertical; or

d. Where diameter of hole at surface of rock exceeds approximately twice the diameter of pole at same level.[At corners, dead ends and other points of extra strain, poles 40 feet or more long must be set 6 inches deeper.]

3.1.3.3 Setting in Solid Rock

"Setting in Solid Rock," as specified in paragraph SETTING DEPTH OF POLE, applies where poles are to be set in solid rock and where hole is substantially vertical, approximately uniform in diameter and large enough to permit use of tamping bars the full depth of hole.

3.1.3.4 Setting With Soil Over Solid Rock

Where a layer of soil 2 feet or less in depth over solid rock exists, depth of hole must be depth of soil in addition to depth specified under "Setting in Solid Rock" in paragraph SETTING DEPTH OF POLE, provided, however, that such depth must not exceed depth specified under "Setting in Soil."

3.1.3.5 Setting on Sloping Ground

On sloping ground, always measure hole depth from low side of hole.

3.1.3.6 Backfill

Thoroughly tamp pole backfill for full depth of the hole and mound excess fill around the pole.

3.1.3.7 Setting Poles

Set poles so that alternate crossarm gains face in opposite directions, except at terminals and dead ends where gains of last two poles must be on side facing terminal or dead end. On unusually long spans, set poles so that crossarm comes on side of pole away from long span. Where pole top pins are used, they must be on opposite side of pole from gain, with flat side against pole.

3.1.3.8 Alignment of Poles

Set poles in alignment and plumb except at corners, terminals, angles, junctions, or other points of strain, where they must be set and raked against the strain. Set not less than 2 inches for each 10 feet of pole length above grade, nor more than 4 inches for each 10 feet of pole length after conductors are installed at required tension. When average ground run is level, consecutive poles must not vary more than 5 feet in height. When ground is uneven, poles differing in length must be kept to a minimum by locating poles to avoid the highest and lowest ground points. If it becomes necessary to shorten a pole, a piece must be sawed off the top. Holes must be dug large enough to permit the proper use of tampers to full depth of hole.

3.1.3.9 Pole Caps

Provide plastic pole caps with 1/4 inch sealing rings and four nailing tabs. Fill sealing area with either a bituminous, elastigum roof cement or an acceptable preservative paste to level of sealing ring to eliminate possibility of condensation. Place on pole top and nail each tab down with a 1 1/4 inch nail.

3.1.4 Steel and Concrete Pole Setting

Poles must be mounted on cast-in-place or power-installed screw foundations. [Concrete poles must be embedded in accordance with the details indicated.] Provide conduit elbows for cable entrances into pole interiors.

3.1.4.1 Cast-In-Place Foundations

Concrete foundations, sized as indicated, must have anchor bolts accurately set in foundations using templates supplied by the pole manufacturer. Concrete work and grouting is specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. After the concrete has cured, pole anchor bases must be set on foundations and leveled by shimming between anchor bases and foundations or by setting anchor bases on leveling nuts and grouting. Poles must be set plumb. Anchor bolts must be the manufacturer's standard, and not less than necessary to meet the pole wind loading specified herein and other design requirements.

3.1.4.2 Power-Installed Screw Foundations

Power-installed screw foundations may be used if they have the required strength, mounting-bolt, and top plate dimensions. Screw foundations must be of at least 1/4 inch thick structural steel conforming to ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M. Mark conduit slots in screw foundation shafts and top plates to indicate orientation. Design calculations indicating adequate strength must be approved before installation of screw foundation is permitted.

3.1.5 Anchors and Guys

Place anchors in line with strain. Indicate the length of the guy lead (distance from base of pole to the top of the anchor rod).

3.1.5.1 Setting Anchors

Set anchors in place with anchor rod aligned with, and pointing directly at, guy attachment on the pole with the anchor rod projecting 6 to 9 inches out of ground to prevent burial of rod eye.

3.1.5.2 Backfilling Near [Plate] Anchors

[Backfill plate, expanding, concrete, or cone type anchors with tightly tamped coarse rock 2 feet immediately above anchor and then with tightly tamped earth filling remainder of hole.

][Backfill plate anchors with tightly tamped earth for full depth of hole.

]3.1.5.3 Screw Anchors

Install screw anchors by torquing with boring machine.

3.1.5.4 Swamp Anchors

Install swamp anchors by torquing with boring machine or wrenches, adding sections of pipe as required until anchor helix is fully engaged in firm soil.

3.1.5.5 Rock Anchors

Install rock anchors minimum depth 12 inches in solid rock.

3.1.5.6 Guy Installation

Provide guys where indicated, with loads and strengths as indicated, and wherever conductor tensions are not balanced, such as at angles, corners and dead-ends. Where single guy will not provide the required strength, provide two or more guys. Where guys are wrapped around poles, at least two guy hooks must be provided. Provide pole shims where guy tension exceeds 6000 pounds. Provide guy clamps 6 inches in length with three 5/8 inch bolts, or offset-type guy clamps, or approved guy grips at each guy terminal. Securely clamp plastic guy marker to the guy or anchor at the bottom and top of marker.Complete anchor and guy installation, dead end to dead end, and tighten guy before wire stringing and sagging is begun on that line section.[Provide strain insulators at a point on guy strand 8 feet minimum from the ground and 6 feet minimum from the surface of pole.][Effectively ground and bond guys to the system neutral.]

3.1.6 Hardware

Provide hardware with washer against wood and with nuts and lock nuts applied wrench tight. Provide locknuts on threaded hardware connections. Locknuts must be M-F style and not palnut style.

3.1.7 Grounding

Unless otherwise indicated, grounding must conform to IEEE C2 and NFPA 70.[Pole grounding electrodes must have a resistance to ground not exceeding 25 ohms. When work in addition to that indicated or specified is directed in order to obtain specified ground resistance, provisions of the contract covering changes must apply.]

3.1.7.1 Grounding Electrode Installation

Install grounding electrodes as follows:

a. Driven rod electrodes - Unless otherwise indicated, locate ground rods approximately 3 feet out from base of the pole and drive into the earth until the tops of the rods are approximately one foot below finished grade. Evenly spaced multiple rods at least 10 feet apart and connected together 2 feet below grade with a minimum No. 6 bare copper conductor.

b. Plate electrodes - Install plate electrodes in accordance with the manufacturer's instructions and IEEE C2 and NFPA 70.

[c. Ground resistance - The maximum resistance of a [driven ground rod] [plate electrode] must not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes [interconnected with grounding conductors] [as indicated], to achieve the specified ground resistance. The additional electrodes will be [up to three, [8] [10] feet rods spaced a minimum of 10 feet apart] [a single extension-type rod, [5/8] [3/4] inch diameter, up to 30 feet long, [driven perpendicular to grade] [coupled and driven with the first rod]]. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

]3.1.7.2 Grounding Electrode Conductors

[On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Bond neutrals, surge arresters, and equipment grounding conductors to this conductor. For single-grounded or ungrounded systems, provide a grounding electrode conductor for the surge arrester and equipment grounding conductors and a separate grounding electrode conductor for the secondary neutrals. Staple grounding electrode conductors to wood poles at intervals not exceeding 2 feet. On metal poles, a preformed galvanized steel strap, 5/8 inch wide by 22 gaugeminimum by length, secured by a preformed locking method standard with the manufacturer, must be used to support a grounding electrode conductor installation on the pole and spaced at intervals not exceeding 5 feet with one band not more than 3 inches from each end of the vertical grounding electrode conductor.]Size grounding electrode conductors as indicated. Connect secondary system neutral conductors directly to the transformer neutral bushings, then connected with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor as indicated. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

3.1.7.3 Grounding Electrode Connections

Make above grade grounding connections on pole lines by exothermic weld or by using a compression connector. Make below grade grounding connections by exothermic weld. Make exothermic welds strictly in accordance with manufacturer's written recommendations. Welds which have puffed up or which show convex surfaces indicating improper cleaning, are not acceptable. No mechanical connectors are required at exothermic weldments. Compression connectors must be type that uses a hydraulic compression tool to provide correct pressure. Provide tools and dies recommended by compression connector manufacturer. An embossing die code or similar method must provide visible indication that a connector has been fully compressed on ground wire.

3.1.7.4 Grounding and Grounded Connections

a. Where no primary or common neutral exists, bond surge arresters and frames of equipment operating at over 750 volts together and connected to a dedicated primary grounding electrode.

b. Where no primary or common neutral exists, bond transformer secondary neutral bushing, secondary neutral conductor, and frames of equipment operating at under 750 volts together and connected to a dedicated secondary grounding electrode.

c. When a primary or common neutral exists, the neutral must be connected to a grounding electrode. Transformer secondary neutral bushing and frames of equipment operating at under 750 volts must be bonded together and connected to a common neutral and to a common grounding electrode.

3.1.7.5 Protective Molding

Protect grounding conductors which are run on surface of wood poles by PVC molding extending from ground line throughout communication and transformer spaces.

3.1.8 CONDUCTOR INSTALLATION

3.1.8.1 Line Conductors

[Unless otherwise indicated, install conductors in compliance with IEEE C2 Grade B requirements and in accordance with revised manufacturer's approved tables of sags and tensions.]Handle conductors with care necessary to prevent nicking, kinking, gouging, abrasions, sharp bends, cuts, flattening, or otherwise deforming or weakening conductor or any damage to insulation or impairing its conductivity. Remove damaged sections of conductor and splice conductor. Conductors must be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor must not be less than the applicable NEMA specification recommendation. Conductors must not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors must be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension must be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

3.1.8.2 Connectors and Splices

Conductor splices, as installed, must exceed ultimate rated strength of conductor and must be of type recommended by conductor manufacturer. No splice must be permitted within 10 feet of a support. Connectors and splices must be mechanically and electrically secure under tension and must be of the nonbolted compression type. The tensile strength of any splice must be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors must be noncorrosive and must not adversely affect conductors. Aluminum-composition conductors must be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools must be of types recommended by the connector manufacturer. Primary line apparatus taps must be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors must be of the solderless pressure type. Noninsulated connectors must be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum must be installed above the copper.

3.1.8.3 Conductor-To-Insulator Attachments

Conductors must be attached to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes must be as specified in TABLE I.

TABLE I - TIE-WIRE REQUIREMENTS

CONDUCTOR Copper (AWG)	TIE WIRE Soft-Drawn Copper (AWG)
6	8

TABLE I - TIE-WIRE REQUIREMENTS	
4 and 2	6
1 through 3/0	4
4/0 and larger	2
AAC, AAAC, or ACSR (AWG	AAAC OR AAC (AWG)
Any size	6 or 4

3.1.8.4 Armor Rods

Provide armor rods for AAC, AAAC, and ACSR conductors. Armor rods must be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods must be in accordance with the manufacturer's recommendations. For span lengths of less than 200 feet, flat aluminum armor rods may be used. Flat armor rods, not less than 0.03 by 0.25 inch must be used on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods must be not less than 0.05 by 0.30 inches. For span lengths of 200 feet or more, preformed round armor rods must be used.

3.1.8.5 Ties

Provide ties on pin insulators tight against conductor and insulator and ends turned down flat against conductor so that no wire ends project.

3.1.8.6 Low-Voltage Insulated Cables

Support low-voltage cables on clevis fittings using spool insulators. Provide dead-end clevis fittings and suspensions insulators where required for adequate strength. Dead-end construction must provide a strength exceeding the rated breaking strength of the neutral messenger. Provide clevis attachments with not less than 5/8 inch through-bolts. Secondary racks may be used when installed on wood poles and where the span length does not exceed 200 feet. Secondary racks must be two-, three-, or four-wire, complete with spool insulators. Racks must meet strength and deflection requirements for heavy-duty steel racks, and must be rounded and smooth to avoid damage to conductor insulation. Each insulator must be held in place with a 5/8 inch button-head bolt equipped with a nonferrous cotter pin, or equivalent, at the bottom. Attach racks for dead-ending four No. 4/0 AWG or four larger conductors to poles with three 5/8 inch through-bolts. Attach other secondary racks to poles with at least two 5/8 inch through-bolts. Minimum vertical spacing between conductors must not be less than 8 inches.

3.1.8.7 Reinstalling Conductors

Existing conductors to be reinstalled or resagged must be strung to "final" sag table values indicated for the particular conductor type and size involved.

3.1.8.8 New Conductor Installation

String new conductors to "initial" sag table values [indicated] [recommended by the manufacturer] for conductor type and size of conductor and ruling span indicated.

3.1.8.9 Fittings

Dead end fittings[, clamp or compression type,] must conform to written recommendations of conductor manufacturer and must develop full ultimate strength of conductor.

3.1.8.10 Aluminum Connections

Make aluminum connections to copper or other material using only splices, connectors, lugs, or fittings designed for that specific purpose. Keep a copy of manufacturer's instructions for applying these fittings at job site for use of the inspector.

[3.1.9 Pole Mounted Metering Equipment

3.1.9.1 Primary Meters

Install primary metering transformers [as indicated] [according to manufacturer's drawings]. Make connections to metering circuits within each transformer conduit connection box.

3.1.9.2 Installing Meter System

Metering enclosure must house kWh meter [and meter test block]. Secure the enclosure to pole at a height of 6 feet above grade to center of the enclosure. Ground enclosure.

a. Connect meter as indicated.

[b. Connect meter test block between meter and metering transformers to isolate meter for removal, test or adjustment.

] c. Indicate phase sequence and color code of potential and current leads. Mark wires which are connected to transformer terminals identified with polarity marks (dots) by a colored plastic tape around the wire at each end.

d. No splices are permissible in metering circuits. Train wire at sides and bottom of enclosure back board and secured by plastic wraps.

]3.1.10 Pole Top Switch Installation

Install pole top switch strictly according to manufacturer's installation drawings and information.

3.1.10.1 Operating Handle

Locate approximately 5 feet above ground on field side of pole.

[3.1.11 Recloser

Install recloser(s) strictly in accordance with manufacturer's instructions.

][3.1.12 Sectionalizer

Install sectionalizer(s) strictly in accordance with manufacturer's

instructions.

]3.1.13 Risers

[Secure galvanized steel conduits on poles by two hole galvanized steel pipe straps spaced as indicated and within 3 feet of any outlet or termination. Ground metallic conduits.][Secure PVC riser shields on poles as indicated.]

3.2 TRANSFORMER INSTALLATION

Transformers must be carefully installed so as not to scratch finishes or damage bushings. Transformers must be installed in accordance with the manufacturer's instructions. After installation, surfaces must be inspected and scratches must be touched up with a finish provided by the transformer manufacturer for this purpose.

[3.3 CROSSARM MOUNTING

Bolt crossarms to poles with 5/8 inch through-bolts with square washers at each end. Extend bolts not less than 1/8 inch nor more than 2 inches beyond nuts. On single crossarm construction, install the bolt head on the crossarm side of the pole. [Fiberglass][Metal][Wood] crossarm braces must be provided on crossarms. Flat braces may be provided for 8 foot crossarms and must be 1/4 by 1-1/4 inches, not less than 28 inches in length. Bolt flat braces to arms with 3/8 inch carriage bolts with round or square washers between boltheads and crossarms, and secured to poles with 1/2 by 4 inch lag screws after crossarms are leveled and aligned. Angle braces are required for 10 foot crossarms and must be 60 inch span by 18 inch drop formed in one piece from 1-1/2 by 1-1/2 by 3/16 inch angle. Bolt angle braces to crossarms with 1/2 inch bolts with round or square washers between boltheads and crossarms, and secured to poles with 5/8 inch through-bolts. Double crossarms must be securely held in position by means of 5/8 inch double-arming bolts. Each double-arming bolt shall be equipped with four nuts and four square washers.

3.3.1 Line Arms and Buck Arms

Set line arms and buck arms at right angles to lines for straight runs and for angles 45 degrees and greater; and line arms must bisect angles of turns of less than 45 degrees. Use dead-end assemblies for turns where shown. Install buck arms , as shown on the pole plate(s), at corners and junction poles. Provide double crossarms at ends of joint use or conflict sections, at dead-ends, and at angles and corners to provide adequate vertical and longitudinal strength. Provide double crossarms at each line-crossing structure and where lines not attached to the same pole cross each other.

3.3.2 Equipment Arms

Set equipment arms parallel or at right angles to lines as required to provide climbing space. Locate equipment arms below line construction to provide necessary wire and equipment clearances.

]3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting must be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.5 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.6 FIELD QUALITY CONTROL

3.6.1 General

[Perform field testing in the presence of the Contracting Officer.]The Contractor must notify the Contracting Officer [_____] days prior to conducting tests. The Contractor must furnish materials, labor, and equipment necessary to conduct field tests. The Contractor must perform tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor must maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

3.6.2 Safety

The Contractor must provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor must replace any devices or equipment which are damaged due to improper test procedures or handling.

3.6.3 Medium-Voltage Preassembled Cable Test

After installation, prior to connection to an existing system, and before the operating test, the medium-voltage preassembled cable system must be given a high potential test. Apply direct-current voltage on each phase conductor of the system by connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, the cables must be isolated by opening applicable protective devices and disconnecting equipment. The method, voltage, length of time, and other characteristics of the test for initial installation must be in accordance with NEMA WC 74/ICEA S-93-639 for the particular type of cable installed, and must not exceed the recommendations of IEEE 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor must make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.6.4 Sag and Tension Test

The Contracting Officer must be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

3.6.5 Low-Voltage Cable Test

For underground secondary or service laterals from overhead lines, the low-voltage cable, complete with splices, must be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage must be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations of conductors in the same trench, duct, or cable, with other conductors in the same trench, duct, or conduit. The minimum value of insulation must be:

R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

Repair each cable failing this test or replace. The repaired cable must then be retested until failures have been eliminated.

3.6.6 Pre-Energization Services

Perform the following services on the equipment listed below. Perform these services subsequent to testing but prior to the initial energization. Inspect the equipment to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Inspect terminations of conductors at major equipment to ensure the adequacy of connections. Inspect bare and insulated conductors between such terminations to detect possible damage during installation. If factory tests were not performed on completed assemblies, perform tests after the installation of completed assemblies. Inspect components for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated must be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested must be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services must be provided, but are not limited to, are the following:

Capacitors.

Switches.

3.6.7 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.6.7.1 Overhead-Type Distribution Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.

(4) Perform specific inspections and mechanical tests as recommended by manufacturer.

(5) Verify correct equipment grounding.

b. Electrical tests

[(1) Insure that the series-multiple voltage-changing switch is in the correct position. Transformers are normally shipped in the series position.

] (2) Perform insulation-resistance tests.

(3) Perform continuity test.

(4) Set tap changer to provide a secondary voltage of [120/240] [120/208] [_____].

3.6.7.2 Pole Top Interrupter Switch

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify appropriate equipment grounding.

(4) Perform mechanical operator tests in accordance with manufacturer's instructions.

(5) Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform dc over-potential tests.

(3) Perform contact-resistance tests across each switch blade.

[3.6.7.3 Reclosers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect alignment and grounding.

(4) Perform mechanical operation and contact alignment tests on both the recloser and its operating mechanism in accordance with manufacturer's instructions.

(5) Verify tightness of accessible bolted electrical connections.

(6) Inspect for correct insulating liquid level.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform a contact resistance test

(3) Sample insulating liquid. Test sample for:

(a) Dielectric breakdown voltage

(b) Color

(c) Visual condition

(4) Test protective functions.

[(5) Perform vacuum bottle integrity test (overpotential) across each vacuum bottle with the recloser in the open position in strict accordance with manufacturer's instructions.

] (6) Perform overpotential tests.

(7) Determine time delay for each programmed reclosing interval.

(8) Verify lockout for unsuccessful reclosing.

(9) Determine reset time.

(10) Verify instantaneous overcurrent lockout.

][3.6.7.4 Sectionalizers

a. Visual and Mechanical inspection

(1) Compare equipment nameplate data with approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect alignment and grounding.

(4) Perform mechanical operation and contact alignment tests on both the sectionalizer and its operating mechanism in accordance with manufacturer's instructions.

(5) Verify tightness of accessible bolted electrical connections.

(6) Inspect for correct insulating liquid level.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform a contact resistance test.

(3) Sample insulating liquid. Test sample for:

(a) Dielectric breakdown voltage

(b) Color

(c) Visual condition

(4) Perform overpotential tests.

(5) Test sectionalizer counting function.

(6) Test sectionalizer lockout function.

(7) Test for reset timing on trip actuator.

][3.6.7.5 Potential Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Verify correct connection.

(3) Verify that adequate clearances exist between primary and secondary circuit wiring.

(4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(5) Verify that all required grounding and shorting connections provide good contact.

(6) Verify correct fuse sizes.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform turns-ratio tests.

][3.6.7.6 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(5) Verify that all required grounding and shorting connections

provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

][3.6.7.7 Metering

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Verify accuracy of meters at 25 percent, 50 percent, 75 percent, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

]3.6.7.8 Grounding System

a. Visual and mechanical inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions

at the time the measurements were made.

3.6.8 Devices Subject to Manual Operation

Each device subject to manual operation must be operated at least three times, demonstrating satisfactory operation each time.

3.6.9 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor must show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function.

-- End of Section --

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SECTION 33 71 01.00 40

OVERHEAD TRANSMISSION AND DISTRIBUTION

11/14, CHG 1: 02/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS ANSI O5.1	(2017) Wood Poles -- Specifications & Dimensions

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering
ANSI C135.14	(1979) Staples with Rolled or Slash Points for Overhead Line Construction

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA A3	(2015) Standard Method for Determining Penetration of Preservatives and Fire Retardants
AWPA C1	(2003) All Timber Products - Preservative Treatment by Pressure Processes
AWPA C4	(2003) Poles - Preservative Treatment by Pressure Processes
AWPA C25	(2003) Sawn Crossarms - Preservative Treatment by Pressure Processes
AWPA T1	(2022) Use Category System: Processing and Treatment Standard

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A475	(2022) Standard Specification for Metallic-Coated Steel Wire Strand
ASTM A575	(2020) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM A576	(2017) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B2	(2013) Standard Specification for Medium-Hard-Drawn Copper Wire
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B230/B230M	(2007; R 2021) Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes
ASTM B231/B231M	(2016; R 2021) Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors
ASTM B232/B232M	(2017) Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)
ASTM B398/B398M	(2015; R 2021) Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes
ASTM B399/B399M	(2004; R 2021) Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors
ASTM D92	(2012a) Standard Test Method for Flash and

	Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D117	(2018) Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Liquids
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1625	(1971; R 2000) Standard Specifications for Chromated Copper Arsenate
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 18	(2012) Standard for Shunt Power Capacitors
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.32	(2002) High-Voltage Switches, Bus Supports, and Accessories - Schedules of Preferred Ratings, Construction Guidelines and Specifications
IEEE C37.41	(2016; Corr 2017) Design Tests for High-Voltage (>1000 V) Fuses and Accessories
IEEE C37.42	(2016) Specifications for High-Voltage (> 1000 V) Fuses and Accessories
IEEE C37.63	(2013) Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC

	Systems
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.20	(2017) Overhead-Type Distribution Transformers, 500 KVA and Smaller: High Voltage, 34 500 Volts and Below; Low Voltage, 7970/13,800 Y V and Below
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.15	(2018) Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE C135.1	(1999) Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction
IEEE C135.2	(1999) Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for Overhead Line Construction
IEEE C135.22	(1988) Standard for Zinc-Coated Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 62271-111	(2019) High Voltage Switchgear And Controlgear - Part 111: Automatic Circuit Reclosers for Alternating Current Systems up to and including 38 kV

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7	(2014) Requirements for Watthour Meter Sockets
ANSI C29.2	(2020) American National Standard for Insulators - Wet-Process Porcelain and Toughened Glass - Distribution Suspension Type
ANSI C29.3	(1986; R 2012) American National Standard for Wet Process Porcelain Insulators - Spool Type
ANSI C29.4	(1989; R 2012) Standard for Wet-Process Porcelain Insulators - Strain Type
ANSI C29.5	(1984; R 2002) Wet-Process Porcelain Insulators (Low and Medium Voltage Pin Type)
ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA C135.4	(1987) Zinc-Coated Ferrous Eyebolts and Nuts for Overhead Line Construction
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA WC 70	(2021) Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard
NEMA/ANSI C29.7	(1996; 2002) American National Standard for Wet Process Porcelain Insulators - High-Voltage Line Post Type

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 202-1	(2004) List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers
RUS Bull 345-67	(1998) REA Specification for Filled Telephone Cables, PE-39
RUS Bull 1728H-701	(1993) Wood Crossarms (Solid and Laminated), Transmission Timbers and Pole Keys

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-90/027F	(1993) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms
EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.3 ADMINISTRATIVE REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section with additions and modifications specified herein.

1.3.1 Pre-Installation Meetings

Within [30] [_____] calendar days after [date of award] [date of receipt by him of notice of award], submit for the approval of the Contracting Officer [six (6)] [_____] copies of specified drawings of all equipment to be furnished under this contract, together with weights and overall dimensions. Submit the following data and drawings:

a. Connection Diagrams

b. Fabrication Drawings

c. Installation Drawings

Submit certification from the manufacturer indicating conformance with the specified poles and transformer losses:

a. Concrete Poles

b. Steel Poles

c. Wood Poles

d. Wood Crossarms

e. Transformer Losses

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

[[Code [CIEE] [_____], NAVFAC [Atlantic] [_____] will review and approve transformer submittals.] As an exception to this paragraph, transformers manufactured by ABB in Athens, GA; by Cooper Power Systems in Lumberton, MS; by ERMCO in Dyersburg, TN; or by Howard Industries in Laurel, MS need not meet the submittal requirements of this contract. Instead, submit the following:

a. Provide certification, from the manufacturer, that the technical requirements of this specification are met.

b. Manufacturer is to conduct routine and other tests (paragraph ROUTINE AND OTHER TESTS, which [will] be witnessed by the Government paragraph TESTS, INSPECTIONS, AND VERIFICATIONS). Provide certified copies of the tests.

c. Provide field test reports (paragraph FIELD QUALITY CONTROL).]

SD-02 Shop Drawings

Connection Diagrams; G[, [____]]

Fabrication Drawings; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Conductors; G[, [____]]

Insulators; G[, [____]]

Concrete Poles; G[, [____]]

Steel Poles; G[, [____]]

Wood Poles; G[, [____]]

Nameplates; G[, [____]]

Pole Top Switch; G[, [____]]

Recloser; G[, [____]]

Sectionalizer; G[, [____]]

Cutouts; G[, [____]]

Transformer; G[, [____]]

Metering Equipment; G[, [____]]

Meters; G[, [____]]

Surge Arresters; G[, [____]]

Guy Strand; G[, [____]]

Anchors; G[, [____]]

SD-05 Design Data

Concrete Pole Design; G[, [____]]

Steel Pole Design; G[, [____]]

Power-Installed Screw Foundations[; G[, [____]]]

SD-06 Test Reports

Wood Crossarm Inspection Report; G[, [____]]

Field Test Plan; G[, [____]]

Field Quality Control; G[, [____]]

Ground Resistance Test Reports; G[, [____]]

SD-07 Certificates

[Wood Crossarms; G[, [____]]

] Transformer Losses; G[, [____]]

SD-09 Manufacturer's Field Reports

Routine and Other Tests; G[, [____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals, Data Package 5; G[, [____]]

SD-11 Closeout Submittals

Transformer Test Schedule; G[, [____]]

1.5 MAINTENANCE MATERIAL SUBMITTALS

1.5.1 Additions to Operations and Maintenance Data

In addition to requirements of Data Package 5, include the following in the operation and maintenance manuals provided:

a. Assembly and installation drawings

b. Prices for spare parts and supply list

c. Date of purchase

1.6 QUALITY CONTROL

1.6.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 and IEEE C2 unless more stringent requirements are specified or indicated.

1.6.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Provide a product that has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, provide items that are products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.2.1 Alternative Qualifications

Products having less than a 2-year field service record are acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.2.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.

1.6.3 Ground Resistance Test Reports

Submit the measured ground resistance of grounding system. When testing grounding electrodes and grounding systems, identify each grounding electrode and each grounding system for testing. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

1.6.4 Wood Crossarm Inspection Report

Furnish an inspection report from an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with applicable AWPA and RUS standards. The RUS approved Quality Mark "WQC" on each crossarm is acceptable, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

1.6.4.1 Field Test Plan

Provide a proposed field test plan [20] [30] [_____] days prior to testing the installed system. Do not perform field test until the test plan is approved. Provide a test plan that consists of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

1.7 DELIVERY, STORAGE, AND HANDLING

Visually inspect devices and equipment when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Replace damaged items. Store oil filled transformers and switches in accordance with the manufacturer's requirements. For wood poles held in storage more than 2 weeks, store in accordance with ATIS ANSI O5.1. Handle wood poles in accordance with ATIS ANSI O5.1, except do not use pointed tools capable of producing indentations more than an inch in depth. Nails and holes are not permitted in top of poles. Handle and store metal poles in accordance with the manufacturer's instructions.

1.8 WARRANTY

Support the equipment items by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Consider materials specified herein or shown on contract drawings which are identical to materials listed in RUS 202-1 as conforming to requirements. Provide equipment and component items, not hot-dip galvanized or porcelain enamel finished, with corrosion-resistant finishes which withstand [120] [480] hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16 inch from the test mark. Provide the described test mark and test evaluation in accordance with ASTM D1654 with a rating of not less than 7 in accordance with TABLE 1, (Procedure A). Coat cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel with a zinc rich paint conforming to the manufacturer's standard.

2.1.1 Design Requirements

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Provide a product that has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, provide items that are products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

2.2 EQUIPMENT

2.2.1 Hardware

Provide hot-dip galvanized hardware in accordance with ASTM A153/A153M and ASTM A123/A123M.

[Provide zinc-coated hardware that complies with IEEE C135.1, IEEE C135.2, NEMA C135.4, ANSI C135.14 IEEE C135.22. Provide steel hardware that complies with ASTM A575 and ASTM A576. Provide pole-line hardware that is hot-dip galvanized [steel.] [steel, except use anchor rods of the copper-molten welded-to-steel type with nonferrous corrosion-resistant fittings]. ++Install washers under boltheads and nuts on wood surfaces and elsewhere as required. Provide washers used on through-bolts and double-arming bolts that are approximately 2-1/4 inches square and 3/16-inch thick. Make the diameter of holes in washers the correct standard size for the bolt on which a washer is used. Provide washers for use under heads of carriage-bolts, of the proper size to fit over square shanks of bolts. Use eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises wherever required to support and to protect poles, brackets, crossarms, guy wires, and insulators.]

2.2.1.1 Pins

Provide pins that are zinc-coated forged steel with lead-thread height to suit the insulator to be installed, but not less than 4-1/2-inches high by 5/8-inch diameter. Provide shoulder that is not less than 2-inch diameter and that is designed to distribute the load uniformly to the crossarm. Provide shank that is not less than 5/8-inch diameter by 5-3/4-inch length, equipped with a 2-inch square washer, nut, and locknut, and that projects not less than 1/8-inch nor more than 2-inches beyond the locknut. Use broad-based corner pins of drop-forged welded steel or malleable iron for turning small angles, as indicated.

2.2.1.2 Hot-Line Clamps

Make connections to overhead primary conductors with hot-line clamps of the screw type with concealed threads. Fill thread chamber with corrosion-resistant compound. Provide hot-line clamp tap conductor of bare soft-drawn seven-strand No. 4 copper, except that for the hot-line clamp tap conductor for lateral lines No. 2 and larger, provide bare soft-drawn copper of the same size and stranding as the lateral line.

Provide stirrups for hot-line clamp connections that are 4 by 4 inches, and are constructed of bare hard-drawn copper the same size as the tap line but not less than No. 4.

2.2.1.3 Secondary Racks

Provide secondary racks that are the 2-, 3-, or 4-wire type as required and are furnished complete with spool insulators.

Provide racks that meet industry requirements for the strength and deflection of heavy-duty steel racks and that are either galvanized steel or aluminum alloy.

Provide top of insulator points that are rounded and smooth. Hold insulators in place with a 5/8-inch buttonhead bolt equipped with a nonferrous cotter pin, or equivalent, at the bottom.

2.2.2 Guy Strand

[ASTM A475, [high-strength] [extra high-strength], Class A or B, galvanized strand steel cable][Class 30 [high-strength][extra high-strength] copper-clad steel]. Provide guy strand that is [_____]-inch in diameter with a minimum breaking strength of [_____] pounds. Provide guy terminations designed for use with the particular strand and developing at least the ultimate breaking strength of the strand.

2.2.3 Round Guy Markers

Vinyl or PVC material, [white] [yellow] colored, 8-feet long and shatter resistant at sub-zero temperatures.

2.2.3.1 Guy Attachment

Thimble eye guy attachment.

2.2.4 Anchors and Anchor Rods

Provide anchors that present holding area indicated on drawings as a minimum. Provide anchor rods that are triple thimble-eye, [3/4] [one]-inch diameter by 8-feet long. Provide anchors and anchor rods that are hot dip galvanized.

2.2.4.1 Screw Anchors

Screw type [swamp] anchors having a manufacturer's rating [of not less than [_____] pounds in loose to medium sand/clay soil, Class 6] [at least equal to rating indicated] and extra heavy pipe rods conforming to ASTM A53/A53M, Schedule 80, and couplings conforming to ASME B16.11, [fitting Class 6000.]

2.2.4.2 Plate Anchors

Minimum area of [_____] square inches and rated by manufacturer for [_____] pounds or more in soils classified as medium dense coarse sand and sandy gravels; firm to stiff clays and silts.

2.2.4.3 Rock Anchors

Rock anchors having a manufacturer's rating of [23,000][36,000] pounds.

2.2.5 Grounding and Bonding

2.2.5.1 Driven Ground Rods

Provide [copper-clad steel ground rods conforming to UL 467][zinc-coated steel ground rods conforming to IEEE C135.30][solid stainless steel ground rods] not less than 3/4-inch in diameter by 10-feet in length. Sectional type rods are acceptable for rods 20-feet or longer.

2.2.5.2 Grounding Conductors

ASTM B8. Provide soft drawn copper wire ground conductors a minimum No. 4 AWG. Provide PVC ground wire protectors.

2.2.5.3 Grounding Connections

UL 467. Exothermic weld or compression connector.

2.2.6 Conduit Risers and Conductors

Provide PVC riser shield containing a PVC back plate and PVC extension shield or a rigid galvanized steel conduit, as indicated, and conforming to UL 6. Provide conductors and terminations as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

[2.2.7 Group-Operated Load Interrupter Switches

2.2.7.1 Manually Operated Type (Switch Handle Operated)

Provide manually operated (switch handle operated) load interrupter switches that comply with IEEE C37.32 and are of the outdoor, manually-operated, three-pole, single-throw type with either tilting or rotating insulators. Provide switches that are equipped with interrupters capable of interrupting currents equal to the switch's continuous current rating. Provide preassembled switches for the indicated configuration and mounting. Provide high-pressure, limited-area type moving contacts, designed to ensure continuous surface contact. Provide fused or non-fused switches as indicated. Provide switches complete with necessary operating mechanisms, handles, and other items required for manual operation from the ground. Locate switch operating handles approximately 42-inches above final grade. Provide insulation of switch operating mechanisms that includes both insulated interphase rod sections and insulated vertical shafts. Provide each handle with a padlock arranged to lock the switch in both the open and the closed position.

[2.2.7.2 Remotely Operated Type (Stored-Energy Actuator)

Provide remotely-operated, [air-insulated] [SF6 insulated] load interrupter switches that are rated in accordance with and comply with the requirements of IEEE C37.32 and are of the outdoor, three-pole, [pole-mounted] [crossarm-mounted] type. Provide interrupter devices that are [air-insulated] [SF6-insulated, puffer-type] switches capable of interrupting currents equal to the switch continuous current ratings indicated. Provide switches that utilize an electric motor-charged, stored-energy (spring-driven) operator to simultaneously trip all phases. Provide a switch-control unit [for push-button operation from the ground] [for push-button operation from the ground and remote switch actuation via telemetry]. Provide a switch-control unit that is pad-lockable, tamper-resistant, in a NEMA ICS 6, Type [3R] [4] [4X] [4X-SS] enclosure, which is connected to the switch actuator by a shielded control cable. Provide control power for closing and tripping by a battery mounted in the control unit enclosure. Provide the switch control unit with a separate 120 volt ac circuit for the battery powered. Power for charging the operator mechanism is 120 volt ac or battery powered. If operator mechanism charging power is from a battery, provide capacity for a minimum of [_____] [four] sequential opening and closing operation without battery charging. Configure the switch control unit for supervisory, control, and data acquisition (SCADA) function, including local and remote operation. Provide voltage and current sensors, one set for each phase, for monitoring of both normal and fault conditions. Provide switches with visual indication of open switch contact for clearance and isolation purposes. Provide switch mechanisms with provisions for grounding of nonenergized metal parts. Provide the switch control unit with switch operations.

]][2.2.8 Recloser

IEC 62271-111. [Provide recloser controller that is [electronically] [hydraulically] operated and utilizes an [oil] [vacuum] operating medium.]

][2.2.9 Sectionalizer

IEEE C37.63.

][2.2.10 Metering Equipment

Provide pole mounted metering equipment that includes current transformers, potential transformers, watthour meter, [meter test switch block,] metering enclosure, wire, conduit and fittings.

2.2.10.1 Potential Transformers

Provide potential transformers that are rated for outdoor service fitted for crossarm mounting and secondary connection box for conduit connection. Provide [2.4] [4.16] [7.2] [12.0] [12.47] [_____] kV to 120 volts ac, 60 Hz voltage rating. Provide transformers that conform to the requirements of IEEE C57.13 BIL [45] [60] [75] [95] kV and accuracy Class 0.3 (min.) of [75 VA] [burden Y].

2.2.10.2 Current Transformers

Provide current transformers that are rated for outdoor service with crossarm mounting and secondary connection box for conduit connection. Provide [2.4] [4.16] [7.2] [12.47] [12.0] [_____] kV voltage rating. Provide [_____] to 5 amperes current rating. Provide transformers that conform to requirements of IEEE C57.13, BIL [45] [60] [75] [95] kV and accuracy Class 0.3 at [B2.0] [50 VA].

2.2.10.3 Watthour Meter

Provide meter with provisions for future pulse initiation.

a. Meters: NEMA/ANSI C12.10 and ANSI C12.1; when providing meter with electronic time-of-use register.

    (1) Form: [5A] [5S] [6A] [6S].

(2) Element: [2] [2 1/2] [3].

(3) Voltage: 120 volts.

(4) Current: 2 1/2 amperes.

(5) Frequency: 60 hertz.

(6) Kilowatt hour register: 5 dial or 5 digit type.

b. Demand register:

(1) Solid state type.

(2) Meter reading multiplier:

(a) Indicate multiplier on the meter face.

(b) Provide multiplier in even hundreds.

(3) Program demand interval length: for [15] [30] [60] minutes with rolling demand up to six subintervals per interval.

c. Mounting:

(1) Provide a meter with [matching socket per ANSI C12.7 with [manual] [automatic] current short-circulating device.] ["A" base type mounting].

[2.2.10.4 Meter Test Block

Provide meter test block with [T] [10] pole group of open knife type switches designed for the isolation of metering devices at meter location by opening each circuit individually. Provide current switches that short circuit current supply before opening meter circuit. Provide black switch handles of potential switches. Provide red switch handles of current switches.

]2.2.10.5 Metering Enclosure

Provide metering enclosure of galvanized steel, weatherproof construction with pole mounting bracket, and 3/4-inch exterior plywood, full size backboard and hinged door arranged for padlocking in closed position. Provide adequate internal space to house equipment and wiring but not smaller than 20 by 30 by 11-inches deep. Paint metal manufacturer's standard finish.

]2.2.11 Capacitors

Provide capacitor equipment that complies with IEEE 18 and that is of the three-phase, grounded-wye, outdoor type rated for continuous operation and automatically switched. Provide equipment suitable for mounting on a single pole. Do not use polychlorinated biphenyl and tetrachloroethylene (perchloroethylene) as the dielectric. Provide equipment that is rated for the system voltage. Provide the indicated kvars that are automatically switched by [single-step] [time switch] [voltage] [current] [kilovar] [control] [multiple-step] [voltage] [kilovar] [control providing the indicated number of steps and switching the indicated kvar]. Provide necessary transformers for sensing circuit variations and for low-voltage control. Provide oil-immersed switches for automatic switching of capacitors, electrically separate from ungrounded capacitor enclosures and metal frames. Provide installations that include one primary fuse cutout and one surge arrester for each ungrounded phase conductor. Provide fuse link ratings in accordance with the manufacturer's recommendations. Provide capacitor equipment, except for low-voltage control and primary fuse cutouts, that is subassembled and coordinated by one manufacturer. Ship units, including metal pole-mounting supports and hardware, in complete sections ready for connection at the site. Provide low-voltage equipment that is socket or cabinet type, mounted on the pole approximately 4-feet above grade. Connect with the necessary wiring in conduit to capacitor equipment, provided with secondary arrester protection against switching surges when recommended by the manufacturer.

2.2.12 Voltage Regulator

Provide voltage regulators that comply with IEEE C57.15 and are of the outdoor, self-cooled, 55/65 degrees C temperature rise, single-phase type. Provide windings and the load-tap-changing mechanism that are mineral-oil-immersed. When operating under load, provide a regulator with plus and minus 10 percent automatic voltage regulation in approximately 5/8 percent steps, with 16 steps above and 16 steps below rated voltage. Provide automatic control equipment with Class 1 accuracy. Provide bypass surge arresters suitable for [a grounded] [an ungrounded] system and for the associated regulator voltage. [Provide [station] [intermediate] class surge arresters that are mounted next to each incoming line bushing on a regulator tank-mounted bracket and connected to a surge arrester ground pad-mounted on the regulator tank].

2.2.12.1 Ratings

Provide the following ratings at 60 Hz:

Maximum voltage..[_____]

Basic Insulation Level (BIL)..............................[_____]

Current...[_____]

2.2.12.2 Bypass and Isolation Switches

Provide switches of the outdoor, stickhook-operated, single-pole, single-throw, vertical-break type suitable for the indicated mounting. Provide switches of a type designed to provide bypass of a single-phase regulator circuit by an integral sequence which always occurs when each switch is opened or closed. Provide opening sequences that initially bypass the single-phase regulator circuit, then open the input and output circuits, and finally interrupt the exciting current. Make opening any single-phase regulator circuit not possible until after the bypass circuit is closed. Provide ratings at 60 Hz in accordance with IEEE C37.41 and as follows:

Maximum voltage..[_____]

Nominal voltage class....................................[_____]

BIL..[_____]

Momentary asymmetrical current in the closed position.....[_____]

Momentary asymmetrical current in the bypass position.....[_____]

Continuous and interrupting current.......................[_____]

2.2.12.3 Miscellaneous

Provide standard accessories and components in accordance with IEEE C57.15. Provide single-phase units with additional components and accessories required by IEEE C57.15 for three-phase units.

2.3 COMPONENTS

2.3.1 Poles

Provide poles of lengths and [classes] [strengths] indicated.

2.3.1.1 Wood Poles

Wood poles machine trimmed by turning, [Douglas Fir] [Lodgepole Pine] [Western Larch] [Southern Yellow Pine] [_____] conforming to ATIS ANSI O5.1 and RUS Bull 345-67. Gain, bore and roof poles before treatment. If additional gains are required subsequent to treatment, provide metal gain plates. Pressure treat poles with [pentachlorophenol,] [ammoniacal copper arsenate (ACA),] [chromated copper arsenate (CCA)], except do not treat Douglas Fir and Western Larch poles with CCA in accordance with AWPA C1 and AWPA C4 as referenced in RUS Bull 345-67. Ensure the quality of each pole with "WQC" (wood quality control) brand on each piece, or by an approved inspection agency report.

a. Preservative

For preservative used for humid, harsh environment, provide Chromated Copper Arsenate type (A)(B)(C) conforming to AWPA T1 and ASTM D1625.

Treat wood poles with waterborne preservatives conforming to AWPA T1.

b. Preservative Application

Apply preservative treatment using a pressure process conforming to and AWPA T1 for Southern Pine. Determine penetration of preservatives as specified in AWPA A3 and obtain complete sapwood penetration.

Before treatment, roof, gain and bore poles that are to be given a full-length preservative treatment. Plug unused holes in poles with treated wood-dowel pins. Treat field-cut gains or field-bored holes in poles with an approved preservative compound.

c. Storage

For poles stored for any reason more than 2 weeks, stack them on pressure treated or decay-resistant skids of such dimensions and so arranged as to support the poles without producing noticeable distortion. Stack poles in a manner that permits free circulation of air; with the bottom poles of the stacks at least 1-foot above ground level or any vegetation growing thereon. No decayed or decaying wood is permitted to remain underneath stored poles.

d. Handling

Do not drag treated poles along the ground. Do not use pole tongs, cant hooks, and other pointed tools capable of producing indentations more than 1 inch in depth, in handling the poles. Do not apply tools to the groundline section of any pole. Groundline section is that portion between 1 foot above and 2 feet below the ground line.

2.3.2 Steel Poles

Provide a steel pole design for withstanding the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors, that are hot-dip galvanized in accordance with ASTM A123/A123M and that are not painted. Provide poles that have tapered tubular members, either round in cross-section or polygonal, and that comply with strength calculations performed by a registered professional engineer. Submit calculations in accordance with the design data portion of paragraph SUBMITTALS. Provide certification, from the manufacturer, that the technical requirements of this specification are met. Provide one piece pole shafts. Provide welded construction poles with no bolts, rivets, or other means of fastening except as specifically approved. Provide pole markings that are approximately 3 to 4 feet above grade and that include manufacturer, year of manufacture, top and bottom diameters, length, and a loading tree. Provide attachment requirements as indicated, including grounding provisions. Climbing facilities are not required. Provide bases of the anchor-bolt-mounted type.

2.3.3 Concrete Poles

Provide a concrete pole design for withstanding the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors. Provide reinforced or prestressed, either cast or spun poles. Provide spun poles that are manufactured by a centrifugal spinning process with concrete pumped into a polished round tapered metal mold. Provide concrete for spun poles that has a compressive strength of at least 5000 psi at 28 days; steel wire that has an ultimate tensile strength of at least 120,000 psi; and reinforcing bars that have an ultimate tensile strength of at least 40,000 psi. After the high speed spinning action is completed, cure a spun pole by a suitable wet steam process. Provide spun poles that have a water absorption of not greater than three percent to eliminate cracking and to prevent erosion. Provide concrete poles that have hollow shafts. Provide poles that have a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water and frost. Do not install poles for at least 15 days after manufacture. Provide fittings and brackets that conform to the concrete pole design. Provide poles that conform to strength calculations performed by a registered professional engineer and submit in accordance with design data portion of paragraph SUBMITTALS. Provide certification, from the manufacturer, that the technical requirements of this specification are met.

2.3.4 Crossarms and Brackets

2.3.4.1 Wood Crossarms

Conform to RUS Bull 1728H-701. Pressure treat crossarms with pentachlorophenol, chromated copper arsenate (CCA), or ammoniacal copper arsenate (ACA). Provide treatment that conforms to AWPA C25. Provide solid wood, distribution type crossarms, with a 1/4-inch 45 degree chamfer on all top edges. Provide cross-sectional area minimum dimensions of 4-1/4 inches in height by 3-1/4 inches in depth in accordance with IEEE C2 for Grade B construction. Provide crossarms that are 8-feet in length, except use 10-foot crossarms for crossarm-mounted banked single-phase transformers or elsewhere as indicated. Provide crossarms that are machined, chamfered, trimmed, and bored for stud and bolt holes before pressure treatment. Provide factory drilling for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Provide required climbing space and wire clearances by drilling. Provide crossarms that are straight and free of twists to within 1/10-inch per foot of length. Provide bend or twist that is in one direction only.

2.3.4.2 Crossarm Braces

Provide [flat steel] [or] [steel angle] as indicated. Provide braces with [38-inch span for 8-foot crossarms] [and] [60-inch span for 10-foot crossarms].

2.3.4.3 Armless Construction

Provide pole mounting brackets for line-post or pin insulators and eye bolts for suspension insulators as shown. Attach brackets to poles with a minimum of two bolts. Provide brackets either integrally as part of an insulator or attached to an insulator with a suitable stud. Provide bracket mounting surface suitable for the shape of the pole. Provide brackets for wood poles that have wood gripping members. Provide horizontal offset brackets that have a 5-degree uplift angle. Provide pole top brackets that conform to IEEE C135.22, except for modifications necessary to provide support for a line-post insulator. Provide brackets that have a strength exceeding that of the required insulator strength, but in no case less than a 2800 pound cantilever strength.

2.3.5 Insulators

Provide wet-process porcelain insulators which are radio interference free.

[a. Line post type insulators: NEMA/ANSI C29.7, Class [_____].

][b. Suspension insulators: ANSI C29.2 [4/52-4 for 34.5 kV on NAVSTA NORVA], Quantity per Phase, [_____], Class [_____].

][c. Spool insulators: ANSI C29.3, Class [_____].

][d. Guy strain insulators: ANSI C29.4, Class [_____], [except provide fiberglass type when used with underground terminal or when other interference problems exist].

][e. Pin insulators: ANSI C29.5, Class [_____].

]2.3.6 Neutral-Supported Secondary and Service Drop Cables

Provide [Service] [Secondary] cables of [aluminum] [copper], [triplex] [quadruplex] with cross-linked polyethylene insulation on the phase conductors. Provide bare [ACSR] [aluminum alloy] [hard drawn copper] that is the same size as the phase conductors unless otherwise indicated. Provide cables that conform to [NEMA WC 70][and][ANSI/NEMA WC 71/ICEA S-96-659] for cross-linked polyethylene insulation.

2.3.7 Surge Arresters

IEEE C62.11, metal oxide, polymeric-housed, surge arresters arranged for [crossarm] [equipment] mounting. Provide [3] [6] [9] [10] [12] [15] [27] [30] [36] kV RMS voltage rating. Provide [Distribution] [Intermediate] [Station] class arresters.

2.3.8 Fused Cutouts

[Open] [Enclosed] type fused cutouts rated [100] [200] amperes and [_____] amperes symmetrical interrupting current at [[7.8] [15] kV ungrounded] [8.3/15 kV gnd Y] [15/26 kV gnd Y] [27/34.5 kV gnd Y], conforming to IEEE C37.42. Type [K] [T] fuses conforming to IEEE C37.42 with ampere ratings [as indicated] [equal to 150 percent of the transformer full load rating]. Open link type fuse cutouts are not acceptable. [Provide heavy duty open drop-out type, rated 15 kV, 200 Amp, 7,100 Amp I.C. (Sym.).]

2.3.9 Transformer (Overhead-Type Distribution)

a. IEEE C57.12.20.

b. Single phase, self-cooled, 65 degrees C. continuous temperature rise, two winding, 60 Hertz.

c. Insulating liquid:

[Mineral oil: ASTM D3487, Type II, tested in accordance with ASTM D117. Provide identification of transformer as "non-PCB" and "Type II mineral oil" on the nameplate.

][Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D877. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid on the nameplate.

Provide fluid that is a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable fluids. Provide fluid that meets the following fluid properties:

(1) Pour point: ASTM D97, less than -15 degrees C

(2) Aquatic biodegradation: EPA 712-C-98-075, 100 percent.

(3) Trout toxicity: OECD Test 203, zero mortality of EPA 600/4-90/027F, pass.

] d. Ratings:

(1) kVA: [_____].

(2) BIL: [95] [75] [60] kV.

(3) Primary voltage: [_____] kV.

(4) Secondary voltage: [_____] volts.

(5) Minimum Tested Impedance at 85 degrees C: [____] percent.

[e. Single-phase connections:

(1) Connect primary: [Phase-to-phase] [Phase-to-ground].

(2) Provide transformer with [_____] high voltage bushing(s).

][f. Three-phase connections:

(1) Connect primary: [Grounded wye] [Ungrounded wye] [Delta].

(2) Connect secondary: [Grounded wye] [Delta], for [_____] volt, three phase, [_____] wire service.

(3) Provide transformer with [_____] high voltage bushings.

] g. Taps:

(1) Provide four 2 1/2 percent full capacity taps, two above and two below rated primary voltage. Provide tap changer that has an external handle.

[h. Externally operated Series-Multiple Voltage-Changing Switch.

] i. Corrosion Protection:

(1) [Provide transformer tanks and covers that are corrosion resistant and are fabricated of stainless steel conforming to ASTM A167, Type 304 or 304L.] Provide paint coating system that complies with IEEE C57.12.28 regardless of tank and cover material. Provide light gray, ANSI color No. 70 finish coat.

j. Show transformer kVA capacity using 2-1/2-inch Arabic numerals placed near the low-voltage bushings.

2.3.9.1 Specified Transformer Losses

Provide no-load losses (NLL) in watts at 20 degrees C, and load losses (LL) in watts at 85 degrees C, as follows:

NAME	KVA	"NLL"	"LL"
[T1]	[_____]	[_____]	[_____]
[T2]	[_____]	[_____]	[_____]

Use the values for the specified losses for comparison with the losses determined during the routine tests. If the routine test values exceed the specified values by more than the tolerances allowed by Table 19 in IEEE C57.12.00, the transformer is unacceptable.

2.3.10 Nameplates

2.3.10.1 Manufacturer's Nameplate

Provide each item of equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable. Provide equipment containing liquid-dielectrics with the type of dielectric on the nameplate.

2.3.10.2 Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Identify the function and, when applicable, the position with each nameplate inscription. Provide melamine plastic, 0.125-inch thick nameplates, white with [black] [_____] center core. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 by 2.5-inches. Minimum size of lettering is 0.25 inch high normal block style.

2.4 MATERIALS

2.4.1 Overhead Conductors, Connectors and Splices

Provide bare [copper] [aluminum (AAC)] [aluminum alloy (AAAC)] [aluminum conductor steel reinforced (ACSR)] Conductors of sizes and types indicated. [Where aluminum conductors are connected to dissimilar metal, use fittings conforming to UL 486A-486B.]

2.4.1.1 Solid Copper

ASTM B1, ASTM B2, and ASTM B3, hard-drawn, medium-hard-drawn, and soft-drawn, respectively. ASTM B8, stranded.

2.4.1.2 Aluminum (AAC)

ASTM B230/B230M and ASTM B231/B231M.

2.4.1.3 Aluminum Alloy (AAAC)

ASTM B398/B398M or ASTM B399/B399M.

2.4.1.4 Aluminum Conductor Steel Reinforced (ACSR)

ASTM B232/B232M, aluminum.

2.4.1.5 Connectors and Splices

Provide connectors and splices of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. Provide aluminum-composition, aluminum-composition to copper, and copper-to-copper that complies with UL 486A-486B.

2.4.2 Electrical Tapes

Provide UL listed tapes for electrical insulation and other purposes in wire and cable splices. Provide terminations, repairs and miscellaneous purposes, electrical tapes that comply with UL 510.

2.4.3 Caulking Compound

Provide compound for sealing of conduit risers that is of a puttylike consistency workable with hands at temperatures as low as 35 degrees F, that does not slump at a temperature of 300 degrees F, and that does not harden materially when exposed to air. Provide compound that readily caulks or adheres to clean surfaces of the materials with which it is designed to be used. Provide compound that has no injurious effects upon the workmen or upon the materials.

2.5 TESTS, INSPECTIONS, AND VERIFICATIONS

2.5.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

(1) Provide a manufacturer that has a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) Provide an accuracy that is directly traceable to the National Institute of Standards and Technology.

(3) Provide instrument calibration frequency schedule that does not exceed 12 months for both test floor instruments and leased specialty equipment.

(4) Provide visible dated calibration labels on all test equipment.

(5) Provide calibrating standard of higher accuracy than that of the instrument tested.

(6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Routine and Other Tests

IEEE C57.12.00 and IEEE C57.12.90. Perform routine and other tests by the manufacturer on [each of] the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Provide required tests as follows:

a. Polarity

b. Ratio

c. No-load losses (NLL) and excitation current

d. Load losses (LL) and impedance voltage

e. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

f. Leak

PART 3 EXECUTION

3.1 INSTALLATION

Provide overhead pole line installation conforming to requirements of [_____] [IEEE C2] [CALPUC G.O. 95] for Grade [B] [C] construction of overhead lines in [light] [medium] [heavy] loading districts and NFPA 70 for overhead services. Provide material required to make connections into existing system and perform excavating, backfilling, and other incidental labor. Consider street, alleys, roads and drives "public." Provide pole configuration as indicated.

3.1.1 Overhead Service

Terminate overhead service conductors into buildings at service entrance fittings or weatherhead outside building. Installation and connection of service entrance equipment to overhead service conductor is included in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide nearby support bracket for overhead wires that is not less than [______] feet above finished grade at building. Provide drip loops that are formed on conductors at entrances to buildings, cabinets, or conduits.

3.1.2 Tree Trimming

Where lines pass through trees, trim trees at least[15 feet][______] clear on both sides horizontally and below for medium-voltage lines, and[5-feet][______] clear on both sides horizontally and below for other lines. Do not allow a branch to overhang horizontal clearances. Where trees are indicated to be removed to provide a clear right-of-way, clearing is specified in Section 31 11 00 CLEARING AND GRUBBING.

3.1.3 Wood Pole Installation

Provide pole holes at least as large at the top as at the bottom and large enough to provide 4-inch clearance between the pole and side of the hole. [Provide a 6-inch band of soil around and down to the base of the pole treated with 2 to 3 gallons of a one percent dursban TC termiticide solution.]

3.1.3.1 Setting Depth of Pole

Provide pole setting depths as follows:

Length of Pole feet	Setting in Soil (feet)	Setting in Solid Rock (feet)
20	5.0	3.0

Length of Pole feet	Setting in Soil (feet)	Setting in Solid Rock (feet)
25	5.5	3.5
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.5	5.0
60	8.0	5.0
65	8.5	5.5
70	9.0	5.5
75	9.5	6.0
80	10.0	6.0
85	10.5	6.5
90	11.0	6.5
95	11.5	7.0
100	12.5	7.5

3.1.3.2 Setting in Soil, Sand, and Gravel

"Setting in Soil" depths, as specified in paragraph SETTING DEPTH OF POLE, apply where the following occurs:

a. Where pole holes are in soil, sand, or gravel or any combination of these;

b. Where soil layer over solid rock is more than 2-feet deep;

c. Where hole in solid rock is not substantially vertical; or

d. Where diameter of hole at surface of rock exceeds twice the diameter of pole at same level. [At corners, dead ends and other points of extra strain, set poles that are 40 feet or more long 6 inches deeper.]

3.1.3.3 Setting in Solid Rock

"Setting in Solid Rock," as specified in paragraph SETTING DEPTH OF POLE applies where poles are to be set in solid rock and where hole is substantially vertical, approximately uniform in diameter and large enough to permit use of tamping bars the full depth of hole.

3.1.3.4 Setting with Soil Over Solid Rock

Where a layer of soil 2-feet or less in depth over solid rock exists, make depth of hole the depth of soil in addition to depth specified under "Setting in Solid Rock" in paragraph SETTING DEPTH OF POLE provided, however, that such depth does not exceed depth specified under "Setting in Soil."

3.1.3.5 Setting on Sloping Ground

On sloping ground, always measure hole depth from low side of hole.

3.1.3.6 Backfill

Thoroughly tamp pole backfill for full depth of the hole and mound excess fill around the pole.

3.1.3.7 Setting Poles

Set poles so that alternate crossarm gains face in opposite directions, except at terminals and dead ends where gains of last two poles are on side facing terminal or dead end. On unusually long spans, set poles so that crossarm comes on side of pole away from long span. Where pole top pins are used, place on opposite side of pole from gain, with flat side against pole.

3.1.3.8 Alignment of Poles

Set poles in alignment and plumb except at corners, terminals, angles, junctions, or other points of strain, set and rake them against the strain. Set not less than 2 inches for each 10 feet of pole length above grade, nor more than 4 inches for each 10 feet of pole length after conductors are installed at required tension. When average ground run is level, vary consecutive poles by not more than 5 feet in height. When ground is uneven, keep poles differing in length to a minimum by locating poles to avoid the highest and lowest ground points. If it becomes necessary to shorten a pole, saw a piece off the top. Dig holes large enough to permit the proper use of tampers to full depth of hole.

3.1.3.9 Pole Caps

Provide plastic pole caps with 1/4-inch sealing rings and four nailing tabs. Fill sealing area with either a bituminous, elastigum roof cement or an acceptable preservative paste to level of sealing ring to eliminate possibility of condensation. Place on pole top and nail each tab down with a 1-1/4-inch nail.

3.1.3.10 Marking

Mark each pole in accordance with the requirements of ATIS ANSI O5.1. Locate marking on the face of the pole approximately 10-feet from the butt on the pole. Mark on the face of the pole at other locations standard with the pole manufacturer, where approved by the Contracting Officer.

Number poles as indicated. Number poles not having numbers indicated as directed by the Contracting Officer. Provide pole numbers that c onsist of aluminum numerals and characters not less than 2-1/2-inches high fastened to the pole with aluminum nails. Locate numerals to provide maximum visibility from the road or patrol route.

3.1.4 Steel and Concrete Pole Setting

Mount poles on cast-in-place or power-installed screw foundations. [Embed concrete poles in accordance with the details shown.] Provide conduit elbows for cable entrances into pole interiors.

3.1.4.1 Cast-In-Place Foundations

Provide concrete foundations, sized as indicated, with anchor bolts accurately set in foundations using templates supplied by the pole manufacturer. Concrete work and grouting is specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. After the concrete has cured, set pole anchor bases on foundations and level by shimming between anchor bases and foundations or by setting anchor bases on leveling nuts and grouting. Set poles plumb. Provide the manufacturer's standard anchor bolts, and not less than necessary to meet the pole wind loading specified herein and other design requirements.

3.1.4.2 Power-Installed Screw Foundations

Use power-installed screw foundations if they have the required strength, mounting-bolt, and top plate dimensions. Provide at least 1/4 inch thick structural steel screw foundations conforming to ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M. Mark conduit slots in screw foundation shafts and top plates to indicate orientation. Design calculations indicating adequate strength require approval before installation of screw foundation is permitted. Submit calculations in accordance with the design data portion of paragraph SUBMITTALS.

3.1.5 Anchors and Guys

Place anchors in line with strain. Provide indicated length of the guy lead (distance from base of pole to the top of the anchor rod).

3.1.5.1 Setting Anchors

Set anchors in place with anchor rod aligned with, and pointing directly at, guy attachment on the pole with the anchor rod projecting 6 to 9 inches out of ground to prevent burial of rod eye.

3.1.5.2 Backfilling Near [Plate] Anchors

[Backfill plate, expanding, concrete, or cone type anchors with tightly tamped coarse rock 2 feet immediately above anchor and then with tightly tamped earth filling remainder of hole.

][Backfill plate anchors with tightly tamped earth for full depth of hole.

]3.1.5.3 Screw Anchors

Install screw anchors by torquing with boring machine.

3.1.5.4 Swamp Anchors

Install swamp anchors by torquing with boring machine or wrenches, adding sections of pipe as required until anchor helix is fully engaged in firm soil.

3.1.5.5 Rock Anchors

Install rock anchors minimum depth 12-inches in solid rock.

3.1.5.6 Guy Installation

Install guys where indicated, with loads and strengths as indicated, and wherever conductor tensions are not balanced, such as at angles, corners and dead-ends. Where a single guy does not provide the required strength, provide two or more guys. Where guys are wrapped around poles, provide at least two guy hooks. Provide pole shims where guy tension exceeds 6000 pounds. Provide guy clamps 6-inches in length with three 5/8-inch bolts, or offset-type guy clamps, or approved guy grips at each guy terminal. Securely clamp plastic guy marker to the guy or anchor at the bottom and top of marker. Complete anchor and guy installation, dead end to dead end, and tighten guy before wire stringing and sagging is begun on that line section.[Provide strain insulators at a point on guy strand 8-feet minimum from the ground and 6-feet minimum from the surface of pole.][Effectively ground and bond guys to the system neutral.]

3.1.6 Hardware

Install hardware with washer against wood and with nuts and lock nuts applied wrench tight. Provide locknuts on threaded hardware connections. Provide M-F style locknuts and not palnut style.

3.1.7 Grounding

Unless otherwise indicated, install grounding that conforms to IEEE C2 and NFPA 70. [Provide pole grounding electrodes with a resistance to ground not exceeding 25 ohms. When work in addition to that indicated or specified is directed in order to obtain specified ground resistance, apply provisions of the contract covering changes.]

3.1.7.1 Grounding Electrode Installation

Install grounding electrodes as follows:

a. Driven rod electrodes - Unless otherwise indicated, locate ground rods approximately 3-feet out from base of the pole and drive into the earth until the tops of the rods are approximately 1-foot below finished grade. Evenly space multiple rods at least 10-feet apart and connect together 2-feet below grade with a minimum No. 6 bare copper conductor.

b. Plate electrodes - Install plate electrodes in accordance with the manufacturer's instructions and IEEE C2 and NFPA 70.

[c. Ground resistance - Provide a [driven ground rod][plate electrode] with a maximum resistance that does not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes [interconnected with grounding conductors][as indicated], to achieve the specified ground resistance. The additional electrodes are [up to three, [8] [10] feet rods spaced a minimum of 10 feet apart][a single extension-type rod, [5/8] [3/4] inch diameter, up to 30 feet long, [driven perpendicular to grade] [coupled and driven with the first rod]]. In high ground resistance, use of UL listed chemically charged ground rods is allowed. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

]3.1.7.2 Grounding Electrode Conductors

[On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Bond neutrals, surge arresters, and equipment grounding conductors to this conductor. For single-grounded or ungrounded systems, provide a grounding electrode conductor for the surge arrester and equipment grounding conductors and a separate grounding electrode conductor for the secondary neutrals. Staple grounding electrode conductors to wood poles at intervals not exceeding 2-feet. On metal poles, use a preformed galvanized steel strap, 5/8-inch wide by 22 gauge minimum by length, secured by a preformed locking method standard with the manufacturer, to support a grounding electrode conductor installation on the pole and space at intervals not exceeding 5-feet with one band not more than 3-inches from each end of the vertical grounding electrode conductor.]Size grounding electrode conductors as indicated. Connect secondary system neutral conductors directly to the transformer neutral bushings, then connect with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor as indicated. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

3.1.7.3 Grounding Electrode Connections

Make above grade grounding connections on pole lines by exothermic weld or by using a compression connector. Make below grade grounding connections by exothermic weld. Make exothermic welds strictly in accordance with manufacturer's written recommendations. Welds which have puffed up or which show convex surfaces indicating improper cleaning, are not acceptable. No mechanical connectors are required at exothermic weldments. Provide compression connectors that are the type that uses a hydraulic compression tool to provide correct pressure. Provide tools and dies recommended by compression connector manufacturer. Provide an embossing die code or similar method as visible indication that a connector has been fully compressed on ground wire.

3.1.7.4 Grounding and Grounded Connections

a. Where no primary or common neutral exists, bond together surge arresters and frames of equipment operating at over 750 volts and connect to a dedicated primary grounding electrode.

b. Where no primary or common neutral exists, transformer secondary neutral bushing, secondary neutral conductor, and bond together frames of equipment operating at under 750 volts and connect to a dedicated secondary grounding electrode.

c. When a primary or common neutral exists, connect all grounding and grounded conductors to a common grounding electrode.

3.1.7.5 Protective Molding

Protect grounding conductors which are run on surface of wood poles by PVC molding extending from ground line throughout communication and transformer spaces.

3.1.8 Conductor Installation

3.1.8.1 Line Conductors

[Unless otherwise indicated, install conductors in accordance with manufacturer's approved tables of sags and tensions.]Handle conductors with care necessary to prevent nicking, kinking, gouging, abrasions, sharp bends, cuts, flattening, or otherwise deforming or weakening conductor or any damage to insulation or impairing its conductivity. Remove damaged sections of conductor and splice conductor. Provide conductors that are paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Make the bend radius for any insulated conductor not less than the applicable NEMA specification recommendation. Do not draw conductors over rough or rocky ground, nor around sharp bends. When installed by machine power, provide conductors that are drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Check the initial sag and tension, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

3.1.8.2 Connectors and Splices

Provide conductor splices, as installed, that exceed ultimate rated strength of conductor and are of the type recommended by conductor manufacturer. No splices are permitted within 10-feet of a support. Provide connectors and splices that are mechanically and electrically secure under tension and are of the nonbolted compression type. Make splices have a tensile strength of not less than the rated breaking strength of the conductor. Provide splice materials, sleeves, fittings, and connectors that are noncorrosive and that do not adversely affect conductors. Wire brush and apply an oxide inhibitor to aluminum-composition conductors before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Provide types of inhibitors and compression tools recommended by the connector manufacturer. Provide primary line apparatus taps by means of hot line clamps attached to compression type bail clamps (stirrups). Provide solderless pressure type low-voltage connectors for copper conductors. Smoothly tape noninsulated connectors to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, install the aluminum above the copper.

3.1.8.3 Conductor-To-Insulator Attachments

Attach conductors to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, provide tie-wire sizes as specified in TABLE I.

TABLE I	
TIE-WIRE REQUIREMENTS	
CONDUCTOR	TIE WIRE
Copper (AWG)	Soft-Drawn Copper (AWG)
6	8

TABLE I	
4 and 2	6
1 through 3/0	4
4/0 and larger	2
AAC, AAAC, or ACSR (AWG)	AAAC OR AAC (AWG)
Any size	6 or 4

3.1.8.4 Armor Rods

Provide armor rods for AAC, AAAC, and ACSR conductors. Install armor rods at supports, except armor rods are not required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Provide lengths and methods of fastening armor rods in accordance with the manufacturer's recommendations. For span lengths of less than 200-feet, use of flat aluminum armor rods is allowed. Use flat armor rods, not less than 0.03 by 0.25 inch on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, provide flat armor rods that are not less than 0.05 by 0.30 inches. For span lengths of 200-feet or more, use preformed round armor rods.

3.1.8.5 Ties

Provide ties on pin insulators tight against conductor and insulator and ends turned down flat against conductor so that no wire ends project.

3.1.8.6 Low-Voltage Insulated Cables

Support low-voltage cables on clevis fittings using spool insulators. Provide dead-end clevis fittings and suspensions insulators where required for adequate strength. Provide dead-end construction that has a strength exceeding the rated breaking strength of the neutral messenger. Provide clevis attachments with not less than 5/8-inch through-bolts. Use secondary racks when installed on wood poles and where the span length does not exceed 200-feet. Provide two-, three-, or four-wire secondary racks, complete with spool insulators. Provide racks that meet strength and deflection requirements for heavy-duty steel racks, and are rounded and smooth to avoid damage to conductor insulation. Hold each insulator in place with a 5/8-inch button-head bolt equipped with a nonferrous cotter pin, or equivalent, at the bottom. Provide racks for dead-ending four No. 4/0 AWG or four larger conductors that are attached to poles with three 5/8-inch through-bolts. Attach other secondary racks to poles with at least two 5/8-inch through-bolts. Provide minimum vertical spacing between conductors of not less than 8-inches.

3.1.8.7 Reinstalling Conductors

String existing conductors to be reinstalled or resagged to "final" sag table values indicated for the particular conductor type and size involved.

3.1.8.8 New Conductor Installation

String new conductors to "initial" sag table values [indicated] [recommended by the manufacturer] for conductor type and size of conductor and ruling span indicated.

3.1.8.9 Fittings

Provide dead end fittings[, clamp or compression type,] that conform to written recommendations of conductor manufacturer and that develop full ultimate strength of conductor.

3.1.8.10 Aluminum Connections

Make aluminum connections to copper or other material using only splices, connectors, lugs, or fittings designed for that specific purpose. Keep a copy of manufacturer's instructions for applying these fittings at job site for use of the inspector.

[3.1.9 Pole Mounted Metering Equipment

3.1.9.1 Primary Meters

Install primary metering transformers [as indicated] [according to manufacturer's drawings]. Make connections to metering circuits within each transformer conduit connection box.

3.1.9.2 Installing Meter System

Provide metering enclosure that houses kWh meter [and meter test block]. Secure the enclosure to pole at a height of 6-feet above grade to center of the enclosure. Ground enclosure.

a. Connect meter as indicated.

[b. Connect meter test block between meter and metering transformers to isolate meter for removal, test or adjustment.

] c. Provide identical phase sequence and color code of potential and current leads. Mark wires which are connected to transformer terminals identified with polarity marks (dots) by a colored plastic tape around the wire at each end.

d. No splices are permissible in metering circuits. Provide wire that is trained at sides and bottom of enclosure back board and secured by plastic wraps.

]3.1.10 Pole Top Switch Installation

Install pole top switch strictly according to manufacturer's installation drawings and information.

3.1.10.1 Operating Handle

Locate approximately 5 feet above ground on field side of pole.

[3.1.11 Recloser

Install recloser(s) strictly in accordance with manufacturer's instructions.

][3.1.12 Sectionalizer

Install sectionalizer(s) strictly in accordance with manufacturer's

instructions.

]3.1.13 Risers

[Secure galvanized steel conduits on poles by two hole galvanized steel pipe straps spaced as indicated and within 3-feet of any outlet or termination. Ground metallic conduits.] [Secure PVC riser shields on poles as indicated.]

3.1.14 Transformer Installation

Carefully install transformers so as not to scratch finishes or damage bushings. Install transformers in accordance with the manufacturer's instructions. After installation, inspect surfaces and touch up scratches with a finish provided by the transformer manufacturer for this purpose.

[3.1.15 Crossarm Mounting

Bolt crossarms to poles with 5/8-inchthrough-bolts with square washers at each end. Extend bolts not less than 1/8-inch nor more than 2-inches beyond nuts. On single crossarm construction, install the bolt head on the crossarm side of the pole. Provide [fiberglass] [metal] [wood] crossarm braces on crossarms. Provide flat braces for 8-foot crossarms 1/4 by 1-1/4-inches, not less than 28-inches in length. Bolt flat braces to arms with 3/8-inch carriage bolts with round or square washers between boltheads and crossarms, and secure to poles with 1/2 by 4-inch lag screws after crossarms are leveled and aligned. Angle braces are required for 10-foot crossarms. Provide angle braces that are 60-inch span by 18-inch drop formed in one piece from 1-1/2 by 1-1/2 by 3/16-inch angle. Bolt angle braces to crossarms with 1/2-inch bolts with round or square washers between boltheads and crossarms, and secure to poles with 5/8-inch through-bolts. Securely hold double crossarms in position by means of 5/8-inch double-arming bolts. Equip each double-arming bolt with four nuts and four square washers.

3.1.15.1 Line Arms and Buck Arms

Provide line arms and buck arms that are set at right angles to lines for straight runs and for angles 45 degrees and greater; and line arms that bisect angles of turns of less than 45 degrees. Use dead-end assemblies for turns where shown. Install buck arms, as shown, at corners and junction poles. Provide double crossarms at ends of joint use or conflict sections, at dead-ends, and at angles and corners to provide adequate vertical and longitudinal strength. Provide double crossarms at each line-crossing structure and where lines not attached to the same pole cross each other.

3.1.15.2 Equipment Arms

Set equipment arms parallel or at right angles to lines as required to provide climbing space. Locate equipment arms below line construction to provide necessary wire and equipment clearances.

]3.1.16 Field Applied Painting

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Provide painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.17 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.2 FIELD QUALITY CONTROL

3.2.1 General

[Perform field testing in the presence of the Contracting Officer.]Notify the Contracting Officer [_____] days prior to conducting tests. Furnish materials, labor, and equipment necessary to conduct field tests. Perform tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Sign and date field reports.

3.2.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.2.3 Medium-Voltage Preassembled Cable Test

After installation, prior to connection to an existing system, and before the operating test, give the medium-voltage preassembled cable system a high potential test. Apply direct-current voltage on each phase conductor of the system by connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, isolate the cables by opening applicable protective devices and disconnecting equipment. Provide the method, voltage, length of time, and other characteristics of the test for initial installation in accordance with NEMA WC 74/ICEA S-93-639 for the particular type of cable installed, and do not exceed the recommendations of IEEE 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. For any cable that fails due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, make necessary repairs or replace cables as directed. Retest repaired or replaced cables.

3.2.4 Sag and Tension Test

Give the Contracting Officer prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits. The Contracting Officer reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

3.2.5 Low-Voltage Cable Test

For underground secondary or service laterals from overhead lines, provide the low-voltage cable, complete with splices, that is tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The 500 volts dc test voltage, applied for one minute between each conductor and ground and between all possible combinations of conductors in the same trench, duct, or cable, with other conductors in the same trench, duct, or conduit. Provide insulation with a minimum value of:

R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

Repair or replace each cable failing this test. Retest the repaired cable then until failures have been eliminated.

3.2.6 Pre-Energization Services

Perform the following services on the equipment listed below. Perform these services subsequent to testing but prior to the initial energization. Inspect the equipment to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Inspect terminations of conductors at major equipment to ensure the adequacy of connections. Inspect bare and insulated conductors between such terminations to detect possible damage during installation. If factory tests were not performed on completed assemblies, perform tests after the installation of completed assemblies. Inspect components for damage caused during installation or shipment and to ensure that packaging materials have been removed. Provide components capable of being both manually and electrically operated that are operated manually prior to the first electrical operation. Provide components capable of being calibrated, adjusted, and tested and calibrate, adjust and test in accordance with the instructions of the equipment manufacturer. Items for which such services are provided, but are not limited to, are the following:

a. Capacitors

b. Switches

3.2.7 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.2.7.1 Overhead-Type Distribution Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.

(4) Perform specific inspections and mechanical tests as recommended by manufacturer.

(5) Verify correct equipment grounding.

b. Electrical tests

[(1) Insure that the series-multiple voltage-changing switch is in the correct position. Transformers are normally shipped in the series position.

] (2) Perform insulation-resistance tests.

(3) Perform continuity test.

(4) Set tap changer to provide a secondary voltage of [120/240] [120/208] [_____].

3.2.7.2 Pole Top Interrupter Switch

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify appropriate equipment grounding.

(4) Perform mechanical operator tests in accordance with manufacturer's instructions.

(5) Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform dc over-potential tests.

(3) Perform contact-resistance tests across each switch blade.

[3.2.7.3 Reclosers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect alignment and grounding.

(4) Perform mechanical operation and contact alignment tests on both the recloser and its operating mechanism in accordance with manufacturer's instructions.

(5) Verify tightness of accessible bolted electrical connections.

(6) Inspect for correct insulating liquid level.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform a contact resistance test.

(3) Sample insulating liquid. Test sample for:

(a) Dielectric breakdown voltage

(b) Color

(c) Visual condition

(4) Test protective functions.

[(5) Perform vacuum bottle integrity test (overpotential) across each vacuum bottle with the recloser in the open position in strict accordance with manufacturer's instructions.

] (6) Perform overpotential tests.

(7) Determine time delay for each programmed reclosing interval.

(8) Verify lockout for unsuccessful reclosing.

(9) Determine reset time.

(10) Verify instantaneous overcurrent lockout.

][3.2.7.4 Sectionalizers

a. Visual and Mechanical inspection

(1) Compare equipment nameplate data with approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect alignment and grounding.

(4) Perform mechanical operation and contact alignment tests on both the sectionalizer and its operating mechanism in accordance with manufacturer's instructions.

(5) Verify tightness of accessible bolted electrical connections.

(6) Inspect for correct insulating liquid level.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform a contact resistance test.

(3) Sample insulating liquid. Test sample for:

(a) Dielectric breakdown voltage

(b) Color

(c) Visual condition

(4) Perform overpotential tests.

(5) Test sectionalizer counting function.

(6) Test sectionalizer lockout function.

(7) Test for reset timing on trip actuator.

][3.2.7.5 Potential Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Verify correct connection.

(3) Verify that adequate clearances exist between primary and secondary circuit wiring.

(4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(5) Verify that all required grounding and shorting connections provide good contact.

(6) Verify correct fuse sizes.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform turns-ratio tests.

][3.2.7.6 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(5) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

][3.2.7.7 Metering

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Verify accuracy of meters at 25 percent, 50 percent, 75 percent, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

]3.2.7.8 Grounding System

a. Visual and mechanical inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. Provide an instrument that is equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.2.8 Devices Subject to Manual Operation

Operate each device subject to manual operation at least three times, demonstrating satisfactory operation each time.

3.2.9 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, give the Contracting Officer 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318M	(2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary
ACI SP-66	(2004) ACI Detailing Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B231/B231M	(2016; R 2021) Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors

ASTM B400/B400M	(2019) Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductors
ASTM B496	(2016; R 2021) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B609/B609M	(2012; R 2021) Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical purposes
ASTM B800	(2005; R 2021) Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers
ASTM B801	(2018) Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation
ASTM C32	(2013; R 2017) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C139	(2017) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C857	(2016) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C990	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM F512	(2019) Standard Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation
ASTM F2160	(2022) Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48	(2020) Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE 400.2	(2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE 495	(2007) Guide for Testing Faulted Circuit Indicators
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-94-649	(2021) Concentric Neutral Cables Rated 5 Through 46 KV

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA C119.4	(2011) Electric Connectors - Connectors

	for Use Between Aluminum-to-Aluminum or Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93 Degrees C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100 Degrees C
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2020) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA TC 7	(2021) Smooth-Wall Coilable and Straight Electrical Polyethylene Conduit
NEMA TC 9	(2020) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 70	(2021) Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

ANSI/SCTE 77	(2013) Specification for Underground Enclosure Integrity

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60005	(Basic; Notice 2) Frames, Covers, Gratings, Steps, Sump And Catch Basin, Manhole

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 94	(2013; Reprint Apr 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 854	(2020) Standard for Service-Entrance Cables
UL 1072	(2006; Reprint Apr 2020) Medium-Voltage Power Cables
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel

[1.2 SYSTEM DESCRIPTION

Items provided under this section must be specifically suitable for the following service conditions. Seismic details must [conform to UFC 3-301-01, "Structural Engineering" and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 26 05 48.00 10 SEISMIC PROTECTION FOR

ELECTRICAL EQUIPMENT] [be as indicated].

a. Fungus Control [_____]

b. Altitude [_____] feet.

c. Ambient Temperature [_____] degrees F.

d. Frequency [_____]

e. Ventilation [_____]

f. Seismic Parameters [_____]

g. Humidity Control [_____]

h. Corrosive Areas [_____]

i. [_____]

]1.3 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.4 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

[d. Underground structures subject to aircraft loading are indicated on the drawings.

]1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

[Aluminum Conductors; G[, [_____]]

][Submit modified drawings and engineering calculations associated with design changes required for use of aluminum conductors.

] Precast Underground Structures; G[, [_____]]

SD-03 Product Data

Medium Voltage Cable; G[, [_____]]

Medium Voltage Cable Joints; G[, [_____]]

Medium Voltage Cable Terminations; G[, [_____]]

[Live End Caps; G[, [_____]]

] Precast Concrete Structures; G[, [_____]]

Sealing Material

Pulling-In Irons

Manhole Frames and Covers; G[, [_____]]

Handhole Frames and Covers; G[, [_____]]

[Frames and Covers for Airfield Facilities; G[, [_____]]

][Ductile Iron Frames and Covers for Airfield Facilities; G[, [_____]]

] Composite/Fiberglass Handholes; G[, [_____]]

Cable Supports (racks, arms and insulators); G[, [_____]]

[Protective Devices and Coordination Study; G[, [_____]]

][Submit the study with protective device equipment submittals. No time extension or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government will not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered or procured prior to approval of the study.

] SD-06 Test Reports

Medium Voltage Cable Qualification and Production Tests; G[, [_____]]

Field Acceptance Checks and Tests; G[, [_____]]

Arc-proofing Test for cable fireproofing tape; G[, [_____]]

[Cable Installation Plan and Procedure; G[, [_____]]

][[Six][_____] copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Separate sections by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

][a. Site layout drawing with cable pulls numerically identified.

][b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

][c. The cable manufacturer and type of cable.

][d. The dates of cable pulls, time of day, and ambient temperature.

][e. The length of cable pull and calculated cable pulling tensions.

][f. The actual cable pulling tensions encountered during pull.

] SD-07 Certificates

Cable splicer/terminator; G[, [_____]]

Cable Installer Qualifications; G[, [_____]]

[Directional Boring Certificate of Conformance; G[, [_____]]

]1.6 QUALITY ASSURANCE

1.6.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings in accordance with ACI SP-66

e. Plans and elevations showing opening and pulling-in iron locations and details

[1.6.2 Certificate of Competency for Cable Splicer/Terminator

[The cable splicer/terminator must have a certification from the National Cable Splicing Certification Board (NCSCB) in the field of splicing and terminating shielded medium voltage (5 kV to 35 kV) power cable using pre-manufactured kits (pre-molded, heat-shrink, cold shrink). Submit "Proof of Certification" for approval, for the individuals that will be performing cable splicer and termination work, 30 days before splices or terminations are to be made.

][Submit certification of the qualification of the cable splicer/terminator for approval, 30 days before splices or terminations are to be made in medium voltage (5 kV to 35 kV) cables. Include the training, and experience of the individual on the specific type and classification of cable to be provided under this contract. Indicate that the individual has had three or more years recent experience splicing and terminating medium voltage cables. List a minimum of three splices/terminations that have been in operation for more than one year. In addition, the individual may be required to perform a dummy or practice splice/termination in the presence of the Contracting Officer, before being approved as a qualified cable splicer. If that additional requirement is imposed, the Contractor must provide short sections of the approved types of cables along with the approved type of splice/termination kit, and detailed manufacturer's instructions for the cable to be spliced. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for certification of an alternate cable splicer.

]]1.6.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

[1.6.4 Directional Boring Certificate of Conformance

Provide certification of compliance with the registered Professional Engineer's design requirements for each directional bore, including: HDPE conduit size and type, bend radius, elevation changes, vertical and horizontal path deviations, conductor size and type and any conductor derating due to depth of conduit. Record location and depth of all directional-bore installed HDPE conduits using Global Positioning System (GPS) recording means with "resource grade" accuracy.

]1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.6.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.6.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.6.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.2.1 Intermediate Metal Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.3 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2,[EPC-40][or][EPC-80][as indicated].

2.1.4 Plastic Duct for Concrete Encasement

Provide[[Type EB-20][Type EB-35] per UL 651, ASTM F512, and NEMA TC 6 & 8][or][Type EPC-40 per UL 651 and NEMA TC 2][, as indicated].

[2.1.5 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring

Smoothwall, approved/listed for directional boring, minimum Schedule 80, ASTM F2160, NEMA TC 7.

]2.1.6 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and capable of adhering to metals, plastics and concrete. Sealant must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function.

2.1.7 Fittings

2.1.7.1 Metal Fittings

UL 514B.

2.1.7.2 PVC Conduit Fittings

[UL 514B, UL 651][NEMA TC 3].

2.1.7.3 PVC Duct Fittings

NEMA TC 9.

[2.1.7.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit must be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and must conform to UL 514A.

]2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements[, or in accordance with NEMA WC 70]. Wires and cables manufactured more than [24][12] months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded.[Conductors No. 6 AWG and smaller must be copper. Conductors No. 4 AWG and larger may be either copper or aluminum, at the Contractor's option. Do not substitute aluminum for copper if the equivalent aluminum conductor size would exceed 500 kcmil. When the Contractor chooses to use aluminum for conductors No. 4 AWG and larger, the Contractor must: increase the conductor size to have the same ampacity as the copper size indicated; increase the conduit and pull box sizes to accommodate the larger size aluminum conductors in accordance with NFPA 70; ensure that the pulling tension rating of the aluminum conductor is sufficient; relocate equipment, modify equipment terminations, resize equipment, and resolve to the satisfaction of the Contracting Officer problems that are direct results of the use of aluminum conductors in lieu of copper.][All conductors must be copper.]

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt,[Type THWN/THHN conforming to UL 83][or][Type[XHHW][or][RHW] conforming to UL 44]. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.[Aluminum conductors must be Type AA-8000 aluminum conductors complying with ASTM B800 and ASTM B801, and must be of an aluminum alloy listed or labeled by UL as "component aluminum-wire stock (conductor material). Type 1350 is not acceptable. Intermixing of copper and aluminum conductors in the same raceway is not permitted.]

[2.2.3 Jackets

Provide multiconductor cables with an overall PVC outer jacket.

][2.2.4 Direct Buried

Provide single-conductor [and multi-conductor]cables identified for direct burial.

]2.2.5 In Duct

Cables must be single-conductor cable.[Cables in factory-installed, coilable-plastic-duct assemblies must conform to NEMA TC 7.]

2.2.6 Cable Marking

Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Identify each cable by means of a fiber, laminated plastic, or non-ferrous metal tags in each manhole, handhole, junction box, and each terminal. Each tag must contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Color code conductors. Provide conductor identification within each enclosure where a tap, splice, or termination is made. Conductor identification must be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Properly identify control circuit terminations. Color must be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals may be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems are as follows:

a. 208/120 volt, three-phase

    (1) Phase A - black

    (2) Phase B - red

    (3) Phase C - blue

b. 480/277 volt, three-phase

    (1) Phase A - brown

    (2) Phase B - orange

    (3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

[d. On three-phase, four-wire delta system, high leg must be orange, as required by NFPA 70.

]2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Provide a uniform compression over the entire conductor contact surface.

Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

[b. For use with aluminum conductors: UL 486A-486B. For connecting aluminum to copper, connectors must be the circumferentially compressed, metallurgically bonded type.

]2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than [24][12] months prior to date of delivery to the site are not acceptable. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide [Type MV cable, conforming to NEMA WC 74/ICEA S-93-639 and UL 1072][concentric neutral underground distribution cable conforming to ICEA S-94-649][metallic armored cables, consisting of three-conductor, multi-conductor cables, with insulation and shielding, as specified, using [a galvanized steel][an aluminum] interlocked tape armor and thermoplastic jacket]. Provide cables manufactured for use in[duct][or][direct burial] applications[as indicated]. Cable must be rated [5 kV][15 kV][25 kV][28 kV][35 kV][as indicated] with [100][133] percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B[compact round] conductors. Provide[aluminum alloy Type AA-8000 aluminum conductors complying with ASTM B800 and ASTM B801][aluminum alloy 1350 cables, 3/4 hard minimum complying with ASTM B609/B609M and ASTM B231/B231M for regular concentric and compressed stranding or ASTM B400/B400M for compacted stranding][soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding].

2.5.3 Insulation

Provide [ethylene-propylene-rubber (EPR) insulation conforming to the requirements of [ANSI/NEMA WC 71/ICEA S-96-659][ANSI/NEMA WC 74/ICEA S-93-639] and [AEIC CS8][ICEA S-94-649]][tree-retardant cross-linked thermosetting polyethylene (XLP) insulation conforming to the requirements of NEMA WC 74/ICEA S-93-639 and [AEIC CS8][ICEA S-94-649]].

2.5.4 Shielding

Cables rated for 2 kV and above must have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper[tape][or][wire] shield for each phase.

2.5.5 Neutrals

[Neutral conductors must be [copper][aluminum], employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.][Concentric neutrals conductors must be copper, having a combined ampacity [equal to][1/3 of] the phase conductor ampacity rating.][For high impedance grounded neutral systems, the neutral conductors from the neutral point of the transformer or generator to the connection point at the impedance must utilize [copper][aluminum] conductors, employing the same insulation level and construction as the phase conductors.]

2.5.6 Jackets

Provide cables with a [PVC][_____] jacket.[Direct buried cables must be rated for direct burial.][Provide type UD cables with an overall jacket.][Provide PVC jackets with a separator that prevents contact with underlying semiconducting insulating shield.]

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Provide terminations, where required, with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Provide terminations in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations must be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator must be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination must not require heat or flame for installation. Termination kit must contain all necessary materials (except for the lugs). Design termination for installation in low or highly contaminated indoor and outdoor locations and must resist ultraviolet rays and oxidative decomposition.

2.6.2 Heat Shrinkable Type

Terminator must consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Design termination for installation in low or highly contaminated indoor or outdoor locations.

[2.6.3 Separable Insulated Connector Type

IEEE 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide connectors of the loadbreak or deadbreak type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points. Do no use separable connectors in manholes/handholes.

[a. 200 Ampere loadbreak connector ratings: Voltage: [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL]. Short time rating: 10,000 rms symmetrical amperes.
]
[b. 600 Ampere deadbreak connector ratings: Voltage: [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL]. Short time rating: 25,000 rms symmetrical amperes.[Connectors must have 200 ampere bushing interface[for surge arresters][as indicated].]
]
[c. Provide[[one][_____] set[s] of three grounding elbows][and][[one][_____] set[s] of three feed-thru inserts]. Deliver [grounding elbows][and][feed-thru inserts] to the Contracting Officer.
]
[d. Install one set of faulted circuit indicators, complying with IEEE 495, on the test points of each set of separable insulated connectors. Indicators must be self powered; with automatic trip with mechanical flag indication upon overcurrent followed by loss of system voltage, and automatic reset upon restoration of system voltage. Indicators must be compact, sealed corrosion resistant construction with provision for hotstick installation and operation.

]]2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints must be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE 404. Connectors for joint must be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.7.1 Heat-Shrinkable Joint

Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding.

Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.7.2 Cold-Shrink Rubber-Type Joint

Joint must be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket must be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice should be packaged three splices per kit, including complete installation instructions.

2.8 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

[2.9 LIVE END CAPS

Provide live end caps using a "kit" including a heat-shrinkable tube and a high dielectric strength, polymeric plug overlapping the conductor. Conform to applicable portions of IEEE 48.

]2.10 TAPE

2.10.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.10.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section [31 23 00.00 20 EXCAVATION AND FILL][31 00 00 EARTHWORK].

2.10.3 Fireproofing Tape

Provide tape composed of a flexible, conformable, unsupported intumescent elastomer. Tape must be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, adhesive-free, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.11 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.12 GROUNDING AND BONDING

2.12.1 Driven Ground Rods

Provide [copper-clad steel ground rods conforming to UL 467][solid copper ground rods conforming to UL 467][solid stainless steel ground rods] not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.12.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.13 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.14 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C857 and ASTM C478. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.14.1 Cast-In-Place Concrete Structures

Concrete must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE.[Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers.][Concrete block must conform to ASTM C139 and Section 04 20 00, MASONRY.][Concrete block is not allowed in areas subject to aircraft loading.]

2.14.2 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures may be provided in lieu of cast-in-place subject to the requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.14.2.1 General

Precast concrete structures must have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures must have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction must be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work must have a 28-day compressive strength of not less than 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.14.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 30 degrees

b. Unit Weight of Soil (Dry) = 110 pcf, (Saturated) = 130 pcf

c. Coefficient of Lateral Earth Pressure (Ka) = 0.33

d. Ground Water Level = 3 feet below ground elevation

e. Vertical design loads must include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads must consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load must be for H20 highway loading per AASHTO HB-17.

f. Horizontal design loads must include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, must be considered, along with a pulling-in iron design load of 6000 pounds.

g. Each structural component must be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.

h. Design must also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.14.2.3 Construction

Provide a uniform thickness for structure top, bottom, and wall not less than 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances are not permitted. Provide quantity, size, and location of duct bank entrance windows as directed, and cast completely open by the precaster. Size of windows must exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows must be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 12 inches in diameter and 4 inches deep for precast structures.

2.14.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to ASTM C990. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.14.3 Manhole Frames and Covers

Provide cast iron frames and covers for manholes conforming to CID A-A-60005. Cast the words "ELECTRIC" or "TELECOMMUNICATIONS" in the top face of power and telecommunications manhole covers, respectively.

2.14.4 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in accordance with standard commercial practice. Provide rolled-steel floor plate covers having an approved antislip surface. Hinges must be of [stainless steel with bronze hinge pin] [wrought steel], 5 by 5 inches by approximately 3/16 inch thick, without screw holes, and must be for full surface application by fillet welding. Hinges must have nonremovable pins and five knuckles. The surfaces of plates under hinges must be true after the removal of raised antislip surface, by grinding or other approved method.

[2.14.5 Frames and Covers for Airfield Facilities

Fabricate frames and covers for airfield use of standard commercial grade steel welded by qualified welders in accordance with AWS D1.1/D1.1M. Provide rolled steel floor plate covers having an approved anti-slip surface. Steel frames and covers must be hot dipped galvanized after fabrication.

][2.14.6 Ductile Iron Frames and Covers for Airfield Facilities

At the Contractor's option, ductile iron covers and frames designed for a minimum proof load of 100,000 pounds may be provided in lieu of the steel frames and covers indicated. Covers must be of the same material as the frames (i.e. ductile iron frame with ductile iron cover, galvanized steel frame with galvanized steel cover). Perform proof loading in accordance with CID A-A-60005 and ASTM A48/A48M. Proof loads must be physically stamped into the cover. Provide the Contracting Officer copies of previous proof load test results performed on the same frames and covers as proposed for this contract. Modify the top of the structure to accept the ductile iron structure in lieu of the steel structure indicated. The finished structure must be level and non-rocking, with the top flush with the surrounding pavement.

]2.14.7 Brick for Manhole Collar

Provide sewer and manhole brick conforming to ASTM C32, Grade MS.

2.14.8 Composite/Fiberglass Handholes and Covers

ANSI/SCTE 77. Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass with a design load (Tier rating) appropriate for or greater than the intended use. All covers are required to have the Tier level rating embossed on the surface which must not exceed the design load of the box.

2.15 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

Zinc coat the metal portion of racks and arms after fabrication.

2.15.1 Cable Rack Stanchions

The wall bracket or stanchion must be 4 inches by approximately 1-1/2 inch by 3/16 inch channel steel, or 4 inches by approximately 1 inch glass-reinforced nylon with recessed bolt mounting holes, 48 inches long (minimum) in manholes. Space slots for mounting cable rack arms at 8 inch intervals.

2.15.2 Rack Arms

Cable rack arms must be steel or malleable iron or glass reinforced nylon and must be of the removable type. Rack arm length must be a minimum of 8 inches and a maximum of 12 inches.

2.15.3 Insulators

Insulators for metal rack arms must be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.16 CABLE TAGS IN MANHOLES

Provide polyethylene tags for each power cable located in manholes. Do not provide handwritten letters. The first position on the power cable tag denotes the voltage. The second through sixth positions on the tag identifies the circuit. The next to last position denotes the phase of the circuit and include the Greek "phi" symbol. The last position denotes the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.16.1 Polyethylene Cable Tags

Provide tags of polyethylene having an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag, having a minimum loop tensile strength of 175 pounds and black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.17 MEDIUM VOLTAGE ABOVE GROUND CABLE TERMINATING CABINETS

Cable terminating cabinets must be hook-stick operable, deadfront construction conforming to the requirements of IEEE C37.20.3, Category A. Provide cabinets with [200 A. loadbreak junctions and elbow-type separable loadbreak connectors, cable parking stands, and grounding lugs][600 A. dead-break junctions and elbow-type separable dead-break connectors, cable parking stands, and grounding lugs]. Provide cable terminating equipment in conformance with IEEE 386.

Ratings at 60 Hz must be:

Nominal voltage (kV)	[_____]
Rated maximum voltage (kV)	[[15][25][35]]
Rated continuous current (A)	[[200][600]]
One-second short-time current-carrying capacity (kA)	[_____]
BIL (kV)	[_____]

2.18 LOW VOLTAGE ABOVE GROUND TERMINATION PEDESTAL

Provide copolymer polypropylene, low voltage above ground termination pedestal manufactured through an injection molding process. Pedestals must resist fertilizers, salt air environments and ultra-violet radiation. Pedestal top must be imprinted with a "WARNING" and "ELECTRIC" identification. Pedestal must contain [three][four] lay-in six port connectors, NEMA C119.4, Class "A", dual rated for aluminum or copper, and capable of terminating conductors ranging from 10 AWG to 500 kcmil. Protect each connector with a clear, hard lexan (plastic) cover. Provide pedestal with rust-free material and stainless steel hardware that is lockable.

2.19 PROTECTIVE DEVICES AND COORDINATION

Provide protective devices and coordination as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.20 SOURCE QUALITY CONTROL

2.20.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer must test one sample assembly consisting of a straight lead tube 12 inches long with a 2 1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing tape per manufacturer's instructions. The arc and fireproofing tape must withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode must be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. Direct the arc toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Test each sample assembly at three unrelated points. Start time for tests must be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time must be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape must indicate that the test has been performed and passed by the manufacturer.

2.20.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70[and IEEE C2][and CALPUC G.O.128] as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.[Treat soil a minimum 12 inches on each side of the installed cable for the entire length in accordance with Section 31 31 16.13 CHEMICAL TERMITE CONTROL.]

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

[3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. [Prepare a checklist of significant requirements][Perform pulling calculations and prepare a pulling plan]and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

[Calculations and pulling plan must include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

]]3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point 5 feet outside the building and projections thereof, except that conductors must be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide [PVC, Type EPC-40][IMC][RGS] conduit from the supply equipment to a point 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

[Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

]3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound must conform to ASTM C309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Manhole locations, as indicated, are approximate. Coordinate exact manhole locations with other utilities and finished grading and paving.

3.5.1 Cast-In-Place Concrete Structures

[Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers.] [Provide concrete block conforming to ASTM C139 and Section 04 20 00 MASONRY.] [Concrete block is not allowed in areas subject to aircraft loading.]

3.5.2 Precast Concrete Construction

Set commercial precast structures on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending 12 inches beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.5.3 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors.

Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor, locate the irons a minimum of 6 inches from the edge of the sump, and in the walls, locate the irons within 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately 4 inches and must be designed to withstand a minimum pulling-in load of 6000 pounds. Hot-dip galvanize irons after fabrication.

3.5.4 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the cables. Space racks in power manholes not more than 3 feet apart, and provide each manhole wall with a minimum of two racks. Space racks in signal manholes not more than 16 1/2 inches apart with the end rack being no further than 12 inches from the adjacent wall. Methods of anchoring cable racks are as follows:

a. Provide a 5/8 inch diameter by 5 inch long anchor bolt with 3 inch foot cast in structure wall with 2 inch protrusion of threaded portion of bolt into structure. Provide 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 800 pounds per foot. Insert channel must be steel of the same length as "vertical rack channel;" and cast flush in structure wall. Provide 5/8 inch steel nuts in channel insert to receive 5/8 inch diameter by 3 inch long steel, square head anchor bolts.

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert must have minimum 800 pound load rating. Provide 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.5 Field Painting

Clean cast-iron frames and covers not buried in concrete or masonry of mortar, rust, grease, dirt and other deleterious materials, and coat with bituminous paint.

[3.6 DIRECT BURIAL CABLE SYSTEM

Direct-bury cables in the earth below the frostline [as indicated][to the requirements of NFPA 70 and IEEE C2, whichever is more stringent].

3.6.1 Trenching

Excavate trenches for direct-burial cables to provide a minimum cable cover of 24 inches below finished grade for power conductors operated at 600 volts or less, and 30 inches below finished grade for over 600 volts in accordance with IEEE C2. When rock is encountered, remove to a depth of at least 3 inches below the cable and fill the space with sand or clean earth free from particles larger than 1/4 inch. Bottoms of trenches must be smooth and free of stones and sharp objects. Where materials in bottoms of trenches are other than sand, a 75 mm 3 inch layer of sand must be laid first and compacted to approximate densities of surrounding firm soil. Trenches must be not less than [6][8] inches wide, and must be in straight lines between cable markers.[Do not use cable plows.] Bends in trenches must have a radius [of not less than 36 inches][consistent with the cable manufacturer's published minimum cable bending radius for the cable installed].

3.6.2 Cable Installation

Unreel cables along the sides of or in trenches and carefully place on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position is not permitted, except as required to pull cables through conduits under paving or railroad tracks.

Where two or more cables are laid parallel in the same trench, space cables laterally at not less than 3 inches apart, except that communication cable must be separated from power cable by a minimum distance of 12 inches.

Where direct-burial cables cross under roads or other paving exceeding5 feet in width, install such cables in[concrete-encased] ducts. Where direct-burial cables cross under railroad tracks, install such cables in [reinforced concrete-encased ducts][ducts installed through rigid galvanized steel sleeves]. Extend ducts at least 5 feet beyond each edge of any paving and at least 5 feet beyond each side of any railroad tracks. Cables may be pulled into duct from a fixed reel where suitable rollers are provided in the trench. Where direct burial cable transitions to duct-enclosed cable, center direct-burial cables in duct entrances, and a waterproof nonhardening mastic compound must be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or railroad tracks may be used in lieu of concrete-encased ducts. Prevent damage to conduit coatings by providing ferrous pipe jackets or by predrilling. Where cuts are made in any paving, restore the paving and subbase to their original condition. Where cable is placed in duct(e.g. under paved areas, roads, or railroads), slope ducts to drain.

3.6.3 Splicing

Provide cables in one piece without splices between connections except where the distance exceeds the lengths in which cables are manufactured.[Where splices are required, provide splices designed and rated for direct burial.][Where splices are required, install splices only in maintenance manholes/handholes or cabinets/pedestals.]

3.6.4 Bends

Bends in cables must have an inner radius not less than those specified in NFPA 70 for the type of cable, or manufacturer's recommendation.

3.6.5 Horizontal Slack

Leave approximately 3 feet of horizontal slack in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought above ground. Where cable is brought above ground, leave additional slack to make necessary connections.[Enclose splices in lead-sheathed or armored cables in split-type cast-iron splice boxes; after completion of the connection, fill with insulating filler compound and tightly clamp the box.]

3.6.6 Identification Slabs[or Markers]

Provide a slab at each change of direction of cable, over the ends of ducts or conduits which are installed under paved areas and roadways[, over the ends of ducts or conduits stubbed out for future use][, and over each splice]. Identification slabs must be concrete, approximately 20 inches square by 6 inches thick, set flat in the ground so that top surface projects not less than 3/4 inch, nor more than 1 1/4 inches above ground. Concrete must have a compressive strength of not less than 3000 psi and have a smooth troweled finish on exposed surface. Inscribe an identifying legend such as "electric cable," "telephone cable," "splice," or other applicable designation on the top surface of the slab before concrete hardens. Inscribe circuit identification symbols on slabs as indicated. Letters or figures must be approximately 2 inches high and grooves must be approximately 1/4 inch in width and depth. Install slabs so that the side nearest the inscription on top includes an arrow indicating the side nearest the cable. Provide color, type and depth of warning tape as specified in Section [31 23 00.00 20 EXCAVATION AND FILL][31 00 00 EARTHWORK].

]3.7 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.7.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Provide a 4/0 AWG bare copper grounding conductor [below][above] medium-voltage distribution duct banks. Bond bare copper grounding conductor to ground rings (loops) in all manholes and to ground rings (loops) at all equipment slabs (pads). Route grounding conductor into manholes with the duct bank (sleeving is not required). Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of [3][4] inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Terminate all PVC conduit end points in utility holes, switching cabinets, transform handholes and buildings with end bells. The bell end of the conduits that enter manholes and handholes must be flush with the wall.

Perform changes in ductbank direction as follows:

a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.

b. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter.

c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections allowed for use in field manufactured longsweep bend: 30 degrees.

3.7.2 Treatment

Keep ducts clean of concrete, dirt, or foreign substances during construction. Make field cuts requiring tapers with proper tools and match factory tapers. Use a coupling recommended by the duct manufacturer whenever an existing duct is connected to a duct of different material or shape. Store ducts to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Thoroughly clean ducts before being laid. Store plastic ducts on a flat surface and protected from the direct rays of the sun.

3.7.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.7.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, must be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, install rigid steel conduit because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks must be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 4 feet on centers.[Hydraulic jet method must not be used.]

[3.7.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

]3.7.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches[, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of [12] inches]. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.7.7 Conduit Plugs and Pull Rope

Provide new conduit indicated as being unused or empty with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.7.8 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 24 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and compacted in 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section [31 23 00.00 20 EXCAVATION AND FILL][31 00 00 EARTHWORK].

3.7.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Extend concrete encasement at least 5 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks. Depths to top of the concrete envelope must be not less than 24 inches below finished grade[, and under railroad tracks not less than 50 inches below the top of the rails].

[3.7.8.2 Directional Boring

HDPE conduits must be installed below the frostline and as specified herein.

[For distribution voltages greater than 1000 volts and less than 34,500 volts, depths to the top of the conduit must not be less than 48 inches in pavement-covered areas and not less than 120 inches in non-pavement-covered areas.][For distribution voltages less than 1000 volts, depths to the top of the conduit must not be less than 48 inches in pavement- or non-pavement-covered areas.][For branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 24 inches in pavement- or non-pavement-covered areas.]

]3.7.9 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Depths to top of the concrete envelope must be not less than 18 inches below finished grade[, except under roads and pavement, concrete envelope must be not less than 24 inches below finished grade][, and under railroad tracks not less than 50 inches below the top of the rails]. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank must be rectangular in cross-section and provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies, prevent floating during concrete pouring by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly.[Provide steel reinforcing in the concrete envelope as indicated.][Provide color, type and depth of warning tape as specified in Section [31 00 00 EARTHWORK][31 23 00.00 20 EXCAVATION AND FILL].]

3.7.9.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.7.9.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and [extend into][bend out to tie into the reinforcing of] the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.7.9.3 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve steel in pad. Cut the steel and [extend into][bend out to tie into the reinforcing of] the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

3.7.9.4 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks.[Remove existing cables which constitute interference with the work.][Abandon in place those no longer used ducts and cables which do not interfere with the work.]

3.7.9.5 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 feet back into the envelope and a minimum of 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately one foot apart. Restrain reinforcing assembly from moving during concrete pouring.

[3.7.9.6 Removal of Ducts

Where duct lines are removed from existing underground structures, close the openings to waterproof the structure. Chip out the wall opening to provide a key for the new section of wall.

]3.7.10 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

3.8 CABLE PULLING

[Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables.]Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with[tape][or][wire] shield must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.8.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.9 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.9.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.10 CONDUCTORS INSTALLED IN PARALLEL

Group conductors such that each conduit of a parallel run contains one

Phase A conductor, one Phase B conductor, one Phase C conductor, and one neutral conductor.

3.11 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set.[Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.]

[3.11.1 Terminating Aluminum Conductors

a. Use particular care in making up joints and terminations. Remove surface oxides by cleaning with a wire brush or emery cloth. Apply joint compound to conductors, and use UL-listed solid aluminum connectors for connecting aluminum conductors. When connecting aluminum to copper conductors, use connectors specifically designed for this purpose.

b. Terminate aluminum conductors to copper bus either by: (1) in line splicing a copper pigtail to the aluminum conductor (copper pigtail must have a ampacity at least that of the aluminum conductor); or (2) using a circumferential compression type, aluminum bodied terminal lug UL listed for AL/CU and steel Belleville spring washers, flat washers, bolts, and nuts. Belleville spring washers must be cadmium-plated hardened steel. Install the Belleville spring washers with the crown up toward the nut or bolt head, with the concave side of the Belleville bearing on a heavy-duty, wide series flat washer of larger diameter than the Belleville. Tighten nuts sufficient to flatten Belleville and leave in that position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

c. Terminate aluminum conductors to aluminum bus by using all-aluminum nuts, bolts, washers, and lugs. Wire brush and apply inhibiting compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection; if bus contact surface is unplated, scratch-brush and coat with joint compound (without grit).

]3.12 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.13 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.13.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods must be as specified elsewhere in this section. Wire must be trained to the sides of the enclosure to prevent interference with the working area.

[3.13.2 Joints in Armored Cables

Enclose armored cable joints in compound-filled, cast-iron or alloy splice boxes equipped with stuffing boxes and armor clamps of a suitable type and size for the cable being installed.

]3.14 CABLE END CAPS

Cable ends must be sealed at all times with coated heat shrinkable end caps. Cables ends must be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps must remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

[3.15 LIVE END CAPS

Provide live end caps for single conductor medium voltage cables where indicated.

]3.16 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.16.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

[3.16.2 Tape-Wrap

Tape-wrap metallic-sheathed or metallic armored cables without a nonmetallic protective covering over the sheath or armor prior to application of fireproofing. Wrap must be in the form of two tightly applied half-lapped layers of a pressure-sensitive 10 mil thick plastic tape, and must extend not less than one inch into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

]3.17 GROUNDING SYSTEMS

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding [25][_____] ohms.

3.17.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus[6 inches][12 inches], installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, provide an additional ground rod in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance

exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.17.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.17.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.[Provide direct connections to the grounding conductor with 600 v insulated, full-size conductor for each grounded neutral of each feeder circuit, which is spliced within the manhole.]

3.17.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.17.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

[3.17.6 Fence Grounding

[Provide grounding for fences as indicated.][Provide grounding for fences with a ground rod at each fixed gate post and at each corner post.] Drive ground rods until the top is 12 inches below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 12 inches of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Bond each gate section to its gatepost by a 1/8 by one inch flexible braided copper strap and ground post clamps. Clamps must be of the anti-electrolysis type.

][3.17.7 Metal Splice Case Grounding

Ground metal splice cases for medium-voltage direct-burial cable by connection to a driven ground rod located within 2 feet of each splice box using a grounding electrode conductor having a current-carrying capacity of at least 20 percent of the individual phase conductors in the associated splice box, but not less than No. 6 AWG.

]3.18 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section [31 23 00.00 20 EXCAVATION AND FILL][31 00 00 EARTHWORK].

3.18.1 Reconditioning of Surfaces

3.18.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct [or direct burial cable]. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.[Provide work in accordance with Section 32 92 19 SEEDING and Section 32 93 00 EXTERIOR PLANTS.]

3.18.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists [, restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.][Make repairs as specified in Section [32 13 13.06 PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES][_____].]

3.19 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.19.1 Concrete Slabs (Pads) for Equipment

Unless otherwise indicated, the slab must be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Place slab on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade must have 1/2 inch chamfer. Slab must be of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

[3.19.2 Sealing

When the installation is complete, seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

]3.20 FIELD QUALITY CONTROL

3.20.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.20.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests must be very low frequency (VLF) alternating voltage withstand tests in accordance with IEEE 400.2. VLF test frequency must be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages must be as follows:

CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING	
5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)
25 kV	31kV rms(peak)
35 kV	44kV rms(peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING	
5 kV	7kV rms(peak)
8 kV	10kV rms(peak)
15 kV	16kV rms(peak)
25 kV	23kV rms(peak)
35 kV	33kV rms(peak)

3.20.1.2 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Verify tightness of accessible bolted electrical connections.

(4) Inspect compression-applied connectors for correct cable match and indentation.

(5) Visually inspect jacket and insulation condition.

(6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

(2) Perform continuity tests to insure correct cable connection.

3.20.1.3 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.20.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

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SECTION 33 73 00.00 40

UTILITY TRANSFORMERS
05/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A345	(2019) Standard Specification for Flat-Rolled Electrical Steels for Magnetic Applications
ASTM B48	(2000; R 2021; E 2021) Standard Specification for Soft Rectangular and Square Bare Copper Wire for Electrical Conductors
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D117	(2018) Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Liquids
ASTM D877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D924	(2008) Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
ASTM D974	(2014; E 2016) Standard Test Method for Acid and Base Number by Color-Indicator Titration
ASTM D1533	(2012) Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D3612	(2002; R 2017) Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 62	(1995; R 2005) Guide for Diagnostic Field Testing of Electric Power Apparatus-Part 1: Oil Filled Power Transformers, Regulators, and Reactors
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.121	(2012) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.10	(2017) Requirements for Liquid-Immersed Power Transformers
IEEE C57.12.34	(2015) Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.19.00	(2009; INT 1 2009; Errata 2010) Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings
IEEE C57.98	(2011) Guide for Transformer Impulse Tests

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-90/027F	(1993) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms
EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Pre-Installation Meeting

Within [30] [_____] calendar days after [date of award] [date of receipt by him of notice of award], submit for the approval of the Contracting Officer [six] [_____] copies of specified drawings of all equipment to be furnished under this contract, together with weights and overall dimensions.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Transformer Test Schedule[; G[, [____]]]

SD-02 Shop Drawings

Connection Diagrams[; G[, [____]]]

Fabrication Drawings[; G[, [____]]]

Installation Drawings[; G[, [____]]]

Equipment Foundation Drawings[; G[, [____]]]

SD-03 Product Data

Power Transformers[; G[, [____]]]

Manufacturer's Instructions[; G[, [____]]]

SD-06 Test Reports

Factory Test Reports[; G[, [____]]]

Acceptance Tests[; G[, [____]]]

SD-07 Certificates

Certificates of Compliance[; G[, [____]]]

SD-11 Closeout Submittals

Final Test Reports[; G[, [____]]]

Operation And Maintenance Manuals[; G[, [____]]]

Warranty[; G[, [____]]]

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.4.2 Qualifications

Provide materials and equipment that are products of manufacturers regularly engaged in the production of oil filled transformers and their component parts and equipment which are of equal material, design and workmanship. Provide products that are of the latest standard design for outdoor service which have been in satisfactory commercial or industrial use for 2 years with no less than 150 units manufactured prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

1.4.3 Certificates of Compliance

Submit certificates of compliance of previous tests on similar units under actual conditions for temperature rise, bushing tests, and short-circuit tests in lieu of factory tests on actual units furnished is acceptable upon approval.

1.5 DELIVERY, STORAGE, AND HANDLING

Do not ship transformer to the site until all factory tests and their results are approved by the Contracting Officer and the equipment is inspected and approved by the Contracting Officer unless he has given the manufacturer a written waiver.

Do not use products manufactured more than one year prior to date of delivery to site, unless specified otherwise.

After the transformer arrives on site and prior to installation, the Government will perform an insulation power factor test and take an oil sample for a dielectric test, dissolved gas analysis, water-in-oil (Karl Fischer) test, oil acidity test, and PCB content determination. Test results will be used as baseline for future maintenance and compared to factory test results to ensure compliance with all requirements.

1.6 MAINTENANCE MATERIAL SUBMITTALS

In addition to requirements of Section 01 78 00, Data Package 5, include the following information on the actual Power Transformers provided:

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, front, top, and side views

c. Routine and field acceptance test reports

d. Automatic load-tap changing equipment and accessories

e. Fuse curves for all fuses

f. Actual nameplate diagram

g. Date of purchase

1.7 WARRANTY

Provide three (3) copies of the warranty to the Contracting Officer. Ensure the equipment items are supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Design Requirements

Provide station power transformers with primary connections to [overhead] [underground] high-voltage incoming lines and [bus connected secondary] [secondary connections to underground cables] [secondary connections to underground distribution lines] that are two-winding, three-phase, 60-hertz (Hz), oil-immersed, 55/65-degree C rise above a 86 degrees Fahrenheit average ambient, [self-cooled Class OA] [forced-air-cooled Class OA/FA] [forced-air-oil-cooled Class OA/FA/FOA] outdoor type conforming to IEEE C57.12.00 and IEEE C57.12.80.

Submit complete design and manufacturer's catalog data on power transformers including transformer tanks, bushings, enclosures, cores, coils, automatic load-tap changing equipment and accessories. Ensure power transformers and all equipment and accessories meet or exceed specified material and performance requirements and reference standards.

Submit manufacturer's instructions for the power transformers including special provisions required to install equipment components and system packages. Provide special notices that detail impedances, hazards and safety precautions.

Submit connection diagrams for power transformers, cores, coils and automatic load-tap changing equipment. Provide connection diagrams that indicate the relations and connections of the following items by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit fabrication drawings for power transformers, transformer tanks, bushings, enclosures, cores, coils, automatic load-tap changing equipment and accessories. Provide fabrication drawings that consist of manufacturers original fabrication and assembly details to be performed at the factory for the project.

Submit engineered Equipment Foundation Drawings for power transformers that includes plan dimensions of foundations and relative elevations, equipment weight and operating loads, horizontal and vertical loads, horizontal and vertical clearances for installation, and size and location of anchor bolts. Ensure submitted drawings are signed and sealed by a licensed professional engineer[in the State of [_____]].

2.1.2 Performance Requirements

2.1.2.1 Impedance

Provide percent impedance voltage at the self-cooled rating in accordance with IEEE C57.12.10.

2.1.2.2 Short-Circuit Withstand

Provide transformers capable of withstanding, without injury, the mechanical and thermal stresses caused by short circuits on the external terminals of the low-voltage windings in accordance with IEEE C57.12.00.

2.1.2.3 Voltage Ratings

Provide primary voltage section that is rated for connection to [69,000][115,000][138,000][230,000] [_____] volt, three-phase, 60 Hz power distribution systems.

Provide secondary voltage section that is [13,800] [13,200] [12,470] [_____] volt, three-phase, 60-Hz, for connection to solidly grounded power distribution systems.

2.1.2.4 Insulation Class

Insulate transformer primary windings for [69,000] [115,000] [138,000] [230,000] [_____] volts for connection to [69,000] [115,000] [138,000] [230,000] [_____] volt, three-phase, 60-Hz, power transmission systems.

2.1.2.5 Basic Impulse Insulation Levels

Provide basic impulse insulation levels (BILs) of the incoming and transforming sections of the transformer in accordance with IEEE C37.121.

2.2 FABRICATION

2.2.1 Painting

After fabrication, clean and paint all exposed ferrous metal surfaces of the transformer and component equipment. Provide the transformer with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and/or abrasive action), and all outdoor installations, refer to

Section 09 96 00 HIGH-PERFORMANCE COATINGS.

2.3 COMPONENTS

Provide transformers that include a core and coil assembly enclosed in a sealed airtight and oiltight tank, with accessories and auxiliary equipment as indicated and specified.

2.3.1 Tank

Provide transformer tank with walls, bottom, and cover fabricated from hot-rolled steel plate with cooling tubes or radiators vertically mounted to the side walls of the tank.

Provide transformer tank that is welded construction with rectangular base designed for rolling in the direction of the centerline of the bushing segments.

[Provide tank that has a manhole in the cover. Provide circular manholes that are not less than 15 inches in diameter. Provide rectangular or oval manholes that are not less than 10 by 16 inches.

][Provide tank that has a handhole in the cover. Provide circular handholes that are not less than 6 inches diameter. Provide rectangular handholes that are not less than 4-1/2 inches wide and that have an area of not less than 65 square inches.

] Provide lifting, moving, and jacking facilities conforming to IEEE C57.12.10.

Provide transformer base that is designed to provide natural draft ventilation under the transformer tank when the transformer is placed on a flat concrete foundation. Undercoat the bottom of the transformer tank with a heavy rubberized protective sealing material at least 1/32 inch thick.

[Weld cooling tubes into headers which in turn are welded into the transformer tank wall.

] Provide a sealed-tank oil-preservation system that seals the interior of the transformer from the atmosphere throughout temperatures ranging to 100 degrees C. Provide constant gas and oil volume with internal gas pressure not exceeding 10 pounds per square inch, gage (psig) positive or 8-psig negative. Make provision for the relief of excessive internal pressure in the transformer tank, by the installation of a pressure relief valve.

Provide a completely assembled transformer that is designed to withstand, without permanent deformation, a pressure 25 percent greater than the maximum operating pressure of the sealed-tank oil-preservation system.

Provide spare mounting gaskets for all bushings, terminal chambers, handholes, and the gasket between the relief cover and flange on the pressure relief valve.

2.3.2 Bushings

Terminate primary windings of the transformer in cover-mounted high-voltage bushings. Terminate secondary windings of the transformer in sidewall bushings enclosed with throats or flanges that are an integral part of the transformer and terminal chambers for electrical connections to the underground distribution system. Provide same insulation class of bushings as the insulation class of the windings to which they are connected. Provide electrical characteristics of transformer bushings in accordance with IEEE C57.12.00. Provide dimensions of transformer bushings in accordance with IEEE C57.19.00.

2.3.3 Cores

Provide cores that are built up with laminated, nonaging, high-permeability, grain-oriented, cold-rolled, silicon sheet steel. Ensure laminations are coated with an insulating film or finish to minimize eddy-current losses. Ensure sheet steel conforms to ASTM A345.

2.3.4 Coils

Provide high- and low-voltage coil sections that consist of insulated copper conductors wound around the core. Provide coil sections that are [concentric] [rectangular] to counteract forces incurred under short-circuit conditions. Provide coil sections with oil ducts to dissipate the heat generated in the windings. Provide coil sections that are electrically connected together and to the respective terminal bushings of the transformer. Ensure copper conductors in the high- and low-voltage coil sections conform to ASTM B48, Type B for applications involving edgewise bending.

Provide primary winding of the transformer that is equipped with four 2.5 percent full-capacity taps, two above and two below normal voltage, brought out to an externally operated manual tap changer. Provide tap changer handles capable of being padlocked in each tap position and is operable when the transformer is deenergized.

2.3.5 Cooling Provisions

[Provide radiators that are detachable all-welded [mild steel] [hot-dipped galvanized steel] construction, with top and bottom connections to the transformer tank wall. Provide tank wall top and bottom connections to radiators that are equipped with valves that permit removal of radiator without draining oil from the transformer tank.

][Provide transformer that is equipped with automatically controlled fans to provide forced-air-cooled transformer ratings in accordance with IEEE C57.12.10. Provide equipment that includes a thermally operated control device, manually operated bypass switch, motor-driven fans, and electrical conduit and wire connections.

][Make provision for future installation of automatically controlled motor-driven fans to give forced-air-cooled transformer ratings conforming to IEEE C57.12.10. Provide necessary mechanical arrangements for a thermally operated control device to be mounted in a well for top liquid-temperature control as described in IEEE C57.12.00. Make provision for the future mounting of control cabinets, conduit, and fans.
]
[Provide a thermally operated control device that consists of a top oil temperature relay with a thermal element mounted in a well responsive to the top liquid-level temperature of the transformer.

][Provide thermally operated control device that consists of a hot-spot temperature relay with thermal element mounted in a well and a bushing type current transformer. Add energy from the current transformer to the top oil temperature of the transformer to indicate the simulated hot-spot condition in one phase of the transformer winding.

] Provide well that conforms to IEEE C57.12.00. Connect manually operated bypass switch in parallel with the automatic control contacts and enclose in a weatherproof cabinet located on the side of the transformer at a height not greater than 60-inches above the concrete foundation. Provide fan motors that are [230] [120] -volt, single-phase, 60-hertz, without centrifugal switch and are [individually fused] [thermally] protected.

2.3.6 Automatic Load-Tap Changing Equipment

Provide transformer that is equipped with three-phase automatic load-tap changing equipment that provides 10 percent voltage adjustment in 16 equal steps above and below rated secondary voltage in accordance with IEEE C57.12.10.

Provide load-tap changing equipment that consists of an arcing tap switch or tap selector and arcing switch, a motor-driving mechanism, position indicator, and automatic control devices contained in weatherproof enclosures mounted on the sidewalls of the transformer tank.

Locate arcing tap switch or tap selector and arcing switch in one or more oil-immersed welded steel plate compartments. Compartments have removable, bolted, external access covers, drain and sampling valve, filling plug, and magnetic liquid-level gage. Make provision for the escape of gas generated by the arcing contacts. Isolate oil in the arcing switch compartment from the oil within the transformer tank.

Provide a motor-drive mechanism that is equipped with a [230] [120]-volt, single-phase, 60-hertz motor and [hand crank] [hand wheel] for automatic and manual operation of the driving mechanism. Provide mechanically operated electric limit switches to prevent overtravel beyond the maximum lower and raise positions.

House automatic control devices in a weatherproof sheet metal cabinet with breather and hinged doors to provide access to the control devices. Make provisions for padlocks.

Provide automatic control devices that include a voltage-regulating relay, time delay, manual/automatic selector switch, line-drop compensator, paralleling switch, current transformers, reactance reversal control switch, operation counter, current and potential test terminals, lampholder and switch, heater and switch, convenience outlet, and protective devices in accordance with IEEE C57.12.10, Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

Make provision for the accurate alignment, positioning, and locking of arcing contacts in each tap position. When the load-tap changing equipment is on a tap position at or above rated secondary voltage, provide a transformer that is capable of supplying its rated kVA.

2.3.7 Insulating Liquid

[Ensure insulating oil conforms to ASTM D3487 Type II with inhibitor. Provide dielectric strength of transformer oils, when shipped, that is not less than 28 kV when measured in accordance with ASTM D117. Ensure the Neutralization Number is not greater than .03 gm KOH/ml when measured in accordance with ASTM D974. Provide emulsified water that does not exceed 25 ppm at 68 degrees F when measured in accordance with ASTM D1533. Provide power factor that does not exceed 0.5 percent at 68 degrees F when measured in accordance with ASTM D924. Provide identification of transformer as "non-PCB" and "Type II mineral oil" on the nameplate.

][Provide less-flammable oil conforming to NFPA 70 and FM APP GUIDE. Provide a non-propagating high fire point transformer insulating liquid having a fire point not less than 572 degrees F when tested per ASTM D92. Ensure liquid has a dielectric strength not less than 33 kilovolts when tested in accordance with ASTM D877 and NFPA 70. Provide identification of the transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

Provide a fluid that is a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable". Ensure the fluid meets the following requirements:

a. Pour point: ASTM D97, less than -15 degree C

b. Aquatic biodegradation: EPA 712-C-98-075, 100 percent

c. Trout toxicity: OECD Test 203, zero mortality of EPA 600/4-90/027F, pass

]2.4 ACCESSORIES

Provide transformer accessories that include a liquid-level indicator, liquid-temperature indicator, pressure/vacuum gage, drain and filter valves, ground pads, and identification plate. Ensure transformer accessories and their locations conform to IEEE C57.12.10.

Locate the nitrogen fill valve above the transformers liquid level.

2.4.1 Space Heaters

Equip primary [and secondary] cable termination compartment with externally energized space heaters. Ensure heaters generate approximately 4 watts per square foot at the outer surface area. Provide heaters that have a power density that does not exceed 4 watts per square inch of heater element surface. Provide heaters that are rated at 240-volts for connection to 120-volts. Locate heaters at the lowest portion of each space to be heated. Cover terminals. Use thermostats to regulate the temperature.

Provide installed and operable heaters at the time of shipment so that the heaters can be operated immediately upon arrival at the site, during storage, or before installation. Provide connection locations that are marked prominently on drawings and shipping covers and that have temporary leads for storage operation. Ensure leads are easily accessible without having to remove shipping protection.

2.4.2 External Voltage Source

Group together all externally powered wiring to the switch as much as possible and connect to a terminal block which is marked with a laminated plastic nameplate having 3/16-inch high white letters on a red background as follows:

DANGER - EXTERNAL VOLTAGE SOURCE

Provide externally powered wiring that includes unit space heaters [, temperature alarm devices] [, fans] [, _____] [, and] [instrumentation circuits].

2.4.3 Miscellaneous

Include the following transformer accessories, a liquid-level indicator, liquid-temperature indicator, pressure/vacuum gage, drain and filter valves, ground pads, and identification plate. Provide transformer accessories and their locations that conform to IEEE C57.12.10.

Transformer kilovolt-ampere (kVA) ratings are continuous and are based on temperature-rise tests. Do not exceed temperature limits when the transformer is delivering rated kVA output at rated secondary voltage in accordance with IEEE C57.12.00.

2.5 FACTORY TESTING

Conduct factory testing and submit Factory Test Reports in accordance with IEEE C57.12.90, IEEE 62, ASTM D3612, and IEEE C57.12.00, Table 16. Ensure at a minimum all tests included in "Design Tests" and Routine and Other Tests" paragraphs are completed. Maximum acceptable insulation power factor is 0.5 percent for mineral oil insulated transformers.

2.5.1 Transformer Test Schedule

The Government [reserves the right to][will] witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

(1) The manufacturer has a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) The accuracy is directly traceable to the National Institute of Standards and Technology.

(3) Instrument calibration frequency schedule does not exceed 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels are visible on all test equipment.

(5) Calibrating standard is of higher accuracy than that of the instrument tested.

(6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80 states that "design tests are made only on representative apparatus of basically the same design." Submit factory test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for each of the specified transformers. Perform design tests prior to the award of this contract.

a. Submit test reports certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a power transformer with the same coil construction, the same kVA, the same cooling type, the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a power transformer with the same BIL, the same coil construction, and a tap changer. Design lightning impulse tests includes the primary windings only of that transformer.

(1) IEEE C57.12.90, paragraph 10.3 LIGHTNING IMPULSE TEST PROCEDURES and IEEE C57.98.

(2) State test voltage levels.

(3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.34.

e. Pressure: "Basically the same design" for the pressure test means a power transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

f. Short circuit: "Basically the same design" for the short circuit test means a power transformer with the same kVA as the transformer specified.

2.5.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests are performed by the manufacturer on [each of] the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence are as follows:

a. Insulation-resistance tests of the windings

b. Turns ratio tests

c. Polarity and phase rotation tests

d. No-load losses (NLL) and excitation current at rated voltage

e. Load losses (LL) and impedance voltage at rated current

f. Insulation power factor tests

g. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

h. Insulating liquid power factor tests

i. Insulating liquid acidity tests

j. Water-in-oil (Karl Fischer) tests

k. Leak

l. Dissolved gas analysis (DGA)

m. Sound tests

n. Bushing tests

PART 3 EXECUTION

3.1 INSTALLATION

Install transformers as indicated and in accordance with the manufacturer's recommendations. Ground transformer tanks.

Provide installation drawings for the power transformer. Include complete details of equipment layout and design on the drawings.

3.2 FIELD QUALITY CONTROL

3.2.1 Acceptance Tests

Retain the services of the manufacturer's service representative to perform initial start-up, commissioning, and acceptance testing. Manufacturer's service representative certification is required on all tests and reports submitted.

Disconnect primary winding of the transformer from the power supply, and ground the secondary windings of the transformer, before conducting insulation and high-voltage tests on primary windings.

Disconnect secondary winding of the transformer from the secondary feeder cables, and disconnect the primary winding of the transformer from the power supply and ground, before conducting insulation and high-voltage tests on secondary windings.

Give windings of the transformer an insulation-resistance test with a 5,000-volt insulation-resistance test set.

Apply tests for not less than 5 minutes and until 3 equal consecutive readings, 1 minute apart, are obtained. Record readings every 30 seconds during the first 2 minutes and every minute thereafter. Minimum acceptable resistance is 100 megohms.

Upon satisfactory completion of the insulation resistance tests, give the transformer windings an insulation power factor test and an excitation test. Maximum acceptable power factor is 0.5 percent. Excitation results vary due to the amount of iron and copper in the windings and are used for baselines only.

Conduct a turns ratio test on the transformer. Provide readings within 1/2 percent of each other.

Upon satisfactory completion of the above electrical tests, give the transformer the following oil tests: Power factor, neutralization number, Karl Fischer, Dissolved gas analysis, and dielectric. Provide results as follows:

Power Factor	less than .5 percent at 20 degrees C
Karl Fischer	less than 25 ppm at 20 degrees C
Neutralization Number	less than .03 gm KOH/ml
Dielectric	greater than 33kV
Dissolved Gas Combustibles	less than 1000 ppm total

Final acceptance depends upon the satisfactory performance of the equipment under test. Do not energize transformer until recorded test data has been approved by the Contracting Officer.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Test Reports

Submit final test reports to the Contracting Officer containing the results of all checks and tests, neatly cataloged and bound, to the Contracting Officer before Final Acceptance.

3.3.2 Maintenance

No less than [30] [_____] days prior to final testing and inspection, submit Operation and Maintenance Manuals to the Contracting Officer for the following equipment:

a. Power transformers

b. Automatic load-tap changing equipment

[c. Space heaters]

-- End of Section --

SECTION 33 75 00.00 40

SWITCHGEAR AND PROTECTION DEVICES
11/14

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 4	(2013) Standard Techniques for High Voltage Testing
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.20.1A	(2020) Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit-Breaker Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.121	(2012) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Switchgear Assemblies[; G[, [____]]]

SD-02 Shop Drawings

Switchgear Assemblies[; G[, [____]]]

Buses[; G[, [____]]]

Switchgear Components[; G[, [____]]]

Automatic/Manual Transfer Switch[; G[, [____]]]

Space Heaters[; G[, [____]]]

Enclosures[; G[, [____]]]

Weatherproof Enclosures[; G[, [____]]]

Installation Drawings[; G[, [____]]]

SD-03 Product Data

Equipment and Performance Data[; G[, [____]]]

Equipment Foundation Data[; G[, [____]]]

Switchgear Assemblies[; G[, [____]]]

Enclosures[; G[, [____]]]

Buses[; G[, [____]]]

Switchgear Components[; G[, [____]]]

Weatherproof Enclosures[; G[, [____]]]

Automatic/Manual Transfer Switch[; G[, [____]]]

Space Heaters[; G[, [____]]]

SD-06 Test Reports

Electrical Acceptance Tests[; G[, [____]]]

High-Voltage Tests[; G[, [____]]]

Current Test[; G[, [____]]]

Insulation-Resistance Test[; G[, [____]]]

Weatherproof Test[; G[, [____]]]

Electrical Current and Voltage Tests[; G[, [____]]]

Ratio and Polarity Tests[; G[, [____]]]

High-Voltage (Hi-Pot) Withstand Test[; G[, [____]]]

Final Test Data[; G[, [____]]]

SD-07 Certificates

Certificates[; G[, [____]]]

SD-08 Manufacturer's Instructions

Switchgear Assemblies[; G[, [____]]]

SD-10 Operation and Maintenance Data

Switchgear Assemblies[; G[, [____]]]

Transfer Switches[; G[, [____]]]

Space Heaters[; G[, [____]]]

1.3 MAINTENANCE MATERIAL SUBMITTALS

Submit manufacturer's instructions for the switchgear assemblies including special provisions required to install equipment components and system packages. Provide special notices that detail impedances, hazards, safety precautions, and installation instructions.

1.4 QUALITY CONTROL

1.4.1 Manufacturer Qualifications

Provide material and equipment under this specification that is the standard catalog product of a manufacturer regularly engaged in the manufacture of switchgear assemblies and their component parts and equipment. Provide equipment that is of the latest standard design for [indoor] [outdoor] service and that has been in repetitive manufacture for at least [50] [_____] units.

1.4.2 Engineer Qualifications

Perform electrical power system's circuit loading requirements and analyses by a professional electrical engineer registered with the National Society of Professional Engineers (NSPE). Select a professional engineer who has conducted electrical coordination studies and tests for not less than five projects of comparable size and complexity. Perform work by or under the direct supervision of the registered professional electrical engineer.

Submit certificates to verify the qualifications of the Registered Professional Electrical Engineer.

1.4.2.1 Engineering Services

Select an electrical engineer holding a valid state license as a Professional Engineer in the jurisdiction where the project is being constructed, and who specializes in relays and coordinating systems associated with electric-power apparatus for the manufacturer of the equipment, to coordinate all circuit-interrupting devices before the substation is energized. Duties and responsibilities of the engineer include the following work.

a. Preliminary Survey and System Coordination Study

Review necessary short-circuit calculations to determine the minimum and maximum values of short-circuit current for faults anywhere in the system. Review values of fault current to be expected at each protective device shown on the one-line diagrams.

Prepare one-line diagrams that indicate by means of single lines and simplified symbols the course and component devices of an electric circuit or system of circuits and their electrical characteristics.

Inspect equipment and determine the intended function of each circuit-interrupting device and the manner in which it is connected to provide a properly coordinated electrical power system under normal load and fault conditions.

Check and compare wiring diagrams furnished by the manufacturer with actual connections of the equipment to verify that each device is properly connected to perform its intended function.

b. Time/Current Curves and Settings

Plot time/current curves on a single sheet of graph paper or electronic format for those devices that are to operate selectively in series with each other using a common current scale, with current ratings at the lowest-voltage level. Plot curves progressively as each circuit is studied, starting with the device farthest from the source. Make each curve on the graph include tolerance band and show degree of coordination with each successive device. Coordinate adjustable and nonadjustable protective devices to operate on the minimum current that permits distinguishing between fault and load current in a minimum amount of time.

Select time and current settings for the adjustable devices that operate in sequence with the nonadjustable devices to isolate a fault with a minimum of disturbance to the unfaulted portion of the system.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit switchgear assemblies that conform to IEEE C37.20.1A.

Submit equipment and performance data for electrical equipment consisting of the following:

a. One-line diagram of electrical equipment and system.

b. Short-circuit calculations and a table of short-circuit fault currents at critical points in the electrical system.

c. Spare Parts Data

d. Time/current coordination curves on 10 1/2 by 15 inch translucent tracing paper for each relay device.

e. Table of recommended relay settings.

Submit equipment foundation data for switchgear assemblies that includes plan dimensions of foundations and relative elevations, equipment weight and operating loads, horizontal and vertical loads, horizontal and vertical clearances for installation, and size and location of anchor bolts.

2.1.1 Design Requirements

Submit connection diagrams indicating the relations and connections of the following items: switchgear assemblies, buses, switchgear components, automatic/manual transfer switch, and space heaters. Show the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit fabrication drawings consisting of fabrication and assembly details to be performed in the factory for the following items: switchgear assemblies, buses, switchgear components, automatic/manual transfer switch, enclosures, and space heaters.

2.2 FABRICATION

2.2.1 Switchgear and Auxiliary Compartments

Stationary mount switchgear assemblies and auxiliary equipment in self-supporting, self-contained, sheet metal enclosures with front-hinged doors and hinged rear covers. Join sheet metal compartments together to form a continuous structure. Provide sheet metal barriers, enclosures, and external covers and doors that are constructed from cold-rolled carbon-steel sheets of commercial quality not less than [14] [_____]-gage, with stretcher-level flatness in accordance with ASTM A1008/A1008M.

Provide unit sheet metal that encloses one or more vertically mounted power circuit breakers or auxiliary equipment in individual sheet metal compartments and a full height rear compartment. Provide housing that is approximately 90-inches high with individual ventilated [front] [rear]-hinged panels and bolted top and rear covers. Provide rear compartment that contains the main bus, main bus-tap connections, cable connections, and instrument transformers.

2.2.2 Compartment Details

Completely wire compartments with cable terminals, cable clamps, control bus, control power switch, and terminal blocks. Provide terminal blocks that are readily accessible for the external connections of metal-clad switchgear.

Run low-voltage wiring for controls and accessories to terminal blocks having numbered points, as indicated, to identify circuits. Run low-voltage wiring in conduit or wiring raceways to isolate the wiring from high-voltage circuits. Identify wiring connections.

Identify each compartment of the switchgear assembly by an identification plate engraved with circuit and function designations.

Provide removable elements of the same type and rating in the switchgear assembly that are physically and electrically interchangeable in corresponding compartments. Provide front-hinged panel that is suitable for mounting instruments, relays, control switches, and indicating lamps.

Provide barriers between a sectionalized bus with bus sectionalizing breakers in a compartment that are sheet steel not less than [11] [_____] gage. Provide other covers, barriers, panels, and doors that are not less than [14] [_____] gage.

Reinforce each compartment with structural members and weld together. Ground welds to a smooth flat surface before painting.

2.2.3 Buses

Completely bus switchgear assemblies utilizing electrical grade, high conductivity, solid copper bus bar having a rectangular cross section. Uniformly position and phase sequence, riser and bus tap connections in accordance with IEEE C37.20.1A. Support and brace buses to withstand both electrically and mechanically the short circuit current ratings.

Silverplate termination and connection points by an electroplating process for all bus bar used in the switchgear. Silver coating methods that do not use the flow of electrical current as part of the process are not acceptable. After plating, do not sand or otherwise abrade the contact surface, but clean it with a soft cloth immediately prior to final assembly.

Make all bus bar connections using silicon bronze bolts with wide flat silicon bronze washers under the bolt head and nut. Tighten and check these connections by use of a calibrated torque wrench. Other connection designs are allowed with the written agreement of the Contracting Officer.

[Provide main bus that is readily accessible for connection of future switchgear assemblies at either end. Provide main and auxiliary control drawout type connections that are silver-to-silver contact, positive pressure, self-aligning, with enclosure-to-enclosure stationary mechanism when breaker is in drawout position.

] Provide voltage rating and insulation level of switchgear assemblies as specified and that conform to IEEE C37.20.1A.

Provide temperature limits for buses and bus-tap connections in switchgear assemblies that are in accordance with IEEE C37.20.1A.

Provide a continuous rigid copper ground bus that extends throughout the entire assembly and that grounds the stationary structure and equipment. Provide ground bus that is capable of carrying the rated short circuit current of the protective devices in the switchgear assembly for a minimum period of one second.

Completely wire compartments with cable terminals, cable clamps, control bus, control power switch, and terminal blocks. Provide terminal blocks that are readily accessible for the external connections of metal-clad switchgear.

Run low-voltage wiring for controls and accessories to terminal blocks having numbered points, as indicated, to identify circuits. Run low-voltage wiring in conduit or wiring raceways to isolate the wiring from high-voltage circuits. Identify wiring connections.

Identify each compartment of the switchgear assembly by an identification plate engraved with circuit and function designations.

Provide metal-enclosed bus of non-segregated group phase construction that includes rigid insulated conductors and supports in a grounded metal enclosure with associated ventilation and space-heater enclosures, condensation barriers, expansion and connection joints, and fittings in accordance with IEEE C37.20.1A.

Completely bus enclosures with an insulated solid rigid copper bus bar of rectangular cross section. Uniformly position and phase sequence bar and connections within the enclosure for adaptation to metal-clad switchgear assemblies and power transformers, in accordance with IEEE C37.20.1A.

Support and brace bus bar to withstand short-circuit stresses with momentary current ratings, in accordance with IEEE C37.20.1A. Silverplate and bolt together contact surfaces of all bus connections to ensure maximum conductivity. Provide voltage and current ratings that conform to IEEE C37.20.1A.

Provide insulating supports that consist of track-resistant, flame-retardant IEEE Class 130 electrical insulating materials. Provide voltage rating and insulation level that conform to IEEE C37.20.1A.

Provide sheet metal weatherproof enclosures that are constructed from carbon steel sheets of commercial quality, not less than [14] [_____] gage. Reinforce each section with structural members and bolt together. Structurally support complete assembly as indicated.

2.2.4 Automatic/Manual Transfer Switch

Make provision for the automatic transfer of load on loss of voltage, low voltage, single phasing, reverse phase rotation of either source, and the automatic transfer of load upon restoration of normal service without a service interruption. Under normal operation, close both main secondary breakers with the main bus tie breaker open and the automatic/manual transfer control switch in the automatic position, and energize and load each source of supply.

Electrically operate main and bus tie breakers with remote pushbutton controls electrically interlocked so that only two of the three breakers close by operation of the respective breaker-closing mechanisms when the automatic/manual transfer control switch is in the manual position.

Ensure main secondary breaker compartments include undervoltage and phase-sequence relays with adjustable time-delay between 30 and 200 cycles.

Provide auxiliary relays that automatically open the proper main secondary breaker and close the main bus tie breaker under fault conditions. Include provisions for the automatic reclosing of the main secondary breakers before opening the main bus tie breaker when normal service is restored.

Provide lockout relays that prevent automatic transfer of load from undervoltage caused by overload or transient conditions. Provide lockout relay controls that are connected into the closing circuit of the main tie breaker to prevent operation under lockout conditions and that are the hand-reset type.

Provide main bus tie breaker compartment that includes an automatic/manual transfer switch which disconnects the automatic transfer features when in the manual position. Provide main secondary and bus tie breakers that are manually inoperable when the automatic/manual transfer control switch is in the automatic position.

Provide a bypass switch to permit manual momentary paralleling of the two sources of supply in restoring normal service without interruption.

Provide main secondary and bus tie breakers that are manually operable when the automatic/manual transfer control switch is in the manual position.

Provide a contactor for the automatic transfer of control power. Provide control power transformers that capable of furnishing power through the selective contactor for the bus tie breaker, feeder breakers, compartment heaters, interior lighting, utility outlets, battery chargers, and other miscellaneous equipment.

Supply secondary switchgear assembly or assemblies from two separate sources, with each source normally carrying load as indicated. Under normal operation, close both main secondary breakers with the main bus tie breaker open. Do not operate two sources of supply in parallel.

2.2.5 Switchgear Assemblies

Provide general arrangement of the number of compartments and each compartment's components as shown.

[Provide bus sectionalizing switchgear compartments that include a metal-enclosed low-voltage power circuit breaker.

][Provide secondary feeder switchgear compartments that include the following equipment:

[a. Metal-enclosed low-voltage power circuit breaker

][b. Provisions for terminating cables of the metal-enclosed bus

]][Provide auxiliary station power compartments that include the following:

[a. Control-power transformer and primary fuses

][b. Circuit overload protection

][c. Potential transformers for relaying purposes

][d. Lamp ground detectors

][e. Batteries and battery charger

][f. Circuit breaker control transformer

]][Provide auxiliary metering compartments that include the following:

[a. Current transformers

][b. Ammeters and ammeter switches

][c. Potential transformers

][d. Voltmeters and voltmeter switches

][e. Watt-hour meters

][f. Reverse current directional relays

][g. Lamp ground detectors

][h. Cooling fans

]][Provide auxiliary bus sectionalizing compartments that include a contactor for automatic transfer of control power and auxiliary devices.

][Provide switchgear compartments for future use that are fully equipped to receive the removable element with complete bus connections, disconnecting devices, rails, and cell interlocks.

][Provide filler compartments incidental to the switchgear assembly that are empty compartments with hinged cover plates.

][Provide main and feeder power circuit breakers that are suitable for fully rated [nonselective] [selective] trip systems in accordance with IEEE C37.121.

]2.2.6 Weatherproof Construction

Provide switchgear assemblies for outdoor applications that are weatherproof NEMA Type 3R enclosures, with ventilated [front] [and rear]-hinged doors, base, and roof sections. Provide flanged access doors that close against rubber or similar gasketing material. Provide ventilated openings with filtered covers and screened vents for protection against the weather and insects. Equip doors with latch, stops, and door-locking mechanism.

Provide roof section that is unit construction with removable sloping cover and overhanging roof drip edge. Provide base section that is unit construction and that supports metal-enclosed switchgear [six] [_____]-inches above the concrete foundation.

[Provide switchgear enclosures that include a removable steel floor plate which is drilled for conduit and cable during installation. Undercoat floor and roof of the switchgear with a heavy rubberized protective sealing material at least [1/32] [_____]-inch thick.

][Equip each enclosure subject to an outside or humid environment with thermostatically controlled electric space heaters and cooling fans to minimize condensation. Make provisions for terminating incoming and outgoing underground cables.

]2.2.7 Painting

After fabrication, prepare and paint exposed ferrous-metal surfaces of switchgear assemblies and component equipment. Provide standard finish by the manufacturer on assemblies and component equipment when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and/or abrasive action), and all outdoor installations, refer to Section 09 96 00 HIGH-PERFORMANCE COATINGS.

2.3 SWITCHGEAR COMPONENTS

2.3.1 Air Interrupter Switches

Provide the manually group-operated three-pole, gang-operated, stationary type air interrupter switches in accordance with IEEE C37.121 and IEEE C37.20.1A, that carry the rated current continuously.

Provide stored energy type quick-make/quick-break operating mechanism with positive action for fault closing and load-interrupting capability. Provide a handle speed that is independent of operation.

[Provide the stored energy type operator, designed for easy inspection with a basic impulse level (BIL) of [95 at 14.4 kilovolts] [110 at 35 kilovolts]. Mechanically interlock access door with a switch mechanism. Provide [12] [_____]-gage minimum sheet steel switch enclosure. Provide switch gear to switch connections that prevent ground transmission to switch.

][Make provision for terminating underground cables and for bus connections to the primary of the transformer transition box. Use flexible connections between primary potheads and the interrupter switch with adequate bracing provided for short circuit stresses.

] Provide switch that has provisions for padlocking in the open and closed positions. Clearly and permanently mark open and closed switch positions on the outside of the enclosure. Provide a mechanical indicator that shows the switch position.

Provide switch with provision to add electrical operation with auxiliary contacts, and is a [two-position, single-throw] [duplex dual feeders] [selector] type.

[Equip interrupter switchgear with three current-limiting [CLE type] [RBA boric acid] power fuses capable of interrupting the available short circuit current with the switch carrying full load rated current. Provide a mechanical interlock to prevent access to the power fuses when the interrupter switch is closed.

]2.3.2 Power Circuit Breakers

Provide air circuit breakers of the [manually] [electrically] operated type as indicated, conforming to Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.3.3 Molded-Case Circuit Breakers

Provide molded-case circuit breakers that conform to Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.3.4 Instruments and Instrument Transformers

Provide indicating instruments, protective relays, current and potential transformers, instrument transfer switches, and control-power transformers that conform to the applicable requirements of Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW

VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.3.5 Control-Power Circuit Overcurrent Protection

Provide branch-circuit breakers that provide circuit overload protection to compartment heater, lights, convenience outlets, transformer fans, and other devices.

2.3.6 Automatic/Manual Transfer Switch

Provide the rotary snap-action type automatic/manual transfer switch with silver-plated contacts. Provide a manually operated two-position transfer switch device designed to interrupt the automatic transfer and close-back features of the system when the transfer switch is in the manual position. Ensure switch permits the transfer of all load to a particular switchgear assembly without a service interruption when the transfer switch is in the automatic position.

2.3.7 Control-Power Circuit Contactor

Provide a contactor for automatic transfer of control-power that is designed for 120/240-volt, single-phase, 60-Hz service with current rating. Provide contactor that is the open type, two-pole, double-throw with solid neutral connections and that automatically transfers its load circuits to the alternate power supply upon loss of power in the normal supply. Provide a device that is electrically operated and mechanically held and that obtains its operating current from the source to which the load is transferred. Provide contactors for automatic transfer of control power that is suitable for installation in metal-clad switchgear.

2.3.8 Service and Maintenance Devices

Include the following service and maintenance devices as a part of the substations:

a. A manual handle for operating the air and power circuit breaker isolating mechanism

b. Removable manual maintenance closing devices for air and power circuit breakers

c. Transfer trucks for air and power circuit breakers

d. Facilities for operating air and power circuit breakers in the test or removed position

e. Facilities for withdrawing air and power circuit breakers for inspection or maintenance

f. Test plugs and cable for meters and relays

2.3.9 Protective Relays and Devices

Provide protective relays and devices that comply with Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.3.10 Space Heaters

Equip each section of the switchgear assembly with externally energized space heaters providing approximately 4 watts per square foot of outer surface area. Provide heaters that have a power density that does not exceed 4 watts per square inch of heater element surface. Provide heaters rated at 240 volts for connection to 120 volts. Locate heaters at the lowest portion of each space to be heated. Cover terminals. Use thermostats to regulate the temperature.

Provide heaters that are installed and operable at the time of shipment so that the heaters can be operated immediately upon arrival at the site, during storage, or before installation. Provide connection locations that are marked prominently on drawings and shipping covers and that have temporary leads for storage operation. Make leads easily accessible without having to remove shipping protection.

2.3.11 External Voltage Source

Group together all externally powered wiring to the switch as much as possible and connected to a terminal block which is marked with a laminated plastic nameplate having 3/16-inch high white letters on a red background as follows:

DANGER - EXTERNAL VOLTAGE SOURCE

Provide externally powered wiring that includes 120-volt unit space heaters.

2.4 FACTORY TESTING

Make factory tests on transformers and switchgear assemblies in accordance with the applicable provisions of the referenced standards.

Perform tests on transformers that include resistance measurements of windings, ratio tests, polarity and phase-rotation tests, no-load loss at rated voltage, excitation current at rated voltage, impedance voltage and load-loss at rated current, insulation power factor tests, and dielectric tests. Conduct tests in accordance with IEEE C57.12.90.

Perform tests on switchgear assemblies that include mechanical operational tests, electrical operation and control-wiring tests, relaying and metering circuit performance tests, and dielectric tests. Conduct tests in accordance with IEEE 4.

PART 3 EXECUTION

3.1 INSTALLATION

Submit installation drawings for the switchgear assemblies. Provide drawings that include complete details of equipment layout and design.

Make installation conform to IEEE C2 and NFPA 70.

Electrically and mechanically connect complete assembly together at the site from coordinated subassemblies shipped in complete sections from the manufacturer. Provide installation that is carefully aligned, leveled, and secured to the foundation and that conforms to the manufacturer's recommendations.

Install noncurrent carrying parts and enclosures of the switchgear; bonded together and grounded to the ground grid with a maximum resistance to ground of 20 ohms. Exothermically weld inaccessible ground connections in accordance with UL 467. The minimum size of ground conductor is 4/0 AWG.

Provide switchgear with an earth ground resistance pad as shown on the drawings. Provide a switchgear resistance to ground that does not exceed the following values:

5,000 kVA and above	3 ohms
5,000 kVA and below	5 ohms

For switchgear assemblies separated for shipping, carefully join assemblies to present a neat appearance. Tighten main and ground bus joints to manufacturer's recommended torque values. Handle assemblies with lifting devices.

3.2 FIELD TESTING

Subject main bus of switchgear assemblies to insulation resistance and high-voltage, 60-hertz withstand tests after installation is completed and ready for operation. Perform electrical current and voltage tests in accordance with referenced standards in this section.

Provide test equipment, labor, and technical assistance to perform the electrical acceptance tests as herein specified.

Disconnect incoming section main bus from the power supply and primary feeder cables, and ground the switchgear enclosure before the insulation and high-voltage tests are conducted.

Disconnect outgoing section main bus from the secondary feeder cables and from the power supply and primary feeder cables. Ground the switchgear enclosure before conducting insulation and high-voltage tests.

Conduct an insulation-resistance test on the main bus of the incoming section with a [5,000] [2,500]-volt insulation-resistance test set.

Conduct an insulation-resistance test on the main bus of the outgoing section with a [1,000] [2,500] [500]-volt insulation-resistance test set.

Apply test for not less than five minutes and until three equal consecutive readings, one minute apart, are obtained. Record readings every 30 seconds during the first two minutes and every minute thereafter. Minimum acceptable resistance reading is 100 megohms.

Upon satisfactory completion of the insulation-resistance test, subject the main bus to a high-voltage (hi-pot) withstand test. Provide test voltage that is equal to [100 percent for 60 Hz] [75 percent for dc] of the values shown in IEEE C37.20.1A for metal-clad switchgear and metal-enclosed low-voltage power-circuit-breaker switchgear. Apply test for one minute.

Upon satisfactory completion of the high-voltage withstand test, give the main bus a second insulation-resistance test as before. Results of the second test are required to be within five percent of the first test and indicate no evidence of permanent injury by the high-potential test.

Subject weatherproof enclosure and switchgear assembly to a weatherproof test conducted at the site in the presence of the Contracting Officer in accordance with IEEE C37.20.1A.

Provide tests on switchgear assemblies that include electrical and mechanical operational tests, control-wiring tests, relaying and metering circuit performance tests, and dielectric tests. Conduct tests in accordance with IEEE 4.

Final acceptance depends upon the satisfactory performance of the equipment under test. Provide final test data to the Contracting Officer. Provide data with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Data - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

3.3 SYSTEM STARTUP

3.3.1 Relay Settings And Tests

Properly coordinate circuit-interrupting devices before the switchgear assemblies are energized. Thoroughly inspect and adjust relays at the site in the presence of and at the discretion of the Contracting Officer.

3.3.2 Preliminary Inspection

Conduct preliminary inspection of electrical equipment. Make relay settings and tests only after the preliminary survey and system coordination survey have been completed. Provide preliminary inspection, relay settings, and tests as follows:

a. Inspect equipment for damage or maladjustment caused by shipment or installation. Remove wedges, ties, blocks, and other packing material installed by manufacturer to prevent damage in shipment.

b. Verify protective relays, auxiliary relays, trip coils, trip circuit seal-in and target coils, fuses, and instrument transformers to be of the proper type and range.

c. Perform electrical continuity tests on current, potential, and control circuits.

d. Perform Ratio and polarity tests on current and potential transformers.

e. Perform insulation tests on relays, wiring, instrument-transformer secondary windings, and instruments.

Remove each adjustable relay from its case and calibrate separately as an instrument, using a variable alternating-current source and an accurate timing device. Verify with this procedure that the relay has not been damaged in shipment and that it performs in accordance with previously prepared time-current coordination curves at specified current tap and time dial settings.

With the relay disconnected and the main current transformer effectively open, apply a current test to the remainder of the secondary circuit to detect any open or short-circuit connections.

Reinstall and connect relays into their current-transformer secondary and control circuits.

Report any defects in electrical equipment, protective devices, wiring, or other conditions that prevent complete coordination and the successful operation of equipment to the Contracting Officer before proceeding with the work.

After the installation has been thoroughly tested and certified to be in satisfactory condition, with relays calibrated and adjusted to the proper current tap and time dial setting, request permission to energize the equipment at system voltage for final testing.

3.3.3 Energizing Switchgear Assemblies

Do not energize switchgear assembly until it is completely installed, tested, approved by the Contracting Officer, and ready for operation. Conduct site testing and obtain approval from the Contracting Officer.

Using ammeter, voltmeter, and wattmeter or phase-angle meter, measure and compare the values and polarities of voltage and current with those expected in the various relay circuits. Inspect and note positions of directional elements and the voltage relays.

After inspection and satisfactory tests have been completed on all active relay circuits under a no-load condition, give each relay an operational test with diverted load currents or simulated ground faults.

Prepare a report with records of connections, electrical constants, settings, test values, operating performance, and failures or weaknesses found on test.

Perform tests and procedures for testing in accordance with the manufacturer's recommendations, as approved by the Contracting Officer. Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

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SECTION 33 77 19.00 40

MEDIUM-VOLTAGE SWITCH
08/16

PART 1 GENERAL

Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES, and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES apply to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D2472	(2000; R 2014) Standard Specification for Sulphur Hexafluoride

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE 592	(2018) Standard for Insulation Shields on Medium-Voltage (15 kV - 35 kV) Cable Joints and Separable Connectors
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.74	(2014) Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 70B	(2019) Recommended Practice for Electrical Equipment Maintenance

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Assembly Drawings; G[, [____]]

SD-03 Product Data

Medium Voltage Switches; G[, [____]]

SD-06 Test Reports

Factory Test Report; G[, [____]]

Acceptance Test Report; G[, [____]]

SD-10 Operation and Maintenance Data

Medium Voltage Switches

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in

these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

Ensure products manufactured more than 3 years prior to date of delivery to site not be used, unless specified otherwise.

1.3.3 Delivery, Storage, and Handling

Handle and store medium voltage switches in accordance with manufacturer's recommendations. Ensure switches are shipped preassembled from the manufacturer.

1.3.4 Predictive Testing and Inspection Technology Requirements

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

PART 2 PRODUCTS

2.1 EQUIPMENT

Provide [manually][automatically] operated, load-interrupting type medium voltage switches for use on a 3-phase, [3][4]-wire system and with ratings as follows:

a. [15][ ] kV Maximum Design Voltage

b. [110][ ] kV Basic Impulse Level (BIL)

c. [600][ ] A Minimum Continuous Current

d. [600][ ] A Minimum Load Break Current

e. [12.5][ ] kA Symmetrical Fault Interrupter Rating

f. [20][ ] kA Asymmetrical Fault Interrupter Rating

Submit product data for medium voltage switches including manufacturer's assembly drawings detailing switch construction, configuration, and mounting and installation.

Provide switches with suitable attachments to permit closing and opening under full rated load current, without damage. Ensure switches are equipped with a visible break option that allows direct viewing or indication of the switch contacts in the open and closed positions.

Provide cable and cable terminations in accordance with Section 26 05 13.00 40 MEDIUM-VOLTAGE CABLES. Equip switches with [600][200] ampere bushing wells and bushing well inserts to accept load break elbows, as indicated.

Provide fittings, lifting eyes, insulators, and other required accessories with the switch as necessary for transportation and installation of the equipment.

Provide all corrosion-resistant metal operating parts of switch assemblies.

2.1.1 Solid Dielectric Switches

Provide [indoor][outdoor] rated switch with switched and protected ways as indicated and rated for the required continuous load and interrupting current. Ensure switch is designed for [front[and]][rear] access to operators, bushings, and terminations. Provide switch enclosures constructed in accordance with [IEEE C57.12.28][IEEE C57.12.29] equipped with ground bus capable of carrying the rated fault current for one second for each way. Ensure enclosure is equipped with hinged access doors equipped with penta head locking bolts and provisions for padlocking.

Provide switch of dead-front design with stainless steel operating mechanism housing equipped with a viewing window for verification of vacuum interrupter contact position with indicator position labeling visible from viewing window. Ensure each switched way is equipped with a two position switch for "Open" position, "Closed" position, and has provisions for grounding.

Provide solid dielectric modules coated with a semi-conductive layer of epoxy tested to IEEE 592. Ensure modules are fully sealed and tested to to prevent ingress of moisture and designed to interrupt all load and fault currents within the vacuum bottle. Provide fault interrupter assembly consisting of switch mechanism consisting of three individual vacuum bottle assemblies mechanically linked to a single spring-assisted operating mechanism. Ensure manual opening and closing of each way is via an operating handle.

Provide stainless steel three line diagram and nameplates installed on switch. Ensure nameplates indicate the manufacturer's name, catalog number, model number, date of manufacture, and serial number.

2.1.2 Sulfur Hexafluoride (SF6) Switches

Provide [indoor][outdoor] rated switch with switched and protected ways as indicated and rated for the required continuous load and interrupting current. Ensure switch is designed for [front[and]][rear] access to operators, bushings, and terminations. Provide switch enclosures constructed in accordance with [IEEE C57.12.28][IEEE C57.12.29] equipped with ground bus capable of carrying the rated fault current for one second for each way. Ensure enclosure is equipped with hinged access doors equipped with penta head locking bolts and provisions for padlocking.

Provide switch with contacts and cable entrance terminations contained in a single welded, [mild steel][304 stainless steel] tank. Ensure switch is factory filled with SF6 gas conforming to ASTM D2472 to a nominal 10 psig positive pressure at 75 degrees F. Paint switch tank using a corrosion resistant-epoxy paint. Ensure switch is equipped with [temperature compensated] SF6 gas pressure gauge and fill valve.[Equip switch with low pressure warning device and dry contact for remote notification if SF6 pressure falls below manufacturer recommended levels.]

Provide switch of dead-front design with stainless steel operating mechanism housing equipped with a viewing window for verification of vacuum interrupter contact position with indicator position labeling visible from viewing window. Ensure each switched way is equipped with a two position switch for "Open" position, "Closed" position, and has provisions for grounding.

Provide solid dielectric modules coated with a semi-conductive layer of epoxy tested to IEEE 592. Ensure modules are fully sealed and tested to to prevent ingress of moisture and designed to interrupt all load and fault currents within the vacuum bottle. Provide fault interrupter assembly consisting of switch mechanism consisting of three individual vacuum bottle assemblies mechanically linked to a single spring-assisted operating mechanism. Ensure manual opening and closing of each way is via an operating handle.

Provide stainless steel three line diagram and nameplates installed on switch. Ensure nameplates indicate the manufacturer's name, catalog number, model number, date of manufacture, and serial number.

Provide provisions for padlocking each handle in any position.

2.2 COMPONENTS

Provide fuses located in a separate compartment on the outgoing feeders as indicated and per Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

2.2.1 Factory Finish

Provide switches with the manufacturer's standard paint finish when used for most indoor installations.

For harsh indoor environments (any area subjected to chemical and/or abrasive action), and all outdoor installations, refer to [Section 09 96 00 HIGH-PERFORMANCE COATINGS][09 90 00 PAINTS AND COATINGS].

Paint [switchgear tank and support frame][enclosure including base] ASTM D1535 Munsell 7GY3.29/1.5 green. Comply with [IEEE C57.12.28][IEEE C57.12.29] for the paint coating system regardless of equipment material.

2.2.2 Pad-Mounting Provisions

Provide mounting frames that are of angle-iron construction, for all [pad] [_____] -mounted switches and are hot-dipped galvanized after fabrication in accordance with [ASTM A123/A123M] [ASTM A153/A153M].

2.2.3 Cable Entrances

Provide cable entrances tested to IEEE 386 and be minimum [15][ ] kV, [110][ ] kV BIL, [600][200] A [dead][load] break apparatus bushings.

2.2.4 Space Heaters

Permanently mark connection diagrams for heater connections on detail drawings and shipping covers.

Equip ventilated cable termination compartment and the fuse compartment on outdoor switches with externally energized space heaters to provide approximately [4] [_____] watts/square foot of outer surface area. Provide heaters that have a power density that does not exceed [4] [_____] watts per square inch of heater element surface. Provide heaters that are rated at [240] [_____] volts for connection at [120] [_____] volts. Locate heaters at the lowest portion of each space to be heated. Cover terminals. Use thermostats to regulate the temperature.

Provide installed and operable heaters at the time of shipment so that the heaters can be operated immediately on arrival at the site, during storage, or before installation. Mark connection locations prominently on drawings and shipping covers with temporary leads for storage operation easily accessible without removal of shipping protection.

[2.2.5 Interrupter Control

Provide an electronic control to monitor load and fault current on all three phases of the interrupter. Ensure the current transformers are encapsulated within the [solid dielectric modules][switch tank] to provide control power and current sensing. Ensure no external power source is required for overcurrent protection.

Ensure the controller provides multiple Time Current Characteristic (TCC) curves and all settings may be inputted via the controller's display or via a computer. Ensure the controller allows for multiple TCC curve modification options, including Instantaneous Trip, Inrush Restraint, Phase Time Delay and a Phase Imbalance (Ground Fault) setting.[Provide a controller that includes a Sequence of Events Recorder (SER) which records the last 16 causes of trip.]

Mount controller in a separate NEMA 4X, stainless steel junction box.[Provide 2, Form C (Single Pole, Double Throw) auxiliary contacts on all ways wired to separate terminal strips in controller junction box].

Provide manufacturer's programming kit for controller.

]2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Factory Test Report

Submit factory test report which include results of design and production tests performed according to IEEE C37.74 to ensure that design performance is maintained in production. Tests are to include but are not limited to:

a. Mechanical operation check.

b. AC hi-potential tested one minute phase-to-phase, phase-to-ground and across the open contacts.

c. Circuit resistance testing.

d. Leak test to insure the integrity of all seals and gaskets[

e. Primary current injection test to test CTs, trip mechanism, and electronic control.][

f. X-ray inspection and a partial discharge test of solid dielectric modules to ensure void-free construction.][

g. SF6 leak tests to ensure that the completed switch assembly has a leak rate less than 0.0000001 cubic centimeters per second by a helium mass spectrometer test.]

PART 3 EXECUTION

3.1 INSTALLATION

Install switches in accordance with the manufacturer's instructions. Include in the installation all necessary hardware, insulators, and connections to line wire or bus. Ensure installation is in accordance with IEEE C2 and NFPA 70.

3.1.1 Grounding

Solidly bond tanks, mounting frames, and operating mechanisms to the station ground counterpoise in accordance with IEEE C37.74 and Section 26 05 26.00 40GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

Identify incoming line position with a warning tag that states "CAUTION: INCOMING LINE, DO NOT GROUND."

3.2 FIELD QUALITY CONTROL

3.2.1 Acceptance Testing

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

Perform acceptance testing in accordance with the manufacturer's recommendations, NFPA 70B, and NETA ATS. Submit acceptance test report documenting result

[3.2.2 Coordination

Program settings into medium voltage switch controllers in accordance with the final, Government approved coordination study.

]3.3 CLOSEOUT ACTIVITIES

Submit operation and maintenance manuals for medium voltage switches.

-- End of Section --

SECTION 33 77 36.00 40

MEDIUM-VOLTAGE UTILITY FUSES
05/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE 399	(1997) Brown Book IEEE Recommended Practice for Power Systems Analysis
IEEE C37.40	(2003; Errata 2003; R 2009) Service Conditions & Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, & Accessories
IEEE C37.41	(2016; Corr 2017) Design Tests for High-Voltage (>1000 V) Fuses and Accessories
IEEE C37.42	(2016) Specifications for High-Voltage (> 1000 V) Fuses and Accessories
IEEE C37.46	(2010) Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
IEEE C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA

20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022)
National Electrical Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Distribution Fuse Cutouts; G[, [____]]

SD-07 Certificates

Testing Certificates

SD-08 Manufacturer's Instructions

Fuse Cutouts

Manufacturer's Installation Instructions

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit fabrication drawings for fuse cutouts consisting of fabrication and assembly details to be performed in the factory.

Submit equipment and performance data for distribution fuse cutouts including life, testing certificates verifying conformance to referenced standards, system functional flows, safety features, and mechanical automated details.

2.2 EQUIPMENT

2.2.1 Standards

Ensure distribution fuse cutouts conform to the following standards:

a. IEEE C37.40

b. IEEE C37.41

c. IEEE C37.42

d. IEEE C37.46

e. IEEE C37.47

f. IEEE 242

g. IEEE 399

h. NEMA ICS 3

i. NEMA ICS 6

k. NFPA 70

2.2.2 Fuse Cutouts

Submit manufacturer's instructions for fuse cutouts, including special provisions required to install equipment components and system packages. Include special notices detailing impedances, hazards, and safety precautions.

Ensure that distribution fuse cutouts are self-contained, enclosed, dropout type, or open type when required for higher voltage or interrupting rating. Install loadbreak cutouts only if specifically indicated.

Ensure the interrupting capacity is sufficient to break the maximum system fault current to which the cutout will be subjected. The minimum interrupting capacity is 16,000 amperes (A) root mean square (rms) asymmetric.

Provide that heavy-duty or extra-heavy-duty classification cutouts. Ensure cutouts installed on three-phase, 13.2 kilovolt (kV) or 13.8 kV systems that are rated at 15 kV. The installation of cutouts rated at 7.8 kV on these systems is not allowed.

Provide fuse links with a continuous rating equal to approximately 150 percent of the full-load line current when used for transformer protection, and approximately [100][110][_____] percent of the conductor-rated capacity when used for circuit protection. Ensure that the 15 kV cutout has a wet withstand, 10-second voltage rating of 37 kV, with a 95 kV basic impulse level (BIL). Provide a continuous current rating of 100 A unless otherwise indicated. Provide fuse disconnects rated not less than 100 amperes, having attachments to permit manual operation of the disconnect under load without external arcing.

Where indicated, combine lightning arresters and fuse cutouts.

PART 3 EXECUTION

3.1 INSTALLATION

Install distribution fuse cutouts in accordance with installation drawings and with the manufacturer's installation instructions.

-- End of Section --

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SECTION 33 82 00

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2016) Optical Fiber Outside Plant Communications Cable; 4th Edition
ICEA S-98-688	(2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements
ICEA S-99-689	(2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C62.61	(1993) American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-46A	(1990) FOTP-46 Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers
TIA-455-78-B	(2020c) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-455-107	(1999a) FOTP-107 Determination of Component Reflectance or Link/System Return Loss using a Loss Test Set
TIA-472D000	(2007b) Fiber Optic Communications Cable for Outside Plant Use
TIA-492AAAA	(2009b) 62.5-um Core Diameter/125-um Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers
TIA-492AAAB	(2009a) 50-Um Core Diameter/125-Um Cladding Diameter Class IA Graded-Index Multimode Optical Fibers
TIA-492CAAA	(1998; R 2002) Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers
TIA-492E000	(1996; R 2002) Sectional Specification for Class IVd Nonzero-Dispersion Single-Mode Optical Fibers for the 1550 nm Window
TIA-526-7	(2015a; R 2022) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC 61280-4-2 edition 2: Fibre-Optic Communications Subsystem Test Procedures - Part 4-2: Installed Cable Plant - Single-Mode Attenuation and Optical Return Loss Measurement
TIA-526-14	(2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber

Cable Plant

TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-568.2	(2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568.3	(2016d; Add 1 2019) Optical Fiber Cabling Components Standard
TIA-569	(2019e) Telecommunications Pathways and Spaces
TIA-590	(1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
TIA/EIA-455	(1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction
RUS Bull 345-50	(1979) Trunk Carrier Systems (PE-60)
RUS Bull 345-65	(1985) Shield Bonding Connectors (PE-65)
RUS Bull 345-72	(1985) Filled Splice Closures (PE-74)
RUS Bull 345-83	(1979; Rev Oct 1982) Gas Tube Surge Arrestors (PE-80)
RUS Bull 1751F-630	(1996) Design of Aerial Plant
RUS Bull 1751F-640	(1995) Design of Buried Plant, Physical Considerations

RUS Bull 1751F-643	(2002) Underground Plant Design
RUS Bull 1751F-815	(1979) Electrical Protection of Outside Plant
RUS Bull 1753F-201	(1997) Acceptance Tests of Telecommunications Plant (PC-4)
RUS Bull 1753F-401	(1995) Splicing Copper and Fiber Optic Cables (PC-2)

UNDERWRITERS LABORATORIES (UL)

UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 497	(2001; Reprint Jul 2013) Protectors for Paired Conductor Communication Circuits
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

1.2 RELATED REQUIREMENTS

[Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING SYSTEM,][Section 33 71 01, OVERHEAD TRANSMISSION AND DISTRIBUTION, and[Section 33 71 02, UNDERGROUND ELECTRICAL DISTRIBUTION] apply to this section with additions and modifications specified herein.

]1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, TIA-606, and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect - (MC).)

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, poles, etc. required to provide signal paths from the closest point of presence to the new facility, including free standing frames or backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at the entrance facility. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use.[The telecommunications contractor must coordinate with the NMCI contractor concerning layout and configuration of the EF telecommunications and OSP. The telecommunications contractor may be required to coordinate work effort for access to the EF telecommunications and OSP with the NMCI contractor.]

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G[, [_____]]

Telecommunications Entrance Facility Drawings; G[, [_____]]

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Wire and Cable; G[, [_____]]

Cable Splices, and Connectors; G[, [_____]]

Closures; G[, [_____]]

Building Protector Assemblies; G[, [_____]]

Protector Modules; G[, [_____]]

Cross-Connect Terminal Cabinets; G[, [_____]]

[Spare Parts; G[, [_____]]

] Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required for certificates in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Pre-installation Tests; G[, [_____]]

Acceptance Tests; G[, [_____]]

Outside Plant Test Plan; G[, [_____]]

SD-07 Certificates

Telecommunications Contractor Qualifications; G[, [_____]]

Key Personnel Qualifications; G[, [_____]]

Minimum Manufacturer's Qualifications; G[, [_____]]

SD-08 Manufacturer's Instructions

Building Protector Assembly Installation; G[, [_____]]

Cable Tensions; G[, [_____]]

Fiber Optic Splices; G[, [_____]]

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G[, [_____]]

SD-10 Operation and Maintenance Data

Telecommunications Outside Plant (OSP), Data Package 5; G[, [_____]]

Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications outside plant (OSP). Submit operations and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein not later than[2][_____] months prior to the date of beneficial occupancy. In addition to requirements of Data package 5, include the requirements of paragraphs TELECOMMUNICATIONS OUTSIDE PLANT SHOP DRAWINGS and TELECOMMUNICATIONS ENTRANCE FACILITY DRAWINGS.

SD-11 Closeout Submittals

Record Documentation; G[, [_____]]

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground system design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA-606. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in specification and drawings.[Provide Registered Communications Distribution Designer (RCDD) approved drawings of the telecommunications outside plant.][Update existing telecommunication Outside Plant T0 drawings to include information modified, deleted or added as a result of this installation in accordance with TIA-606.] The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals.

1.6.1.2 Telecommunications Entrance Facility Drawings

[Provide T3 drawings for EF Telecommunications in accordance with TIA-606 that include telecommunications entrance facility plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and[cabinet][, rack][, backboard][and] wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.][Provide T3 drawings for EF Telecommunications as specified in the paragraph TELECOMMUNICATIONS SPACE DRAWINGS of Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.] The telecommunications entrance facility shop drawings shall be included in the operation and maintenance manuals.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel.

Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, the supervisor (if different from the installer), and the cable splicing and terminating personnel. A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

Supervisors and installers assigned to the installation of this system or any of its components shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.

Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications outside plant systems, including broadband cabling, and provide the names and locations of at least two project installations successfully completed using[optical fiber and] copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer's Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of[3][_____] years experience in the manufacturing, assembly, and factory testing of components which comply with, TIA-568.1, TIA-568.2 and TIA-568.3. In addition, cabling manufacturers shall have a minimum of[3][_____] years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the[copper conductor][and][optical fiber] cables, components, and accessories for approval by the Contracting Officer. Include a cut-over plan with procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least[30][_____] days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with TIA-568.1 and RUS Bull 1753F-201. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least[2][1] year[s] prior to bid opening. The[2][1]-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the[2][1]-year period. Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.4.1 Alternative Qualifications

Products having less than a[2][1]-year field service record will be acceptable if a certified record of satisfactory field operation for not less than[6000][3000] hours, exclusive of the manufacturers' factory or laboratory tests, is provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5.1 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels in [500][1000][_____] feet length with a minimum overage of 10 percent. Radius of the reel drum shall not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this project.

[Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided[in hard copy format][on electronic media using Windows based computer cable management software.][A licensed copy of the cable management software including documentation, shall be provided.][Update existing record documentation to reflect campus distribution T0 drawings and T3 drawing schedule information modified, deleted or added as a result of this installation.] Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall [include only the required data fields][include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility]in accordance with TIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - Provide a record of installed patch panels, cross-connect points, campus distributor and terminating block arrangements and type in accordance with TIA-606. Documentation shall include [only]the required data fields[as a minimum] in accordance with TIA-606.

][Provide record documentation as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

][1.8.2 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking. Spare parts shall be provided no later than the start of field testing.

]1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Building Protector Assemblies

Provide self-contained[5 pin][screw type] unit supplied with a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for [_____] pairs of outside cable. Building protector assembly shall have interconnecting hardware for connection to interior cabling at full capacity. Provide manufacturers instructions for building protector assembly installation. Provide copper cable interconnecting hardware as specified in Section 27 10 00 BUILDING

TELECOMMUNICATIONS CABLING SYSTEM.

2.2.2 Protector Modules

Provide in accordance with UL 497[three][two]-electrode gas tube or solid state type[5 pin][screw type] rated for the application. Provide gas tube protection modules in accordance with RUS Bull 345-83 and shall be[heavy duty, A>10kA, B>400, C>65A][maximum duty, A>20kA, B>1000, C>200A] where A is the maximum single impulse discharge current, B is the impulse life and C is the AC discharge current in accordance with ANSI C62.61. The gas modules shall shunt high voltage to ground, fail short, and be equipped with an external spark gap and heat coils in accordance with UL 497. Provide the number of surge protection modules equal to the number of pairs of exterior cable of the building protector assembly.

2.2.3 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Aerial Cable Closures

Provide cable closure assembly consisting of a frame with clamps, a lift-off polyethylene cover, cable nozzles, and drop wire rings. Closure shall be suitable for use on Figure 8 cables. Closures shall be free breathing and suitable for housing[straight-through type][branch type][of the type indicated] splices of non-pressurized communications cables and shall be sized as indicated. The closure shall be constructed with ultraviolet resistant PVC.

2.3.1.2 Underground Cable Closures

a. Aboveground: Provide aboveground closures constructed of[not less than 14 gauge steel][ultraviolet resistant PVC] and acceptable for[pole][stake] mounting in accordance with RUS 1755.910. Closures shall be sized and contain a marker as indicated. Covers shall be secured to prevent unauthorized entry.

b. Direct burial: Provide buried closure suitable for enclosing a straight, butt, and branch splice in a container into which can be poured an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity in the buried environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with RUS Bull 345-72.

c. In vault or manhole: Provide underground closure suitable to house a straight, butt, and branch splice in a protective housing into which can be poured an encapsulating compound. Closure shall be of suitable thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with RUS Bull 345-72.

2.3.2 Fiber Optic Closures

2.3.2.1 Aerial

Provide aerial closure that is free breathing and suitable for housing splice organizer of non -pressurized cables. Closure shall be constructed from heavy PVC with ultraviolet resistance.

2.3.2.2 Direct Burial

Provide buried closure suitable to house splice organizer in protective housing into which can be poured an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity, when metallic, in buried environment. Encapsulating compound shall be reenterable and shall not alter chemical stability of the closure.

2.3.2.3 In Vault or Manhole

Provide underground closure suitable to house splice organizer in a protective housing into which can be poured an encapsulating compound. Closure shall be of thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure.

2.4 PAD MOUNTED CROSS-CONNECT TERMINAL CABINETS

Provide in accordance with RUS 1755.910 and the following:

a. Constructed of 14 gauge steel or [_____].

b. Equipped with a double set of hinged doors with closed-cell foam weatherstripping. Doors shall be locked and contain a marker as indicated.

c. Equipped with spool spindle bracket, mounting frames, binding post log,[and] jumpering instruction label[, and load coil mounting provisions].

d. Complete with cross connect modules to terminate number of pairs as indicated.

e. Sized as indicated.

2.5 CABLE SPLICES, AND CONNECTORS

2.5.1 Copper Cable Splices

Provide[multipair,[foldback][in-line]][single pair,[in-line][butt][box tap]] splices of a moisture resistant,[two][three][_____]-wire [insulation displacement] connector held rigidly in place to assure maximum continuity in accordance with RUS Bull 1753F-401. Cables greater than 25 pairs shall be spliced using multipair splicing connectors, which accommodate 25 pairs of conductors at a time. Provide correct connector size to accommodate the cable gauge of the supplied cable.

[2.5.2 Copper Cable Splice Connector

Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 22 to 26 AWG solid wire with a maximum insulation diameter of 0.065 inch. Fill connector with sealant grease to make a moisture resistant connection, in accordance with RUS Bull 1753F-401.

][2.5.3 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for[fusion][mechanical] methods at locations shown on the construction drawings. The splice insertion loss shall be 0.3 dB maximum when measured in accordance with TIA-455-78-B using an Optical Time Domain Reflectometer (OTDR). Splices shall be designed for a return loss of 40.0 db max for single mode fiber when tested in accordance with TIA-455-107. Physically protect each fiber optic splice by a splice kit specially designed for the splice.

][2.5.4 Fiber Optic Splice Organizer

Provide splice organizer suitable for housing fiber optic splices in a neat and orderly fashion. Splice organizer shall allow for a minimum of 3 feet of fiber for each fiber within the cable to be neatly stored without kinks or twists. Splice organizer shall accommodate individual strain relief for each splice and allow for future maintenance or modification, without damage to the cable or splices. Provide splice organizer hardware, such as splice trays, protective glass shelves, and shield bond connectors in a splice organizer kit.

]2.5.5 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor in accordance with RUS Bull 345-65.

2.6 CONDUIT

Provide conduit as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.7 PLASTIC INSULATING TAPE

UL 510.

2.8 WIRE AND CABLE

2.8.1 Copper Conductor Cable

Solid copper conductors, covered with an extruded solid insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable core wrapping material, a corrugated copper or plastic coated aluminum shield, and an overall extruded jacket. Telecommunications contractor shall verify distances between splice points prior to ordering cable in specific cut lengths. Gauge of conductor shall determine the range of numbers of pairs specified; 19 gauge (6 to 400 pairs), 22 gauge (6 to 1200 pairs), 24 gauge (6 to 2100 pairs), and 26 gauge (6 to 3000 pairs). Copper conductor shall conform to the following:

2.8.1.1 Underground

Provide filled cable meeting the requirements of ICEA S-99-689 and [RUS 1755.390] [RUS 1755.890].

2.8.1.2 Aerial

Provide filled cable meeting the requirements of[ICEA S-99-689][ICEA S-98-688], and RUS 1755.390 except that it shall be suitable for aerial installation and shall be Figure 8 distribution wire with 6,000 pound Class A galvanized steel or 6,000 pound aluminum-clad steel strand.

2.8.1.3 Screen

Provide screen-compartmental core cable filled cable meeting the requirements of ICEA S-99-689 and RUS 1755.390.

2.8.2 Fiber Optic Cable

Provide[single-mode, 8/125-um, 0.10 aperture 1310 nm fiber optic cable in accordance with TIA-492CAAA][single-mode, 8/125-um, 0.10 aperture 1550 nm fiber optic cable in accordance with TIA-492E000][and][multimode 62.5/125-um, 0.275 aperture fiber optic cable in accordance with TIA-492AAAA][multimode 50/125-um, 0.275 aperture fiber optic cable in accordance with TIA-492AAAB], TIA-472D000, and ICEA S-87-640 including any special requirements made necessary by a specialized design. Provide[12][____] optical fibers[as indicated]. Fiber optic cable shall be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with TIA/EIA-598

2.8.2.1 Strength Members

Provide[central][non-central],[non-metallic][metallic] strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a pulling strength member.

[2.8.2.2 Shielding or Other Metallic Covering

Provide[copper, copper alloy or copper and steel laminate][copper and stainless steel, coated stainless steel or bare low carbon steel][bare aluminum or coated aluminum],[single][dual] tape covering or shield in accordance with ICEA S-87-640.

]2.8.2.3 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.8.3 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B8, for sizes No. 6 AWG and larger. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.9 T-SPAN LINE TREATMENT REPEATERS

Provide as indicated. Repeaters shall be pedestal mounted with non-pressurized housings, sized as indicated and shall meet the requirements of RUS Bull 345-50.

2.10 POLES AND HARDWARE

Provide poles and hardware as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

2.11 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags shall be[stainless steel][or][polyethylene] and labeled[as indicated][in accordance with TIA-606]. Handwritten labeling is unacceptable.

[2.11.1 Stainless Steel

Provide stainless steel, cable tags 1 5/8 inches in diameter 1/16 inch thick minimum, and circular in shape. Tags shall be die stamped with numbers, letters, and symbols not less than 0.25 inch high and approximately 0.015 inch deep in normal block style.

][2.11.2 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

]2.12 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590. Provide color, type and depth of tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 00 00, EARTHWORK.

2.13 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections for dependable shield bonding in accordance with RUS 1755.200. Braid shall be made from flat tin-plated copper.

2.14 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.15 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with[black][_____] center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.16 TESTS, INSPECTIONS, AND VERIFICATIONS

2.16.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA-568.1 and TIA-568.3. Use TIA-526-7 for single mode fiber and TIA-526-14 Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of ICEA S-99-689. Enhanced performance air core OSP copper cables shall meet the requirements of ICEA S-98-688. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

3.1.3 Direct Burial System

Installation shall be in accordance with RUS Bull 1751F-640. Under railroad tracks, paved areas, and roadways install cable in conduit encased in concrete. Slope ducts to drain. Excavate trenches by hand or mechanical trenching equipment. Provide a minimum cable cover of 24 inches below finished grade. Trenches shall be not less than 6 inches wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a radius of not less than [36][_____] inches. Where two or more cables are laid parallel in the same trench, space laterally at least 3 inches apart. When rock is encountered, remove it to a depth of at least 3 inches below the cable and fill the space with sand or clean earth free from particles larger than 1/4 inch. Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position. Provide color, type and depth of warning tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 00 00 EARTHWORK.

3.1.3.1 Cable Placement

a. Separate cables crossing other cables or metal piping from the other cables or pipe by not less than [3][_____] inches of well tamped earth. Do not install circuits for communications under or above traffic signal loops.

b. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.

c. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

d. Leave a horizontal slack of approximately 3 feet in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought aboveground. Where cable is brought aboveground, leave additional slack to make necessary connections.

3.1.3.2 Identification Slabs [Markers]

Provide a marker at each change of direction of the cable, over the ends of ducts or conduits which are installed under paved areas and roadways and over each splice. Identification markers shall be of concrete, approximately 20 inches square by 6 inches thick.

3.1.3.3 Backfill for Rocky Soil

When placing cable in a trench in rocky soil, the cable shall be cushioned by a fill of sand or selected soil at least 2 inches thick on the floor of the trench before placing the cable or wire. The backfill for at least 4 inches above the wire or cable shall be free from stones, rocks, or other hard or sharp materials which might damage the cable or wire. If the buried cable is placed less than 24 inches in depth[, a protective cover of[metal][concrete] shall be used].

3.1.4 Cable Protection

Provide direct burial cable protection in accordance with NFPA 70 and as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete minimum of 6 inches per 12 inches burial depth beyond the edge of the surface where cable protection is required; all conduits shall be sealed on each end. Where additional protection is required, cable may be placed in galvanized iron pipe (GIP) sized on a maximum fill of 40 percent of cross-sectional area, or in concrete encased 4 inches PVC pipe. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at 6 inches lift so that the earth is restored to the same density, grade and vegetation as adjacent undisturbed material.

3.1.4.1 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.1.5 Underground Duct

Provide underground duct and connections to existing[manholes,][handholes,][concrete pads,][and][existing ducts] as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION with any additional requirements as specified herein.

3.1.6 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.1.7 Penetrations

Caulk and seal cable access penetrations in walls, ceilings and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.8 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.8.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.1.8.2 Pulling Eyes

Equip cables 1.25 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 1.25 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping shall not be beaten into the cable sheath. Use a swivel of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.1.8.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 4 feet. In existing manholes, handholes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with corrosion-resistant embossed metal tags.

3.1.9 Aerial Cable Installation

Pole installation shall be as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Where physical obstructions make it necessary to pull distribution wire along the line from a stationary reel, use cable stringing blocks to support wire during placing and tensioning operations. Do not place ladders, cable coils, and other equipment on or against the distribution wire. Wire shall be sagged in accordance with the data shown. Protect cable installed outside of building less than 8 feet above finished grade against physical damage.

3.1.9.1 Figure 8 Distribution Wire

Perform spiraling of the wire within 24 hours of the tensioning operation. Perform spiraling operations at alternate poles with the approximate length of the spiral being 15 feet. Do not remove insulation from support members except at bonding and grounding points and at points where ends of support members are terminated in splicing and dead-end devices. Ground support wire at poles to the pole ground.

3.1.9.2 Suspension Strand

Place suspension strand as indicated. Tension in accordance with the data indicated. When tensioning strand, loosen cable suspension clamps enough to allow free movement of the strand. Place suspension strand on the road side of the pole line. In tangent construction, point the lip of the suspension strand clamp toward the pole. At angles in the line, point the suspension strand clamp lip away from the load. In level construction place the suspension strand clamp in such a manner that it will hold the strand below the through-bolt. At points where there is an up-pull on the strand, place clamp so that it will support strand above the through-bolt. Make suspension strand electrically continuous throughout its entire length, bond to other bare cables suspension strands and connect to pole ground at each pole.

3.1.9.3 Aerial Cable

Keep cable ends sealed at all times using cable end caps. Take cable from reel only as it is placed. During placing operations, do not bend cables in a radius less than 10 times the outside diameter of cable. Place temporary supports sufficiently close together and properly tension the cable where necessary to prevent excessive bending. In those instances where spiraling of cabling is involved, accomplish mounting of enclosures for purposes of loading, splicing, and distribution after the spiraling operation has been completed.

3.1.10 Cable Splicing

3.1.10.1 Copper Conductor Splices

Perform splicing in accordance with requirements of RUS Bull 1753F-401 except that direct buried splices and twisted and soldered splices are not allowed. Exception does not apply for pairs assigned for carrier application.

3.1.10.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss[not greater than 0.2 dB for fusion splices][not greater than 0.4 db for mechanical splices].

3.1.11 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, shall have surge protection installed at each end which meet the requirements of RUS Bull 1751F-815.

3.1.12 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

3.1.12.1 Telecommunications Master Ground Bar (TMGB)

The TMGB is the hub of the basic telecommunications grounding system providing a common point of connection for ground from outside cable, CD, and equipment. Establish a TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.12.2 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs. Ground shields of incoming cables in the EF Telecommunications to the TMGB.

3.1.12.3 Campus Distributor Grounding

a. Protection assemblies: Mount CD protector assemblies directly[on the telecommunications backboard][in the telecommunications [rack][cabinet]]. Connect assemblies mounted on each vertical frame with No. 6 AWG copper conductor to provide a low resistance path to TMGB.

[b. TMGB connection: Connect TMGB to TGB with copper conductor with a total resistance of less than 0.01 ohms.

][3.1.13 Cut-Over

All necessary transfers and cut-overs, shall be accomplished by the telecommunications contractor.

]3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware shall be provided using[thermal ink transfer process][laser printer][_____].

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice.[Tag only new wire and cable provided by this contract.][Tag new wire and cable provided under this contract and existing wire and cable which are indicated to have splices and terminations provided by this contract.] The labeling of telecommunications cable tag identifiers shall be[as indicated][in accordance with TIA-606].[Tag legend shall be as indicated.] Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks and protection modules using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

[Provide ferrous metallic enclosure finishes in accordance with the following procedures. Ensure that surfaces are dry and clean when the coating is applied. Coat joints and crevices. Prior to assembly, paint surfaces which will be concealed or inaccessible after assembly. Apply primer and finish coat in accordance with the manufacturer's recommendations.][Provide ferrous metallic enclosure finishes as specified in Section 09 90 00 PAINTS AND COATINGS.]

[3.3.1 Cleaning

Clean surfaces in accordance with SSPC SP 6/NACE No.3.

][3.3.2 Priming

Prime with a two component polyamide epoxy primer which has a bisphenol-A base, a minimum of 60 percent solids by volume, and an ability to build up a minimum dry film thickness on a vertical surface of 5.0 mils. Apply in two coats to a total dry film thickness of 5 to 8 mils.

][3.3.3 Finish Coat

Finish with a two component urethane consisting of saturated polyester polyol resin mixed with aliphatic isocyanate which has a minimum of 50 percent solids by volume. Apply to a minimum dry film thickness of 2 to 3 mils. Color shall be the manufacturer's standard.

]3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 FIELD QUALITY CONTROL

Provide the Contracting Officer[10][_____] working days notice prior to[each][_____] test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.5.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.5.1.1 Cable Capacitance

Perform capacitance tests on at least 10 percent of the pairs within a cable to determine if cable capacitance is within the limits specified.

3.5.1.2 Loop Resistance

Perform DC-loop resistance on at least 10 percent of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

3.5.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least[5][_____] working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

3.5.2 Acceptance Tests

Perform acceptance testing in accordance with RUS Bull 1753F-201 and as further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least[14][_____] days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis.

3.5.2.1 Copper Conductor Cable

Perform the following acceptance tests in accordance with TIA-758:

a. Wire map (pin to pin continuity)

b. Continuity to remote end

c. Crossed pairs

d. Reversed pairs

e. Split pairs

f. Shorts between two or more conductors

3.5.2.2 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455 and as further specified in this section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. In addition, a Bandwidth Test shall be performed on all multimode optical fibers. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber,[66][____] feet minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with TIA-526-7 for single-mode fiber and TIA-526-14 for multimode fiber. Splice losses shall not exceed 0.3 db.

b. Attenuation Test: End-to-end attenuation measurements shall be made on all fibers, in both directions, using a[850][1300][1310][1550] nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with[TIA-455-46A for multimode][and][TIA-526-7 for single-mode] fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.

c. Bandwidth Test: The end-to-end bandwidth of all multimode fiber span links shall be measured by the frequency domain method. The bandwidth shall be measured in both directions on all fibers. The bandwidth measurements shall be in accordance with TIA/EIA-455-204.

3.5.3 Soil Density Tests

[a. Determine soil-density relationships for compaction of backfill material in accordance with ASTM D1557, Method D.

][b. Determine soil-density relationships as specified for soil tests in Section 31 00 00 EARTHWORK.

] -- End of Section --

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SECTION 41 22 13.14

BRIDGE CRANES, OVERHEAD ELECTRIC, TOP RUNNING
11/19, CHG 1: 02/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 908 (1989B; R 1999) Information Sheet: Geometry Factors for Determining the Pitting Resistance and Bending Strength of Spur, Helical and Herringbone Gear Teeth

ANSI/AGMA 2001 (2004D; R 2010) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth

ANSI/AGMA 2015-1 (2001A; R 2014) Accuracy Classification System - Tangential Measurements for Cylindrical Gears

ANSI/AGMA 6013 (2006A; R 2016) Standard for Industrial Enclosed Gear Drives

ANSI/AGMA 6113 (2016B) Standard for Industrial Enclosed Gear Drives (Metric Edition)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360 (2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B30.2 (2017) Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)

ASME B30.10 (2019) Hooks

ASME HST-4 (2021) Performance Standard for Overhead Electric Wire Rope Hoists

ASME NOG-1 (2020) Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)

AMERICAN SOCIETY OF SAFETY PROFESSIONALS (ASSP)

ASSP Z359 (2013) Fall Protection Code

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding Code - Steel

AWS D14.1/D14.1M (2019) Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment

ASTM INTERNATIONAL (ASTM)

ASTM A275/A275M (2018) Standard Practice for Magnetic Particle Examination of Steel Forgings

ASTM A668/A668M (2022) Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use

ASTM A931 (2008; R 2013) Standard Test Method for Tension Testing of Wire Ropes and Strand

ASTM A1023/A1023M (2021) Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes

ASTM E125 (1963; R 2013) Photographs for Magnetic Particle Indications on Ferrous Castings

ASTM E543 (2021) Standard Specification for Agencies Performing Non-Destructive Testing

ASTM E1417/E1417M (2016) Standard Practice for Liquid Penetrant Testing

ASTM F3125/F3125M (2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 70 (2015) Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 5	(2017) Industrial Control and Systems: Control Circuit and Pilot Devices
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 8	(2011) Crane and Hoist Controllers
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS (RCSC)

RCSC A348	(2020) RCSC Specification for Structural Joints Using High-strength Bolts

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. AIR FORCE (USAF)

AFMAN 91-118	(2010) Safety Design and Evaluation Criteria for Nuclear Weapon Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.179	Overhead and Gantry Cranes
29 CFR 1910.306	Specific Purpose Equipment and Installations

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 489	(2016; Rev 2019) UL Standard for Safety

	Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1004-1	(2012; Reprint Nov 2020) UL Standard for Safety Rotating Electrical Machines - General Requirements
UL 1449	(2021) UL Standard for Safety Surge Protective Devices

1.2 DEFINITIONS

a. Bridge Crane: That part of an overhead crane system consisting of girder(s), end trucks, end ties, walkway, and drive mechanism which carries the trolley(s) and travels along the runway rails parallel to the runway.

b. Crane Runway: The track system along which the crane operates horizontally, including track hangar rods, track connection devices, and runway structural supports.

c. Dead Loads: The loads on a structure which remain in a fixed position relative to the structure.

d. Girder: The principal horizontal beam of the crane bridge. It is supported by the crane end trucks.

e. Lifted Load: The load consisting of the rated load and the weight of lifting devices attached to the crane such as the load block, bucket, or other supplemental devices.

f. Pendant: A control for a hoist and a crane. The pendant hangs from the hoist or the crane by a cable at a height that is easy for the operator to reach.

g. Rated Load: The maximum working load suspended under the load hook.

h. Standard Commercial Cataloged Product: A product which is currently being sold, or previously has been sold, in substantial quantities to the general public, industry or Government in the course of normal business operations. Models, samples, prototypes or experimental units do not meet this definition. The term "cataloged" as specified in this section is defined as "appearing" on the manufacturer's published product data sheets. These data sheets must have been published or copyrighted prior to the issue date of this solicitation and have a document identification number or bulletin number.

i. Top Running Crane: An electric overhead traveling crane that runs on rails on top of support girders.

j. Trolley Load: Weight of the trolley and its associated equipment carried by the trolley wheels.

k. Operating Environments:

(1) General Purpose Service: This applies to most cranes and are, in

large measure, the manufacturers' standard designs. Cranes should be classified as General Purpose Service if they are operating in routine environments.

(2) Ordnance/Explosives Handling: Cranes handling palletized or unpackaged ammunition, missiles, torpedoes, and other types of ordnance. Minimum requirement of CMAA service class D.

(3) Hazardous (Explosive) Environments: Cranes operating in hazardous environments as defined by the cognizant activity safety office must be equipped with electrical safety features that meet NEC Article 500. The activity safety office will identify the specific Class, Division, and Group, as well as the envelope that the hazard exists, to allow proper design and shall list these in this section. Choose materials for mechanical components to minimize the potential for sparking, typically bronze, stainless steel, or aluminum. Hazardous environments are split into two groups: minimum anti-spark protection and maximum anti-spark protection.

(a) Minimum Anti-Spark Protection is used when only the load block enters the explosive area.

(b) Maximum Anti-Spark Protection is used when the hazardous area envelops the entire crane.

1.3 SYSTEM DESCRIPTION

[The requirements for the crane runway system and rail supporting structures are specified in Section 05 12 00 STRUCTURAL STEEL, and must conform to AISC 360.

]1.3.1 Crane Design Criteria

Cranes will operate in the given spaces and match the runway dimensions and rails indicated. Hook coverage, hook vertical travel, clear hook height, lifting capacity, and load test weight must not be less than that indicated.

1.3.1.1 General

Include the following: Number of cranes [_____], located in building identified as [_____], with the capacity expressed in [_____] tons pounds, for each overhead electric traveling (OET) crane. Also clearly locate and identify each multiple girder hoist and system components.

1.3.1.2 Classification

Provide top running overhead electric traveling (OET) multiple girder crane[s] conforming to CMAA 70 service class [A] [B] [C] [D] [E] [F] for operation in an [indoor] [outdoor] environment, [general purpose] [ordnance handling] [hazardous area] service, meeting the requirements of ASME B30.2, with an ambient temperature range of [_____] to [_____] degrees Fahrenheit. This crane must operate in an NEC Class [_____], Division [_____], Group [_____] hazardous area. Hazardous protection is required for the [full height of the crane][18 inches above ground level][_____]. The crane span must be [_____] feet with a vertical lift of [_____] feet and as specified herein.

The crane must be [pendant controlled] [radio controlled] [cab controlled] and operate in the spaces and within the loading conditions indicated.[The pendant controller must be mounted on a separate festooned cable system from the trolley power supply.] The crane must operate on [_____]-volts AC, [60] [50] [_____] Hz, [single] [three] phase power source. Maximum crane wheel loads (without impact) due to dead, trolley, and lifted loads, with the trolley in any position, must not cause a more severe loading condition in the runway support structure than that produced by the design wheel loads and spacing indicated.

1.3.1.3 Rated Capacity and Speeds

Provide crane with rated capacity of [_____] tons pounds.[Provide auxiliary hoist with [_____] tons pounds capacity.] Lower load block or assembly of hook, swivel bearing sheaves, pins, and frame suspended by the hoisting ropes are not considered part of the rated capacity.

Rated (maximum) speeds plus or minus 10 percent (feet/min) for the main hoist, [auxiliary hoist,] bridge, and trolley at the rated load are specified in the table below. The minimum speed must not exceed the values listed.[Values in the table are for a fully loaded crane. Using overspeed, the hoist function must be capable of [_____] when not loaded.]

Rated Speeds feet/min		
Description	Minimum	Maximum
Main Hoist	[_____]	[_____]
[Auxiliary Hoist]	[_____]	[_____]
Trolley	[_____]	[_____]
Bridge	[_____]	[_____]

1.4 VERIFICATION OF DIMENSIONS

The Contractor is responsible for the coordination and proper relation of their work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overhead Electric Traveling Crane; G[, [_____]]

Complete Schematic Wiring Diagram; G[, [_____]]

Control System and Network Drawings; G[, [_____]]

SD-03 Product Data

Gear Reducers; G[, [_____]]

Hoist Brakes; G[, [_____]]

Travel Brakes; G[, [_____]]

Couplings; G[, [_____]]

Load Blocks and Hooks; G[, [_____]]

Wheels; G[, [_____]]

Hoists; G[, [_____]]

Sheaves; G[, [_____]]

[Commercial Hoist and Trolley Units; G[, [_____]]

] End Trucks; G[, [_____]]

Bridge Rails; G[, [_____]]

End Stops; G[, [_____]]

Bumpers; G[, [_____]]

[Operator's Cab; G[, [_____]]

] Variable Frequency Drives; G[, [_____]]

Motors; G[, [_____]]

Runway Conductor System; G[, [_____]]

Bridge Conductor System; G[, [_____]]

Limit Switches; G[, [_____]]

[Radio Control System; G[, [_____]]

][Pendant Pushbutton Station; G[, [_____]]

][Pendant Conductor System; G[, [_____]]

][Cab Control Station; G[, [_____]]

] Controls; G[, [_____]]

[Control Parameter Settings; G[, [_____]]

] Runway Conductor System; G[, [_____]]

Bridge Conductor System; G[, [_____]]

Capacity Overload Protective Device; G[, [_____]]

[Load Indicating Device; G[, [_____]]

] Painting System; G[, [_____]]

Control System and Network; G[, [_____]]

SD-05 Design Data

Load and Sizing Calculations; G[, [_____]]

SD-06 Test Reports

[Hook Proof Test; G[, [_____]]

][Hook Non-destructive Test (NDT); G[, [_____]]

] Post-erection Inspection; G[, [_____]]

Operational Tests; G[, [_____]]

Hook Tram Measurement; G[, [_____]]

Load Tests; G[, [_____]]

SD-07 Certificates

Wire Ropes; G[, [_____]]

Crane Runway System; G[, [_____]]

Hazardous Material; G[, [_____]]

Loss of Power Test; G[, [_____]]

Coupling Alignment Verification Record; G[, [_____]]

Overload Test; G[, [_____]]

Brake Adjustment Record; G[, [_____]]

Compliance with Listed Standards; G[, [_____]]

Contractor Hazardous Environment; G[, [_____]]

Public Domain Software; G[, [_____]]

Software and Services; G[, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

SD-11 Closeout Submittals

Disabled Ports, Connectors, and Interfaces; G[, [_____]]

Network-Capable Control Devices; G[, [_____]]

Control System Access Control; G[, [_____]]

Control System Account Management; G[, [_____]]

Patch Management and Updates; G[, [_____]]

Malware Detection and Protection; G[, [_____]]

Wireless Technology Provisions; G[, [_____]]

Control System Inventory; G[, [_____]]

Evaluation Status of Hardware and Software; G[, [_____]]

1.6 QUALITY ASSURANCE

1.6.1 Manufacturer Qualification

Overhead Electric Traveling Crane must be designed and manufactured by a company with a minimum of 10 years of specialized experience in designing and manufacturing the type of overhead crane required to meet requirements of the Contract Documents. Crane design shall be accomplished by, or directly supervised by, a registered professional engineer (PE). PE licensing must be by a board or agency authorized to license and register professional engineers. The PE may be a Contractor's regular employee or a consultant. The PE's review and attestation of specification compliance and professional responsibility must be signified by his or her PE original seal and dated signature on the final drawings. The professional engineers must only undertake and perform work under this contract in the branch(s) of engineering in which they are licensed.

1.6.2 Pre-Delivery Inspections

Contractor is responsible for performance of quality control inspections, testing, and documentation. Submit all crane test data recorded on appropriate test record forms suitable for retention for the life of the crane.

1.6.2.1 Inspection of Steel Castings

Visually inspect [and test]load-carrying steel castings[using the magnetic-particle inspection method][using ultrasonic testing].[Reference allowable degree of discontinuities to ASTM E125, and relationship to service loads and stresses, critical configuration, location and type.] All load bearing components, couplings, shafts, and gears, in the hoist drive train must be rolled or forged steel, except brake drums which may be ductile iron. Methods of repairing the discontinuities is subject to review by the Contracting Officer.

1.6.2.2 Inspection of Hook Assembly

Inspect hook[by a magnetic-particle type inspection] [and X-rayed] [and tested ultrasonically] prior to delivery. Furnish documentation of hook inspection to Contracting Officer prior to field operational testing. As part of the acceptance standard, linear indications[greater than 1/16 inch] are not allowed. Welding repairs of hook are not permitted. A hook showing linear indications, damage or deformation is not acceptable and must be replaced immediately.

[1.6.2.2.1 Hook Non-Destructive Test (NDT)

Magnetic-particle inspect the hook over the entire area in accordance with ASTM A275/A275M. Acceptance standard is no defects. A defect is defined as a linear indication that is greater than [1/8 inch][1/16 inch] long. For hooks of non-magnetic material, NDT will be liquid penetrant (PT) method in accordance with ASTM E1417/E1417M. For PT testing of hooks containing stainless steels, titanium, or nickel based alloys, total halogens and Sulphur used in the NDT process must be controlled as specified in T9074-AS-GIB-010/271.

Inspect each hook and shank over the entire surface area by magnetic particle inspection.

a. Procedure: Conduct magnetic particle inspection in accordance with ASTM A275/A275M with the following restrictions: Do not use DC yokes (including switchable AC/DC yokes used in the DC mode) or permanent magnet yokes. Do not use automatic powder blowers or any other form of forced air other than from a hand-held bulb for the application or removal of dry magnetic particles. Remove arc strikes. Equipment ammeters must have an accuracy of plus or minus 5 percent of full scale (equipment ammeter accuracy other than that stated is acceptable provided the MT procedure states that a magnetic field indicator is used to establish and verify adequate field strength for all aspects of the inspection.)

b. Acceptance Criteria: Defects found on the hook will result in rejection of defective items for use on furnished hoist. For this inspection, a defect is defined as a linear indication for which the largest dimension is greater than 1/16 inch.

c. Test Report: Submit a test report of the magnetic particle inspection of each hook provided the Contracting Officer for approval prior to final acceptance of hoist installation. Certify test reports by the testing organization. The performing organization must provide a written statement of certification to ASTM E543, current within one year of the date the NDT was performed. The NDT procedures including technique sheets specific to the types, shapes, and size of the parts being examined must adequately describe the orientation of the hooks within the magnetizing equipment. The performing organization must have the NDT procedures and its technique sheet used for testing of the hook reviewed and approved by an independent Level III examiner. Submit the (Level III examiner) approved procedures, technique sheet, and certification to the Contracting Officer with the test report.

][1.6.2.3 Hook Proof Test

Proof test the load hook per ASME B30.10. Perform the proof test prior to Hook NDT.

]1.6.3 Certificates

All certifications must be dated and bear the original signature (above the printed name) of the authorized representative of the Contractor or the manufacturer of the items or equipment being certified. Each certification will clearly identify the crane, the drives, components, and location (as applicable) to which it applies:

a. Submit a Wire Ropes Certification with the wire rope manufacturer's certification that the rope meets the published breaking strength or the actual breaking strength of a sample taken from the reel and tested. Certification is to be traceable to the hoist, crane, and reel.

b. Submit a Crane Runway System Certificate stating that the new crane will operate properly on the runway; if the crane(s) cannot operate without restriction, the Contractor must indicate crane limitations.

c. Submit a Hazardous Material Certificate that the crane does not contain hazardous material including asbestos, lead, cadmium, chromium, PCBs, or elemental mercury. Products required for the designing and manufacturing of cranes must not contain the prohibited materials.

d. Submit a Loss of Power Test Certificate stating that a test may be performed in which power is removed from the crane while the hoist, bridge, and trolley are in operation.

e. Submit a Certificate of the Coupling Alignment Verification Record.

f. Submit an Overload Test Certificate stating that the crane can be periodically load tested to 125 percent (plus 0 minus 5 percent) of rated load.

g. Submit an Overload Test Certificate stating that the crane can be periodically load tested to 125 percent (plus [0] [_____] minus [5] [_____] percent) of rated load.

h. Submit a Certificate of the Brake Adjustment Record. Provide a brake adjustment record and installation/maintenance manuals for each brake on the crane. Each brake measurement must have a tolerance traceable to the associated brake manual or documentation provided by the brake manufacturer, location of measurements, and the actual brake setting. Changes made to settings of the brake, at any time, will void the record.

i. Submit a Certificate of Compliance with Listed Standards

j. Provide a Contractor Hazardous Environment Certificate stating that the new crane and all associated components excluding the hoist are designed for operation in the hazardous environment specified in the Classification section.

k. The Contractor shall provide a Public Domain Software Certificate declaring that public domain software (e.g., freeware, shareware) is not used in the system.

l. The Contractor shall provide a certificate stating that all Software and Services that are not required for operation and/or maintenance of the product have been removed. The software/services to be removed are identified in paragraph SOFTWARE AND SERVICES.

1.6.4 Drawings: Overhead Electric Traveling Crane

a. Submit drawings showing the general arrangement of all components in plan, elevation, and end views. Show all major features of the crane including: hook approaches on all four sides, clearances and principal dimensions, assemblies of hoist, trolley and bridge drives, motor nameplate data, overcurrent protective device ratings, and electrical schematic drawings. Include weights and centers of gravity of major components. Provide maximum wheel loads (without impact) and spacing imparted to the crane runway system track beams. Indicate the crane speeds along the runway, the trolley speeds along the bridge girder, and the hoist lifting speeds; all speeds indicated are speeds with hoist loaded with rated crane capacity load.

b. Submit shop drawings of all fabricated components. Shop drawing quality must be equivalent to the contract drawings accompanying this solicitation. Drawings must be reviewed, signed, and sealed by a registered professional engineer.

c. Provide integral schedule of crane components on each drawing. The schedule must provide a cross reference between manufacturer data and shop drawings. Components listed on the schedule of crane components must include total quantity, description, original manufacturer, and part number. Distributing agents will not be acceptable in lieu of the original manufacturer.

d. Provide control system and network drawings. Network diagram must show equipment locations, names, models, and IP addresses on network communications schematic for all Programmable Logic Controllers (PLCs), Remote Terminal Unit (RTU), Supervisory Controller, and Other

Network-Capable Devices. In addition, the drawings shall consist of all software block, flow, and ladder diagrams.

1.6.5 Design Data: Load and Sizing Calculations

Submit complete list of equipment and materials, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Submit calculations reviewed, signed, and sealed by a registered professional engineer verifying the load cases, sizing of the bridge girders, end trucks, travel drives, brake selections, and overcurrent protection for motors, controllers, and branch circuits. Provide a list of all codes and standards, design assumptions, equations, specified efficiencies, limits, factors of safety, component ratings, and sources of values used. Include free body diagrams or sketches of each load case.[Include seismic analysis of crane.]

1.6.6 Welding Qualifications and Procedures

Welding must be in accordance with qualified procedures using AWS D14.1/D14.1M as modified. Written welding procedures must specify the Contractor's standard dimensional tolerances for deviation from camber and sweep and not exceed those specified in AWS D14.1/D14.1M and CMAA 70. Welders and welding operators must be qualified in accordance with AWS D1.1/D1.1M or AWS D14.1/D14.1M.

1.7 CRANE SAFETY

Comply with the mandatory and advisory safety requirements of ASME B30.10, ASME B30.2[, ASME HST-4], CMAA 70, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306, and all applicable provisions of 29 CFR 1910 and NFPA 70. Where personal fall arrest anchorages are provided, design anchorages in accordance with ASSP Z359.

[1.7.1 Nuclear Safety Analysis

Nuclear certification, testing, and rules of construction must be in accordance with 29 CFR 1910.147 and ASME NOG-1. Air Force Nuclear certified hoists must meet requirements of AFMAN 91-118. Submit analysis and test reports to Contracting Officer for approval.

]PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide materials and equipment which are standard products of manufacturers regularly engaged in the fabrication of complete and totally functional cranes including necessary ancillary equipment. Material will be free from defects and imperfections that might affect the serviceability and appearance of the finished product. All material must be new and unused.

2.1.2 Nameplates

Secure nameplates to each major component of equipment with the manufacturer's name, address, type or style, model or catalog number, and serial number. Provide two bridge identification plates, one for each side of the bridge. Provide noncorrosive metal identification plates with letters which are easily read from the floor, showing a separate number such as BC-1, BC-2, for each bridge crane.

2.1.3 Capacity Marking

Mark the rated capacity in ton pounds units on each side of the crane on the bridge girders. Capacity marks must be large enough to be clearly visible from the floor. The markings must be positioned to be visible at the operator's position after the crane has been installed.[Provide additional markings in operator's cab.]

2.1.4 Safety Warnings

Affix labels in a readable position to each lift block or control station in accordance with ASME B30.2. Submit safety warnings, diagrams and other instructions suitably framed and protected for display as indicated by the Contracting Officer as follows:

Design and locate the word "WARNING" or other legend to bring the label to the attention of the operator. Provide durable type warning labels and display the following information concerning safe-operating procedures: Cautionary language against lifting more than the rated load; operating the hoist when the hook is not centered under the hoist; operating hoist with twisted, kinked or damaged rope; operating damaged or malfunctioning hoist; operating a rope hoist with a rope that is not properly seated in its hoist drum groove; lifting people; lifting loads over people; and removing or obscuring the warning label.

2.2 STRUCTURAL REQUIREMENTS

Structural requirements must be in accordance with CMAA 70, Section 3. Structural steel materials must conform to the standards permitted in CMAA 70 and AISC 360.

2.2.1 Structural Connections

High-strength bolted structural connections must be designed and installed in accordance with RCSC A348. Bolts must be of ASTM F3125/F3125M Grade A325/A325M or Grade A490/A490M material. Galvanized bolts are not acceptable.

Welded connections must be performed in accordance with AWS D14.1/D14.1M. Allowable stress values must comply with CMAA 70.

2.2.2 Bridge Girder or Girders

Provide [welded structural steel box section] [wide flange beam, standard I-Beam, or section fabricated from rolled plates and shapes] bridge girders. If the ends of bridge girders are notched to fit over the end trucks, the notches must be reinforced with vertical diaphragms and horizontal stiffeners.

2.2.3 Bridge Rails

Provide bridge rails, crane girders and other sections that are straight and true. Make all rail joints flush and true without misalignment of running tread and design to minimize vibration. The gap between adjacent rail ends and the vertical misalignment of running treads shall not exceed 1/32 inch. Solid stock (e.g. square bar, roundstock) is not permitted as bridge rail. Center bridge rail on top flange or position bridge rail over girder web for torsion box girders. Fasten rail to girder with welded clips. Position rail clips in pairs and at not more than 36 inches on center. Bolt bridge rail joints using standard joint bars. Stagger and position rail joints directly over girder diaphragms. Provide a positive stop at bridge rail ends to prevent creep.

2.2.4 End Ties and Bridge Girder End Connections

If equalizing end trucks are used, provide rigid end ties between girders to form a frame that is rigid about the vertical and horizontal axes. If compensating end trucks are used, provide end ties which are rigid about the vertical axis but relatively flexible about the horizontal axis to permit partial rocking motion for wheel load compensation. Provide full depth diaphragms at girder connections and jacking points. Provide horizontal gusset plates at the elevation of top and bottom end tie flanges for connection to girder ends. Make end connections with high-strength bolts in accordance with the Structural Connections section of this specification. Use tapered alignment pins to maintain original shop alignment between bridge girders and end ties/trucks.

2.2.5 End Trucks

Provide [rotating] [fixed axle] type end trucks fabricated from structural steel plate to provide a rigid box section structure. Center wheels between the webs of the box section. Configure bridge and trolley trucks with a feature that limits load movement to 1 inch in the event of wheel or shaft failure. Provide jacking pads for removal of wheel assemblies. Wheel axle bearing seats must be designed such that wheel and axle bearing assembly can be removed with not more than 3 inches of jacking.

[2.2.6 Trolley Frame

Provide trolley frame as a one-piece structural steel weldment. Provide pads for the use of jacks or wedges when changing truck wheels. Make all trolley yokes and load bars of drop forged, cast or rolled steel.[Equip trolley with permanent lifting attachments.]

]2.2.7 End Stops and Bumpers

Fit bridge girders with structural steel end stops. Locate stops to permit maximum trolley travel. Fit bridge end trucks and trolley frames with shock-absorbing bumpers capable of decelerating and stopping the bridge and trolley within the limits stated by 29 CFR 1910 and CMAA 70. Bumpers must fully engage end stops. Mount bumpers so that there is no direct shear on mounting bolts (if any) upon impact. Bumpers must provide adequate clearance between the crane and surrounding structure when compressed to preclude damaging equipment. Ensure bridge and trolley bumper retention in accordance with ASME B30.2. When more than one crane is located and operated on the same runway, bumpers shall be provided on their adjacent ends or on one end of one crane. Fit the other end of the end-truck with a structural steel stop to engage the bumpers of the adjacent crane. Ensure bridge bumpers are properly aligned with runway end stops. Metal to metal contact at the bumper to end stop connection is not permitted.

[2.2.8 Footwalks

Set the location and construction of footwalks conforming to ASME B30.2 and 29 CFR 1910. A structural platform is required on the drive girder side of the crane. The length of the drive side footwalk shall be [adequate to provide access to the trolley and provide sufficient room for mounting control cabinets] [along the entire length of the bridge]. Provide checkered steel flooring for platform.[To give access to the opposite side of the trolley, bridge conductors, or other equipment, mount a footwalk [twice the length of the trolley] [the full length of the girder] on the opposite side of the crane. Provide a cross-over footwalk over an end tie between the two girder footwalks.] Mate the drive side footwalk with the crane access platform. Footwalks must be free of exposed hazardous moving parts and electrical components that may injure personnel and not require the use of safety harnesses or other extraordinary means.

][2.2.9 Operator's Cab

[2.2.9.1 Design

Design and construct operator's cab in accordance with CMAA 70 and ASME B30.2. Locate cab access to facilitate entry and exit by crane operator. Provide space for a carbon-dioxide, dry chemical, or equivalent hand fire extinguisher. In addition to the operator's seat, the cab must have a seat for a back-up operator.

][2.2.9.2 Cab Construction

Provide [fixed cab mounted on bridge] [trolley mounted cab] of the [open] [enclosed] type for [indoor] [outdoor] use, and designed to provide a clear view of the operating floor and hook for the operator.[Provide cab with a suitable [heating] [heating and air conditioning] unit]. Locate cab on the [_____] of the [bridge] [trolley] with the operator facing [_____].[Provide [sliding] [fixed] windows of laminated safety type glass.]

]]2.2.10 Additional Provisions for Outside Service

Seal weld structural members on outdoor cranes. Provide crane bridges with parking brakes which will sufficiently hold the crane against a wind pressure of 5 psf for in-service conditions. Provide crane bridges with manually-operated pin locks at each rail, designed to securely anchor the crane against a wind pressure of 30 psf for out-of-service conditions. Design members to prevent the collection of water on crane.

[2.2.11 Seismic Forces

Perform a seismic analysis as a part of the design of the crane in accordance with ASCE 7-16 or ASME NOG-1. The seismic analysis must be included in the CMAA 70 extraordinary load case (Case 3). For project locations beyond the scope of ASCE 7-16, a widely accepted design standard may be used for seismic analysis.

]2.3 MECHANICAL REQUIREMENTS

a. Provide steel shafts, gears, keys, and couplings. Cast iron and aluminum used to support components of the hoist power transmission train must be ductile. Gray cast iron load bearing parts are prohibited.

b. All bearings, except those subject only to small rocker motion, must be anti-friction type. All connections subject only to small rocking motion are to be fitted with bushings or thrust washers in the pivot pin bore, as applicable. Bronze bushings must have provisions for grease lubrication.

c. All mechanical components must be accurately aligned and positively secured to maintain the alignment. Parts must not be forced into position to obtain apparent alignment.

2.3.1 Hoists

Provide hoist conforming to ASME B30.2 and CMAA 70 service class [A] [B] [C] [D] [E] [F] or better, double reeved, except as modified and supplemented in this section.[Standard commercial hoist and trolley units (packaged hoists), if used, must meet ASME HST-4 Duty Class [H1] [H2] [H3] [H4] or better.] For custom hoist shafts, the fatigue design factor must be a minimum of 1.5.

2.3.2 Drives

2.3.2.1 Bridge Drives

Provide [either A-1 or] [A-4] bridge drive arrangement as specified in CMAA 70 consisting of a single electric motor mechanically connected through gear reduction and drive shafts to the drive wheels or separate drive motors at each end of bridge. Outdoor cranes must have half of the total wheels driven.

Acceleration and deceleration must meet the requirements specified in this section. Gears must conform to applicable AGMA standards. Provide oil tight fully enclosed gear reducers with pressure or splash type lubrication. Bridge travel limit switches are optional.

2.3.2.2 Trolley Drives

Provide complete trolley drive arrangement with a minimum of two wheels driven by an integral electric motor. Drive mechanism must run in totally enclosed oil bath. Limit switches are optional for drive mechanism. Acceleration and deceleration controls must meet requirements specified in this section.

2.3.3 Load Blocks and Hooks

The load block must be constructed of steel non-sparking materials and designed to prevent steel-to-steel contact of moving parts. The block must be fully enclosed, concealing the sheaves and wire ropes, except for wire rope slots and drain holes. The block must be clearly marked with the capacity in pounds on both sides. The load block sheaves must be constructed of non-sparking materials.[An insulated link must be provided on each hook block per the requirements of NAVSEA OP-5.] Standard commercial blocks may be used at their published ratings when their published design factors are 5.0 or greater.

Provide an unpainted single barbed forged steel hook complying with ASTM A668/A668M. Provide an unpainted single barbed hook of non-sparking material with a minimum material longitudinal elongation of 16 percent in 2 inches. Bronze clad hooks are prohibited. Hook dimensions must be as shown on the drawings. Fit hook with a safety latch designed to preclude inadvertent displacement of slings from the hook saddle. The hook and hook nut must be removable without unreeving of the hoist. Provide hook nut with a removable type set screw or other similar fastener, installed in a plane parallel to the longitudinal axis of the hook shank. Do not weld hook nut. Uniquely mark the hook in a permanent fashion that is traceable to the NDT certification. The hook nut must be of non-sparking materials. Hook must be free to rotate through 360 degrees when supporting the test load up to 125 percent of the rated capacity. Provide only hooks which are designed and commercially rated in accordance with CMAA and conforming to ASME B30.10 and CMAA 70. Upper hooks of hook suspended hoists shall be of non-sparking materials.

2.3.4 Wire Ropes

a. Wire ropes must conform to ASTM A1023/A1023M and be tested as required by ASTM A931. The wire rope must be in a double reeved configuration and equalized with a sheave. Provide wire rope with a minimum design factor of [5 to 1] [_____ to 1] based on the load experienced at rated capacity and minimum breaking strength of the wire rope.

b. Provide hoisting ropes with improved plow steel, extra improved plow steel, or extra-extra improved plow steel, regular lay, bright, and uncoated with an independent wire rope, wire strand, or otherwise, steel core. Hot-dipped galvanized wire rope is not permitted.

b. Provide stainless steel construction hoist ropes.

c. Maximum hoisting rope fleet angles must be 4 degrees for drums and 4.75 degrees for sheaves. Hoisting rope end connections, other than drum connections, must be speltered sockets with forged steel terminals or swaged fittings installed in a fashion that provides 100 percent of the breaking strength of the wire rope. Provide proof of Wire Rope breaking strength. Wedge sockets or aluminum swages are not permitted on wire rope end connections.

2.3.5 Sheaves

Provide steel sheaves. Minimum pitch diameters must be [16] [18] [20] [24] times the rope diameter for running sheaves, and no less than 12 times the rope diameter for equalizer sheaves. Sheave surfaces which contact wire rope are not to be painted.

The sheaves must be heat treated to a minimum hardness of 320 Brinell Hardness Number (BHN) in the wire rope contact area, have a groove depth not less than 1.5 times the hoisting rope diameter, with a throat angle of 30 to 40 degrees.

2.3.6 Hoist Drum

Provide drum made of steel. Design the drum such that all hoisting rope is wound in a single layer and so that not less than two dead wraps of hoisting rope remain on each anchorage when the hook is in its extreme low position. Drum grooving must be machined right and left hand beginning at the ends and grooving toward the center of the drum. Minimum drum groove depth must be 0.375 times the rope diameter. Minimum drum groove pitch must be either 1.14 times the rope diameter or the rope diameter plus 1/8 inch, whichever is smaller. Minimum drum pitch diameter must be [16] [18] [20] [24] times the rope diameter. Do not paint, coat, or galvanize the surface of the drum which comes in contact with wire rope.

For wire rope drums installed directly onto the output shaft of the hoist speed reducer without an intermediate flexible coupling, the drum to shaft connection must be a barrel coupling.

2.3.7 Gearing

Provide gearing of the enclosed gear reducers type. Provide steel spur, helical, or herringbone type gears and pinions only. Gearing must conform to ANSI/AGMA 2001 and AGMA 908. Internal and external gear dimensional tolerances must conform to the applicable AGMA standard for tooth geometry and tolerances. Open-type gearing is not acceptable, except for final drives.

2.3.7.1 Gear Reducers

Gear reducers must be [integral components of standard hoists or hoist/trolley units of manufacturers regularly engaged in the design and manufacture of hoists or hoist/trolley units for Class A, B, or C cranes][or][standard items of manufacturers regularly engaged in the design and manufacture of gear reducers for Class D and E cranes]. Gear reducers must be designed, manufactured, and rated in accordance with ANSI/AGMA 6113 (ANSI/AGMA 6013) (for trolley drives only), as applicable. Except for final reduction, the gear reduction units must be fully enclosed in oil-tight housing.[Enclosed gearing must be selected for ["Industrial Duty"] ["Mill Duty"].] Gearing must be designed to AGMA standards and operate in an oil bath. Operation must be smooth and quiet.

2.3.7.2 Open Gearing

Provide all gears and pinions with adequate strength and durability for the crane service class and manufactured to ANSI/AGMA 2015-1 Accuracy Grade A8 or better. Open gears must be enclosed with safety guards provided with openings with covers for inspection and access for grease lubrication.

2.3.8 Wheels

Provide double flanged, straight tread trolley and bridge travel wheels of rolled-to-shape or roll-forged steel. Provide double flanged, straight tread trolley and bridge travel wheels of non-sparking materials with sufficient diameter and hardness to meet allowable wheel loads. The rim, flanges, and wheel tread must be hardened to not less than 320 Brinell Hardness Number (BHN). Wheel sizing and flange-to-rail head clearances must be in accordance with CMAA 70 recommendations.

2.3.9 Bridge and Trolley Travel Brakes

Provide bridge and trolley drives with electro-mechanical brakes or non-freecoasting mechanical drive capable of stopping the motion of the bridge or trolley within a distance in feet equal to 10 percent of the full load speed in feet per minute when traveling at full speed with a full load. The brakes must have a minimum torque rating per CMAA 70 according to the applicable environment, but not sized larger than 150 percent of the motor torque. Brakes must have an externally accessible means to manually release the brake. The brakes must be equipped with a manual self-return to ON brake release and designed to permit inspection and adjustment without disassembly of the brake.

2.3.10 Hoist Brakes

a. Equip hoist with a minimum of two holding brakes, each with a minimum torque rating of 125 percent of the rated load hoisting torque.[Provide a brake configuration with [one electro-mechanical or thruster brake and one mechanical load brake that stops and holds 125 percent of the hoist's rated load and does not require the load to be raised before being lowered.] [two electro-mechanical or thruster brakes.]][A mechanical load brake may be utilized in lieu of one of the hoist holding brakes provided it stops and holds 125 percent of the hoist's rated load and does not require the load to be raised before being lowered].

[b. For cranes with two electro-mechanical or thruster brakes, designate each brake as primary or secondary with the primary brake being the brake mounted closer to the motor. Provide the primary brake with a non-time delayed setting and secondary brake with an adjustable setting time delay, set between one to three seconds after the primary brake in any stopping condition. Do not use an uninterruptible power supply (UPS) to create the secondary brake time delay.

] c. Electro-mechanical or thruster brake [must be adjustable to 50 percent of its rated capacity, and]must have an externally accessible means of manual release. On drives where the brakes are utilized as holding brakes only, torque adjustment is not required. The brakes must be equipped with a manual self-return to ON brake release and designed to permit inspection and adjustment without disassembly of the brake.

2.3.11 Couplings

Chain and continuous sleeve type couplings must not be used. Spline couplings are acceptable as installed on c, d, or p-face assemblies. Conventional couplings must not be loaded in the radial direction. Brake wheel or brake disc couplings (if used) must be compatible with the required coupling type. Flexible couplings must not be relied upon to compensate for inaccurate alignment. Ends of coupled shafts must be aligned within the recommended installation criteria of the coupling manufacturer.

[2.3.12 Drip Pans

a. The crane must be designed to preclude leakage of lubricants onto the lifted loads or the floor. Equipment or components, which cannot be made leak-proof, must be fitted with unpainted corrosion resistant steel drip pans or must have the foundations seal welded to create a dam. Drip pans that utilize liquid sealant to prevent leakage of lubricants are not permitted.

b. The drip pans must be sized to hold the entire gear case fluid capacity, installed under all drive machinery, designed to permit easy removal of collected lubricant. A trolley floor designed to contain any lubricant drips may be used as fluid containment for any equipment that is mounted on it.

c. Provide drip pans fitted around the shank of the hook and extending outward to encompass all possible points of lubrication drips from the load block or wire rope. The drip pans must be easily removable without disassembly of the hook or load block and cannot interfere with the crane structure during testing of the upper limits.

]2.4 ELECTRICAL REQUIREMENTS

2.4.1 Motors

Motors must meet all applicable requirements of NEMA MG 1 and UL 1004-1.

All motors must have a minimum of a 60 minute duty rating and be Totally Enclosed Non Ventilated (TENV), Totally Enclosed Fan Cooled (TEFC), or Totally Enclosed Blower Cooled (TEBC).[Provide inverter duty motors for Open Loop Variable Frequency Drives (VFD).][Provide vector duty motors for Closed Loop VFDs.][Provide [two] [single] speed AC squirrel cage induction type motors for the bridge and trolley drives.][Provide two speed, AC squirrel cage induction type motor for the hoist.] Provide motors with a minimum of Class F insulation. Provide motor overload protection utilizing a thermal sensitive device embedded in its windings. Provide motors painted to manufacturer's standard for "wash-down" service. Motors located outdoors must be furnished with anti-condensation heaters that remain energized when the mainline contactor is deenergized.

2.4.2 Controls

[a. Provide static reversing, variable frequency drives (VFD) for the [bridge,] [trolley] [and] [hoist] electric controls.[Provide static reversing, VFD, speed regulated, closed loop, flux vector electric controls for the hoist[s]. For feedback, provide hoist motors with encoders. The hoist controller must enable the drive motor to develop full torque continuously at zero speed. The hoist secondary brake shall be controlled separate from the primary and connected to different output (within the drive) from the primary brake.] VFD controllers must meet NEMA ICS 8, Part 8 and at a minimum, provide under-voltage protection, electronic instantaneous over current protection, DC bus over voltage protection, and be able to withstand output line to line shorts without component failure. Select bridge and trolley drives such that the continuous rating of the controller is not less than the calculated motor full load current based on CMAA 70 5.2.9.1.1.1 and NEC Table 430.250. Select hoist drives such that the continuous rating of the controller is not less than 130 percent of the calculated motor full load current based on CMAA 70 5.2.9.1.1.1 and NEC Table 430.250. All hoist drives must have a motor over-torque limit to lock out the hoist and prevent gross overload of the associated hoist. Provide dynamic braking for each electric drive that is sized per VFD manufacturer's requirements. Submit VFD Control Parameter Settings.

b. Provide speed control which is infinitely variable for each function, controlled via [radio control system][and][pendant pushbutton station][and][cab control station].[Provide controls designed such that the maximum speed of each function will be limited to 25 percent of rated speed when a slow speed switch is actuated on the controller[s]. Energize a yellow/amber light/indicator while in slow speed mode.]

[c. The hoist control system may utilize overspeed up to 120hz, unloaded only, if the drivetrain equipment has all been balanced and is rated for the resulting speed.

] d. The [hoist][,] [trolley][,] and [bridge] brakes must set after the associated controller decelerates the drive motor to a controlled stop. The hoist, trolley, and bridge controllers must be sized to provide sufficient starting torque to initiate motion of that crane drive mechanism from standstill with 0 to 125 percent of rated load on the hook. The hoist controller must prove torque before release of the brakes and enable the drive motor to develop full torque continuously at zero speed. Motors must operate smoothly at all speeds without torque pulsations, and must only be energized within the frequency range of 50-60 Hz at rated speed.

][e. Provide [one][two]-speed magnetic controls for the [bridge drive][,] [trolley drive][,][and][hoist] drive. Controllers must meet the requirements of NEMA ICS 8. Ensure that an energized drive motor initially rotates only in the direction selected by the operator by activating the corresponding direction; i.e., is not overhauled. For AC squirrel cage motor controllers, the requirements of NEMA ICS 2, Part 2, for general-purpose controllers, must be met.

[f. Provide the bridge and trolley motor control systems with a drift point between OFF and the first speed control point in each direction.

]]g. The use of definite purpose contactors is prohibited. If IEC contactors are used, the application cannot exceed the contactor manufacturer's AC3 ratings for the contactor at a minimum.

h. On hoist function roll-up must be less than 1/8 inch measured at the hook block and roll-back must not occur over the entire load range.

i. Use of Uninterruptable Power Supplies (UPS) is prohibited. Feed control circuits from a single phase, air cooled, double wound transformer with a grounded metal screen between the primary and secondary windings of the transformer.

j. Provide a main line contactor. Energization of the main line contactor must be controlled by the POWER-OFF/POWER-ON switch/pushbutton on all controllers. Upon actuation of the POWER-OFF pushbutton; power to all drive motors, brakes, and controls must be removed. The mainline contactor must not be able to be energize while the POWER-OFF pushbutton is actuated. The POWER-OFF pushbutton circuitry must be independent of all controls or any other electronic devices.

2.4.3 Protection

Protection must not be less than that required by NEMA ICS 8, CMAA 70, NFPA 70,UL 1004-1, UL 1449, UL 489, UL 50, UL 943, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306 and all applicable provisions of 29 CFR 1910. Provide enclosed type circuit breaker readily accessible to the crane operator for crane disconnect. Provide an On/Off button that removes power from the motors, brakes and control circuit on all operator control stations[and][or] [radio controllers]. Provide for lockout/tagout of all hazardous energy sources.

2.4.4 Resistors

Provide resistors with natural convection cooling sized as recommended by the VFD OEM and fabricated of corrosion resistant metal; the use of "wire wound" type resistors is prohibited for segments of 8 ohms or less. Mount resistors in substantial, ventilated enclosures constructed entirely of non-combustible materials. When mounted outdoors provide stainless steel resistor enclosures. Provide resistors with terminals fitted in the coolest position in the enclosure.

[2.4.5 Transients and Harmonics Protection

a. Provide contactors and relays with appropriate Metal Oxide Varistors (MOV) or resistor-capacitor (R-C) surge absorbers installed across the respective coil.

b. Provide transient protection for electronic drive controllers that is either internal to the drive or via an MOV connected line-to-ground close to the line terminals of the drive.

c. Provide line reactors rated for continuous duty operation based upon the motor nameplate amperes. With motors of 50 horsepower or greater, harmonics protection must be provided by an isolations transformer or as recommended by the VFD OEM. For a drive motor branch circuit that exceeds 150 feet in length, a reactor must also be connected in series with the controller load (output) terminals to provide standing wave protection or as otherwise recommended by the VFD or motor OEM.

]2.4.6 Limit Switches

a. Limit switches must be rated for the NEC Hazardous Classifications specified in the Classification section of this specification.

b. Provide primary upper and lower geared limit switches. Geared limits must allow reversing direction to back out of the limit without resetting. The lower limit switch must be set such that there are a minimum of two wraps of rope on the hoist drum.

c. Provide a backup mechanical hook block activated upper limit switch wired independent of the directional controllers and the primary upper limit switch that removes power from the hoist motor, hoist brake and hoist controls conforming to NEMA ICS 5. The backup limit must require hoist resetting prior to operation of the hoist in any direction.

[d. Travel limit switches must be provided for the [bridge][and][trolley] motion to slow the crane to [25 percent] [_____] of its rated speed [[10] [_____] feet before the bridge end stops][and][[5] [_____] feet from the trolley end stops]. Limit switches must be mounted rigidly in a manner so as to protect the switch from misalignment or damage. The target/trip arm must be large enough to provide interception given a misalignment were to occur.

]2.4.7 Operator Controls

[a. Provide crane equipped with a [pendant pushbutton station] [cab control station] [radio control system].

][b. Provide crane equipped with both a [pendant pushbutton station] [cab control station] [radio control system] (see paragraph PENDANT PUSHBUTTON STATION) and a [pendant pushbutton station] [cab control station] [radio control system] (see paragraph RADIO CONTROL SYSTEM). Provide a selector switch to allow the use of only one of the two available control stations [in the operator's cab] [on the pendant controller].

] c. If VFD controls are not provided, provide directional contactors with both mechanical and electrical interlocks.

d. Operator controls must be rated for the NEC Hazardous Classifications specified in the Classification section of this specification.

[2.4.7.1 Pendant Pushbutton Station

The cranes must be controlled from a pendant pushbutton station suspended from [the trolley] [an independent festooned messenger track system, operating the length of the bridge]. Provide multiconductor flexible cords for pendant pushbutton stations with No. 16 AWG minimum conductors. Provide a method of strain relief to protect the electrical conductors from damage. Locate the pendant pushbutton station [4 feet] [_____] above the finished floor. Pushbutton pendant station must have its elements legibly marked and arranged vertically, in order, in accordance with CMAA 70.[Provide [one speed] [two speed] [3-step infinitely variable] [2-step infinitely variable] pendant pushbuttons for control of the [hoist] [bridge][and][trolley].] Provide pendant pushbuttons for control that spring return to the OFF position. Voltage in the pendant pushbutton station must not exceed 150 Volts AC or 300 Volts DC.[Provide a maintained two-position selector switch for slow speed selection.] The pendant must be rated for the NEC Hazardous Classifications specified in the Crane Design Criteria "Classification" Section.

[2.4.7.1.1 Pendant Conductor System

Provide a festoon type pendant conductor system. The festoon cables must be flat cables suspended from carriers riding on an I-beam or C-track. The pendant controller must be capable of traveling the entire length of the bridge and move independently of the trolley. Festoon loops must not extend below the high hook position.

]][2.4.7.2 Radio Control System

Provide each system with a [belly box] [handheld] [_____] type portable transmitter unit [and an identical back-up transmitter unit].[Provide each transmitter with an adjustable belt or harness to support it when worn by the operator]. Only one transmitter at a time can control the crane and there must be no interference from one crane's controller affecting operation of the other cranes in the building. Each transmitter must include: individual [infinitely variable spring return joystick motion control levers] [push button controls] for each hoist, trolley, and bridge; a maintained contact, keyed switch, marked ON-OFF, for portable transmitter unit power; indication of Battery Power, and indication of Transmitting Status; a red emergency STOP mushroom pushbutton; [and]a floodlight on/off pushbutton[and a maintained slow speed selector switch]. The transmitters and all controls must each be clearly and permanently labeled with functionality and direction. Directions for controllers must be in accordance with CMAA 70 recommendations. The remote radio control system must be designed to meet the requirements of NEMA ICS 8, Part 9 and ECMA 15. Each radio remote control lever must be in the OFF position before the associated crane function can begin. The system frequency must be within the unlicensed FCC Part 15 range. Each control unit must maintain a continuous status signal to the associated receiver during operation. There must be no significant loss in systems efficiency and function at the end of eight hours of continuous battery use. Provide a contact monitoring board with the crane radio system receiver.

][2.4.7.3 Cab Control Station

All crane motions/functions must be able to be controlled from an integral operator's control chair.[Provide three master switches integrated into the chair, two on the left side and one on the right side.][All master switches must be of the single axis type operating in the forward/reverse direction.][Provide all master switches with infinitely variable speed control to the particular function.] Directional contacts must be utilized to ensure proper motions are executed. Provide all master switches with a detent neutral position. All master switch operating handles must be in the OFF position before any initial crane function can begin. Provide all master switches with dead man controls. All controllers must be clearly and permanently labeled for proper function and direction. Provide pushbuttons that are guarded to prevent accidental activation, except for the STOP/POWER OFF pushbutton.[Directions for controller movement must be in the general direction of movement of load and in accordance with CMAA 70 recommendations. The two left side master switches must control the bridge function (outermost stick) and the trolley function (innermost stick). The right master switch must control the Main hoist.]

[2.4.7.3.1 Left-Hand Operator Control Panel

Identified as follows:

NAMEPLATE: Description - Function.

a. POWER ON: Blue momentary pushbutton - Energizes the mainline contactor as long as all joysticks are in the OFF position.

b. POWER OFF: Push-pull type, red mushroom head pushbutton - Emergency Stop / De-energizes the mainline contactor.

][2.4.7.3.2 Right-Hand Operator Control Panel

Identified as follows:

NAMEPLATE (SECOND LINE OF NAMEPLATE): Description - Function.

a. SPEED RANGE (MICRO - NORMAL): Two-position selector switch - Toggles between the micro and normal drive operations.

b. HORN: Black momentary pushbutton - Sounds the warning horn mounted outside of the operator's cab.

c. FLOODLIGHTS: Two-position selector switch - Toggles the floodlights On/Off.

]]2.4.8 Electrification Systems

2.4.8.1 Runway Conductor System

[a. Provide a rigid runway Conductor Bar System for the runway conductor system, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. Provide electrification system with three power conductors and an equipment grounding conductor. UV resistant. Steel (non-stainless) conductor bars are prohibited. The crane must be grounded through the runway electrification system. The grounded conductors must be a minimum of 70 square millimeters. Provide runway conductors sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. If there is any way the hook block or wire rope can swing into the runway electrification, provide a guard installed to prevent contact.

b. Provide two Collector Shoes (tandem design) for each conductor; each collector shoe must be rated for not less than the overcurrent protective device for the runway conductor system, so as to provide redundancy.

][c. Provide a Festoon System for the runway conductor system utilizing cables suspended from carriers riding on an I-beam or C-track for the crane, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. Provide electrification system with three power conductors and an equipment grounding conductor. Conductors must be fabricated from copper. The crane is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG. Provide conductors sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. Festooned cable loops must not extend low enough to come into contact with any obstructions.

][d. Provide a Cable Reel System for the runway conductor system, including all necessary cables and hardware to connect the cable reel to the floor level fused disconnect switch. The cable reel must have three power conductors and an equipment grounding conductor. The crane is required to be grounded through this conductor system. Conductors must be fabricated from copper, and sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. The grounded conductors must be a minimum of 2/0 AWG.

][e. Provide a totally enclosed flexible cable tray electrification system (cable chain) for the runway conductor system, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. The cable chain must have three power conductors and an equipment grounding conductor. The conductors must be selected so as to be of the longest length without splices. Conductors must be fabricated from copper, and sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. The crane is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG.

]2.4.8.2 Bridge Conductor System

[a. Provide Festoon System for the bridge conductor system utilizing cables suspended from carriers riding on an I-beam or C-track. Conductors must be fabricated from copper. A minimum of 20 percent of the festoon control circuit conductors for each electrification system must be spares at the time of crane acceptance. The trolley is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG. Festooned cable loops must not extend low enough to come into contact with any obstructions.

][b. Provide a Cable Reel System for the bridge conductor system. The cable reel must have three power conductors, an equipment grounding conductor, and all necessary control cables. A minimum of 20 percent of the festoon control circuit conductors for each electrification system must be spares at the time of crane acceptance. The trolley must be grounded through the cable reel connection and all conductors must be of copper construction. The grounded conductors must be a minimum of 2/0 AWG.

][c. Provide a totally enclosed flexible cable tray electrification system (cable chain) for the bridge conductor system. The cable chain must have three power conductors, an equipment grounding conductor, and all necessary control cables. The conductors must be selected so as to be of the longest length without splices and must be copper. A minimum of 20 percent of the control circuit conductors in the flexible cable tray system must be spares at the time of crane acceptance. The trolley is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG.

]2.4.9 Capacity Overload Protective Device [and Load Indicating Device]

a. Provide a capacity overload protective device for all hoist systems [using VFD drive capacity overload protection (separate from torque limiting feature of the VFD)] [using the load indicating device (LID) described in the next paragraph]. Set hoist capacity overload protection at [_____]. Hoist capacity overload protection must be adjustable between 80 and 150 percent of hoist capacity. Provide a keyed override or other means to disable the hoist capacity overload protection when performing a load test.[If a non-adjustable slip clutch is utilized, the OEM factory setting is acceptable and must be identified.]

[b. Provide an LID for the [main][and][auxiliary] hoist[s].[Provide [a display] [displays] installed on the underside of the bridge of each crane to provide load information from the load indicating system, to be displayed in pounds, for [both] the [main][and][auxiliary] hoist[s].][Provide [a display] [displays] installed in the cab of each crane to provide alarm circuits and continual load readout information from the load indicating system, to be displayed in pounds, for [both] the [main][and][auxiliary] hoist[s].] The display[s] must be large enough so that the operator can read the load value[s] [from the ground level] [while seated in the operator's cab]. The load indicating system capacity is to be compatible with the maximum test load for each hoist. The accuracy of the load indicating system is to be such that the indicated load is not less than 100 percent of the actual load, and not more than 110 percent of the actual load. The load indicating system must be configured with a set point for an overload limit. Provide Tare (zero) functionality at each operator's station for [the] [each] load indicating system. Any load bearing components used in the LID system must be steel, have a minimum design factor of 5 to 1 based on ultimate tensile strength and a hardness not to exceed HRC 40. Precipitation hardened stainless steel load bearing elements must be aged hardened at a minimum temperature of 1025 degrees F.

][c. Initially, set the torque limiting capability of the VFD (that is separate from the capacity overload protective device) to 150 percent of the motor torque (amperage) necessary to hoist 100 percent load. It may be adjusted up only to avoid nuisance trips and adjusted down if possible while still avoiding nuisance trips.

]2.4.10 Enclosures

a. Provide enclosures for control panels, controls, and brakes in accordance with NEMA 250 and NEMA ICS 6, Classification Type [1 indoor, general purpose] [12 indoor without knockouts, general purpose] [2 indoor, drip-proof] [3 outdoor, dust-tight, rain-tight, sleet-resistant] [4X outdoor] [7 indoor Class I hazardous] [9 indoor Class II hazardous] [8 indoor/outdoor Class I hazardous][_____]. Provide enclosures with listed drains to prevent accumulation of water within the enclosure. There must not be any condensation inside the control panels. If anti-condensation heaters are provided, these heaters must remain energized when the main line contactor is deenergized.

b. Provide a non-resettable hour meter, connected across the main line contactor, readable from the exterior of the main control panel, to indicate the elapsed number of hours the crane is energized.

c. Gaskets of enclosures and fixtures, and joints and contact surfaces of hazardous/explosive enclosures must be kept free of any paint to prevent damage during removal and reinstallation of gaskets of enclosures.

[2.4.11 Warning Devices

[Provide a warning horn that is operable from a push button at the [pendant pushbutton] [radio control] station.][Provide a warning [strobe] [rotating beacon] that is illuminated at all times during movement of the hoist, trolley, or bridge function.]

][2.4.12 Floodlights[and Walkway Illumination]

Provide evenly spaced floodlights along the bridge. Select floodlights to provide an illumination level of 40 foot-candles at three feet above the finished floor. All lights must be vibration resistant and designed to prevent any material from falling from the fixture. Switch the floodlights from the [pendant pushbutton] [radio controlled] station.

[[Exterior] footwalks, ladders and stairs must be illuminated to 5 foot-candles.

]][2.4.13 Indicator Lights

Provide Indicator Lights mounted in an enclosure on the bottom of the bridge with lights sized and positioned to be visible from the ground. The lights must be the dual-lamp type. Provide a white light to indicate that power is available on the load side of the crane disconnect and a blue light to indicate that the main contactor is energized. Light voltage must be 115 VAC. Provide nameplates that are legible from ground level. The nameplates must read, in their respective order, "POWER AVAILABLE" and "CRANE ENERGIZED". The POWER AVAILABLE light must be supplied by a separate, fused transformer for its energization.

]2.4.14 Wind Speed Indicating System

Provide a wind speed indicating device. The transmitter must be mounted on the highest unobstructed location.

[2.4.15 Electrical Outlets

Provide a minimum of [one] [_____] 120 VAC duplex outlet[s] on the crane, mounted [on] [in] the [outside of the control panel(s)] [trolley] [cab] [_____]. The circuit(s) supplying receptacles must incorporate ground-fault circuit-interrupter protection for personnel and be protected by a circuit breaker with a minimum rating of [15] [20] amps.

]2.4.16 Cyber Security of Control Systems

a. Provide the following for PLC, RTU, Supervisory Controller, or other network-capable (whether networked or not upon delivery) control devices as applicable:

(1) Hardware list (Hardware list must include the following for each device):

(a) Manufacturer
(b) Model
(c) Location
(d) Key technical ratings (e.g. memory)
(e) Serial number
(f) MAC addresses
(g) IP addresses

(2) Software List (Software list must include the following for each device):
(a) Manufacturer
(b) Version/subversion
(c) Location/device
(d) Used network ports/protocols/services

(3) List and discussion of all security features of Contractor hardware and software.

b. For every PLC, RTU, Supervisory Controller, or other network-capable control devices (whether networked or not upon delivery), deliver the following on CD/DVD:

(1) Original firmware
(2) Original firmware hash
(3) SOP for application of firmware updates/patches
(4) POC or website for firmware updates/patches
(5) Count of interfaces and types
(6) Protocols in use, per interface
(7) Configuration file
(8) SOP for configuration

2.4.16.1 Control System and Network

[a. Provide a rugged laptop type workstation (computer) complete with all compatible software (including software licenses), redundant physical back-up copies on CD/DVD of the installed software, and all necessary cables and special connectors to allow crane software to be troubleshot, checked and upgraded, and for the data recorder to be accessed and information retrieved. Equip the workstation with a CD/DVD drive and the associated CD/DVD burning software. The workstation must also be equipped with USB ports (2.0 and 3.0), an Ethernet port, and a serial port. Delivering the software on a USB (flash drive) device is prohibited.

b. The laptops must be designed for an industrial environment and must be shock resistant and weatherproof as a minimum. Provide the laptop with a built-in CD/DVD reader with the capability to burn CDs and DVDs including associated software to burn CDs and DVDs.

] c. The Contractor must provide all equipment, including software and hardware, necessary for testing, installation, and communicating/troubleshooting all systems provided with the crane (e.g. engine/generator, control system, LID, etc.). The Contractor must provide all crane specific operational software files (e.g. ladder logic, functional block programming, etc.) for their associated systems (e.g. control systems, LID, engine generator, etc.).

d. A single common networked design must not be used for the control systems. A network for an individual function may be used as long as a failure of the network does not affect any other function/network except as defined for specific safety interlocks (e.g. LMI system). A common crane network may be used in a monitoring mode for recording faults and trending and is encouraged. Failure of the monitoring system must not affect crane functions.

e. All provided hardware and software must be currently marketed products, not currently scheduled for end of life or obsolescence, to ensure system sustainability.

f. Ensure there is no remote access capability enabled as remote access capabilities are prohibited. Physically disable or remove all modem/network devices not required for operational purposes.

2.4.16.2 Software and Services

a. Remove all Software and Services not required for operation and/or maintenance of the product. If removal is not technically feasible, then disable software not required for the operation and/or maintenance of the product. Configure the product to allow the ability to re-enable ports and/or services if they are disabled by software. The removal of software or services may not impede the primary function of the product. If software that is not required cannot be removed or disabled, document a specific explanation and provide risk mitigating recommendations and/or specific technical justification. The software/service to be removed and/or disabled includes, but is not limited to:

(1) Cameras

(2) Games

(3) Device drivers for product components not procured/delivered

(4) Messaging services (e.g., email, instant messenger, peer-to-peer file sharing)

(5) Source code

(6) Software compilers in user workstations and servers

(7) Software compilers for programming languages that are not used in the control system

(8) Unused networking and communications protocols

(9) Unused administrative utilities, diagnostics, network management, and system management functions

(10) Backups of files, databases, and programs used only during system development

(11) All unused data and configuration files

(12) Remove and/or disable, through software, physical disconnection, or engineered barriers, all services and/or ports in the procured product not required for normal operation, emergency operations, or troubleshooting. This includes communication ports and physical input/output ports (e.g., USB docking ports, video ports,

and serial ports).

b. Provide documentation showing all disabled ports, connectors, and interfaces for all network-capable devices. In addition, the documentation shall provide summary documentation of the procured product's security features and security-focused instructions on product maintenance, support, and reconfiguration of default settings.

c. For the evaluation status of hardware and software, the Contractor must provide information on Common Criteria or National Information Assurance Partnership (NIAP) or Federal Information Processing Standards (FIPS) evaluation status of hardware and software.

2.4.16.3 Access Control

a. The Contractor must configure each component of the procured product to operate using the principle of least privilege. This includes operating system permissions, file access, user accounts, application-to-application communications, and energy delivery system services.

b. Provide user accounts with configurable access and permissions associated with one or more organizationally defined user role(s), where roles are used.

c. Provide a system administration mechanism for changing user(s') role (e.g., group) associations.

d. The Contractor must document control system access control options by defining access and security permissions, user accounts, and applications with associated roles.

e. Provide recommended methods for the Acquirer to prevent unauthorized changes to the Basic Input/Output System (BIOS) and other firmware. If it is not technically feasible to protect the BIOS to reduce the risk of unauthorized changes, the Contractor must document this case and provide mitigation recommendations.

2.4.16.4 Control System Account Management

The Contractor must document all accounts (including, but not limited to, generic and/or default) that need to be active for proper operation of the procured product.

Remove or disable any accounts that are not needed for normal or maintenance operations, emergency, or troubleshooting of the energy delivery system.

2.4.16.5 Session Management

The Contractor may not allow multiple concurrent logins using the same authentication credentials, allow applications to retain login information between sessions, provide any auto-fill functionality during login, or allow anonymous logins.

Provide account-based and group-based configurable session-based logout and timeout settings (e.g., alarms and human-machine interfaces).

2.4.16.6 Authentication/Password Policy and Management

Provide a configurable account password management system that allows for, but is not limited to, the following:

a. Changes to passwords (including default passwords)

b. Selection of password length

c. Frequency of change

d. Setting of required password complexity

e. Number of login attempts prior to lockout

f. Inactive session logout

g. Screen lock by application

h. Comparison to a library of forbidden strings

i. Derivative use of the user name

j. Denial of repeated or recycled use of the same password

The Contractor must time stamp log files.

2.4.16.7 Logging and Auditing

Provide logging capabilities that cover the following events, at a minimum (as appropriate to their function):

a. Information requests and server responses

b. Successful and unsuccessful authentication and access attempts

c. Account changes

d. Privileged use

e. Application start-up and shutdown

f. Application failures

g. Major application configuration changes

2.4.16.8 Heartbeat Signals

The Contractor must identify heartbeat signals or protocols and recommend which should be included in network monitoring. At a minimum, a last gasp report from a dying component or equivalent shall be included in network monitoring.

The Supplier must provide packet definitions of the heartbeat signals and examples of the heartbeat traffic if the signals are included in network monitoring.

2.4.16.9 Patch Management and Updates

The Contractor must verify that procured products (including third-party hardware, software, firmware, and services) have appropriate updates and patches installed prior to delivery.

Provide documentation of the patch management program and update process (including third-party hardware, software, and firmware). This documentation must include resources and technical capabilities to sustain this program and process. Provide the Contractor's method or a recommendation for how the integrity of the patch is validated by the Acquirer as well as the Supplier's approach and capability to remediate newly reported zero-day vulnerabilities.

2.4.16.10 Malware Detection and Protection

a. The Contractor is required to implement at least one of the following:

   (1) Provide a host-based malware detection capability that quarantines (instead of automatically deleting) suspected infected files. Provide an updating scheme for malware signatures. The Contractor must test and confirm compatibility of malware detection application patches and upgrades.

   (2) If the Contractor is not providing the host-based malware detection capability, the Contractor must suggest malware detection products to be used and provide guidance on malware detection and configuration settings that will work with Contractor products.

b. The Contractor must validate that cybersecurity services running on the procured product (e.g., virus checking and malware detection) do not conflict with other such services running on the procured product.

c. For malware detection and protection, the Contractor must provide, or specify how to implement, the capability to automatically scan any removable media that is introduced to the product being acquired.

2.4.16.11 Physical Security

Provide lockable or locking enclosures or rooms for energy delivery systems and system components (e.g., servers, clients, and networking hardware) and for the systems used to manage and control physical access (e.g., servers, lock controllers, and alarm control panels). Provide a method for tamper detection on lockable or locking enclosures. If a physical security and monitoring system is used, tamper detection must be compatible. The Contractor must ensure that physical security features do not hamper the crane system operations. Provide the tools and instructions for making changes to locks, locking codes, keycards, and any other keyed entrances.

2.4.16.12 Wireless Technology

For wireless technology provisions, the Contractor must document:

a. Specific protocols and other detailed information required for wireless devices to communicate with the control network, including other wireless equipment that can communicate with the Contractor-supplied devices.

b. Use, capabilities, and limits for the wireless devices.

c. Power and frequency requirements of the wireless devices (e.g., microwave devices meet the frequency requirements of Generic Requirements [GR]-63 Network Equipment Building System [NEBS] and GR-1089).

d. Range of the wireless devices and verify that the range of communications is minimized to both meet the needs of the Acquirer's proposed deployment and reduce the possibility of signal interception from outside the designated security perimeter.

e. Wireless technology and associated devices compliance with standard operational and security requirements specified in applicable wireless standard(s) or specification(s) (e.g., applicable IEEE standards, such as 802.11).

f. Configuration control options that enable varying of the security level of the devices.

2.4.16.13 Control System Inventory

Provide the complete control system inventory. The Control System Inventory must include the following attributes, in tabular format, as applicable:

General Information	Location Information	Hardware Details	Operating System and Platform	Network Information (Actual Function, not potential function)
Unique ID	Facility Name	Device Type	Embedded OS (Yes/No)	MAC Address(es)
Barcode or Identifier	NFAID	Device Sub-Type	OS Contractor	IP Address(es)
Region	Commodity	Device Function	Operating System (O/S)	Upstream Device
Installation	Floor	Manufacturer	O/S Version	Protocols In Use
Special Area (Option DNA1)	Room	Product Line	Platform Contractor	Host Name
	Location	Model No.	Platform Product Line	
	System Type	Serial No.	Platform	
	Functional System or Equipment Control	Remote Connectivity: (Wired / Wireless / None)	Platform Version	
		Network Type Used: (Serial / Ethernet / Both / None)		

2.5 PAINTING SYSTEM

a. Remove all grease, oil, and surface debris by solvent wiping or detergent/water scrubbing, prior to blast cleaning. Prepare surfaces to be coated by abrasive blasting to SSPC SP 6/NACE No.3, Commercial Blast Cleaning, or in accordance with the coating manufacturer's requirements, whichever is more stringent.

b. Use a painting system appropriate for the conditions provided in the Crane Design Criteria section. Paint exposed portions of the crane using a [three] [_____]-coat system as follows: [zinc-rich primer consisting of a minimum of 85 percent zinc by weight in the dry film, an anticorrosive epoxy intermediate coat, and an aliphatic polyurethane top coat] [_____]. All paint products must be supplied by a single manufacturer and free of chromates, lead, and mercury. Apply each coat in accordance with manufacturer's instructions and requirements. Ensure each coat is smooth, even, and free of runs, sags, orange peel, and other defects. Desired color of finish coat is [brilliant yellow] [_____]. Submit product data for painting system.

c. Coat faying surfaces of bolted connections per RCSC A348, but do not apply finish paint.

d. Paint the load block [brilliant yellow] [_____] with black diagonal striping. Paint, coatings, or galvanizing on the following items or areas is not acceptable: hoist wire ropes, hooks, hook nuts, running bearing surfaces (including sheaves and wheel treads), grease fittings, or other items not normally painted.

e. Factory paint electrical and mechanical equipment in accordance with the manufacturer's best standard practice (for the specified environment), except that electrical equipment doors, which expose current-carrying electrical conductors when opened, must be orange.

2.6 IDENTIFICATION PLATES

Furnish and install identification plates. Provide non-corrosive metal identification plates with clearly legible permanent lettering giving the manufacturer's name, model number, serial number, capacity in both kilogram and pound units printed in different colors, and other essential information or identification.

2.6.1 Markings on Crane, Trolley, and Hook

To avoid operation of the crane in the wrong direction, affix the appropriate directions (NORTH, SOUTH, EAST, and WEST) with arrows on the bottom of the girder where they can be easily seen by the operator and from the loading point. Provide labels on the controls with corresponding directional (NORTH, SOUTH, EAST, and WEST) markings. Markings shall agree with the markings on controller. Do not indicate directional arrows on controller.

Mark the hook rated capacity in pounds on both sides of the hoist load block.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, and before performing any work, verify all dimensions in the field. The Contractor is responsible for the coordination and proper relation of the contracted work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

[3.2 SHOP ASSEMBLY AND TESTS

Shop assemble major components as completely as possible, except for reeving of drums and sheaves. Functionally test the crane system at the construction facility prior to shipment. The Government reserves the right to inspect the crane for compliance with this specification and to witness the functionality tests. Notify the Contracting Officer [14] [_____] days prior to starting testing operations.

]3.3 ERECTION AND INSTALLATION

Perform the entire crane erection in accordance with manufacturer's instructions under the full-time supervision of the manufacturer's representative.

3.3.1 Mechanical Alignment

Align motors, couplings, brakes, gear boxes and drive components in accordance with manufacturer's instructions. Complete the Coupling Alignment Verification Record.

3.3.2 Electrical Adjustments

Adjust control system in accordance with manufacturer's instructions. Store a copy of all Control Parameter Settings (PLC, VFD). Provide the final alignment data on the Complete Schematic Wiring Diagram, including but not limited to, timer settings, resistor tap settings, potentiometer settings, test-point voltages, supply voltages, motor voltages, motor currents. Provide the test conditions such as ambient temperature, motor load, date performed and person performing the alignment as part of the Operational Tests report.

3.3.3 Field Welding

Perform welding indoors, where possible. Surface of parts to be welded must be free from rust, scale, paint, grease or other foreign matter. Minimum preheat and interpass temperatures must conform to the requirements of AWS D14.1/D14.1M. Perform welding of girders and beams conforming to AWS D14.1/D14.1M.

3.3.4 Field Painting

Perform painting indoors, where possible. Field painting (including touch-up) must conform to the requirements of the coating manufacturer and as specified in PAINTING SYSTEM.

3.4 FIELD QUALITY CONTROL

3.4.1 Post-Erection Inspection

[After erection, the Contractor[, the Activity Crane Inspector/Test Director,] and the Contracting Officer must jointly inspect the crane bridge and hoist systems and components to determine compliance with specifications and approved submittals. Notify the Contracting Officer [_____] days before the inspection.]Provide a report of the inspection indicating the crane is considered ready for operational tests.

3.4.2 Operational Tests

Check the clearance envelope of the entire crane prior to picking or traversing any load to ensure there are no obstructions. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the crane is operational.[The Contractor must furnish test weights, operating personnel, instruments, and other apparatus necessary to conduct field tests on each crane. Solid weights must be measured using calibrated equipment traceable to National Institute of Standards and Technology (NIST) with a minimum accuracy of plus or minus two percent.]

3.4.2.1 No-Load Test

Raise and lower each hook through the full range of normal travel at rated speed for three complete cycles. Raise and lower each hook, testing other speeds of the crane. Verify proper operation of hoist limit switches. Operate the bridge and trolley in each direction the full distance between end stops. Operate through the entire speed range and verify proper brake operation. Verify correct operation of all indication and ancillary devices.

3.4.3 Test Data

Record test data on appropriate test record forms suitable for retention for the life of the crane. Record operating and startup current measurements for hoist, trolley, and bridge motors using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) must be justified or appropriate adjustments performed. In addition, note, investigate, and correct any high temperatures or abnormal operation of any equipment or machinery. Record hoist, trolley, and bridge speeds during each test cycle.

3.4.4 Hook Tram Measurement

Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus 1/64 inch). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening from the base measurement is cause for rejection.

3.4.5 Load Tests

Perform the following tests for each hoist, as specified below.

Test loads used in this section are defined as the following:

Wire rope run-in load: 25 - 50 percent of rated load.

Rated load test: [100 percent (plus 0 minus 10)] [100 percent (plus [_____] minus [_____])] of rated load.

Overload test: [125 percent (plus 0 minus 5)] [125 percent (plus [0] [_____] minus [5] [_____])] of rated load.

3.4.5.1 Wire Rope Run-In

The primary purpose of this procedure is to exercise the newly installed wire rope.

Place the load on the hook. Start at ground level and hoist up to one foot below upper limit at slow speed. Hoist down to lower limit at slow speed. Repeat hoisting and lowering of the load for approximately 10 hoisting cycles, increasing the speed for each cycle. During this test, the capacity overload lockout should not activate.

3.4.5.2 Rated Load Test

3.4.5.2.1 Hoist

a. Static Load Test: With the trolley in the center of the bridge span, raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the load and hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes. Verify that maximum beam and girder deflections do not exceed CMAA 70 design limits.

   For hoists with primary and secondary holding brakes, raise the test load and release the secondary holding brake while testing the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage secondary holding brake and release the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage the primary holding brake. Recheck proper operation of time delay and ensure smooth positive stopping.

b. Hoist Mechanical Load Brake (if present): Raise test load approximately 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

c. Raise and lower test load through the full lift range and visually observe smooth control and acceleration between points. Completely stop the machinery at least once in each direction to ensure proper brake operation.

d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet. While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.2.2 Trolley

Operate the trolley (if space is available) the full distance of the bridge rails in each direction with a test load on the hook. Check proper functioning through the range of speeds. Verify proper brake action.

3.4.5.2.3 Bridge

With a test load on the hook, operate the bridge for the full length of the runway (if space is available) in one direction with the trolley at the far end of the bridge, and in the opposite direction with the trolley at the opposite end of the bridge. Use extreme caution. Check proper functioning through the range of speeds. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

3.4.5.2.4 Trolley Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed of trolley travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the trolley stops and that the brake sets properly. Measure the distance required for the trolley to stop.

3.4.5.2.5 Bridge Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed of bridge travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the bridge stops and that the brake sets properly. Measure the distance required for the bridge to stop.

3.4.5.3 Overload Test

3.4.5.3.1 Hoist

Disconnect or adjust the overload limit device to allow the hoist to lift the test load. Verify proper operation of the overload limit device after it is reconnected.

a. Static Load Test: With the trolley in the center of the bridge span, raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the load and hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes.

For hoists with primary and secondary holding brakes, raise the test load and release the secondary holding brake while testing the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage secondary holding brake and release the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage the primary holding brake. Recheck proper operation of time delay and ensure smooth positive stopping.

b. Raise and lower test load and visually observe smooth control. Stop the load during raising and lowering to verify that the brakes holds the load.

c. Hoist Load Brake (if present): Raise test load approximately 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet. While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.3.2 Trolley

Operate the trolley the full distance of the bridge rails in each direction with a test load on the hook (one cycle) through the range of speeds. Verify proper brake action.

3.4.5.3.3 Bridge

With a test load on the hook, operate the bridge for the full length of the runway in one direction with the trolley at the extreme end of the bridge, and in the opposite direction with the trolley at the opposite extreme end of the bridge (one cycle). Check proper functioning through the range of speeds. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

3.5 MANUFACTURER'S FIELD SERVICE REPRESENTATIVE

Furnish a qualified experienced manufacturer's field service representative to supervise the crane installation, assist in the performance of the on-site testing, and instruct personnel in the operational and maintenance features of the equipment.

3.6 OPERATION AND MAINTENANCE MANUALS

Provide [two] [_____] hard copies of operation and [two] [_____] hard copies of maintenance manuals for the equipment furnished along with an electronic copy (PDF) of each on a Compact Disc. Provide one complete set prior to performance testing and final copies upon acceptance. Provide operation manuals that detail the step-by-step procedures required for system startup, operation and shutdown. Include the manufacturer's name, model number, parts list, and brief description of all equipment and basic operating features. List in the maintenance manuals routine maintenance procedures, including weekly, monthly, semi-annual, and annual required maintenance items, possible breakdowns and repairs, and troubleshooting guides. Also include as-built drawings, piping and equipment layout, design calculations, Control Parameter Settings and printouts of any software, and simplified wiring and control diagrams of the system as installed. Secure approval of operation and maintenance manuals prior to the field training course.

[3.7 FIELD TRAINING

Conduct a training course for [_____] operating and maintenance staff[and provide a copy of the training material to each participant]. Provide a training period consisting of a total of [_____] hours of normal working time and starting after the system is functionally completed but prior to final acceptance. Cover all pertinent points involved in operating, starting, stopping, and servicing the equipment, including all major elements of the Operation and Maintenance Manuals. Demonstrate in course instructions all routine maintenance operations such as lubrication, general inspection, and [_____].

][3.8 FINAL ACCEPTANCE

Final acceptance of crane system will not be given until Contractor has successfully completed all testing operations, corrected all material and equipment defects, made all proper operation adjustments, and removed paint or overspray on wire rope, hook, and electrical collector bars.

] -- End of Section --

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SECTION 41 22 13.15

BRIDGE CRANES, OVERHEAD ELECTRIC, UNDER RUNNING
02/20, CHG 1: 02/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 908	(1989B; R 1999) Information Sheet: Geometry Factors for Determining the Pitting Resistance and Bending Strength of Spur, Helical and Herringbone Gear Teeth
ANSI/AGMA 2001	(2004D; R 2010) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
ANSI/AGMA 2015-1	(2001A; R 2014) Accuracy Classification System - Tangential Measurements for Cylindrical Gears
ANSI/AGMA 6013	(2006A; R 2016) Standard for Industrial Enclosed Gear Drives
ANSI/AGMA 6113	(2016B) Standard for Industrial Enclosed Gear Drives (Metric Edition)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B30.10	(2019) Hooks
ASME B30.16	(2022) Overhead Underhung and Stationary Hoists

ASME B30.17	(2020) Overhead and Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoists)
ASME HST-1	(2012) Performance Standard for Electric Chain Hoists
ASME HST-4	(2021) Performance Standard for Overhead Electric Wire Rope Hoists
ASME NUM-1	(2016) Rules for Construction of Cranes, Monorails, and Hoists with Bridge or Trolley or Hoist of the Underhung Type.

AMERICAN SOCIETY OF SAFETY PROFESSIONALS (ASSP)

ASSP Z359	(2013) Fall Protection Code

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D14.1/D14.1M	(2019) Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment

ASTM INTERNATIONAL (ASTM)

ASTM A275/A275M	(2018) Standard Practice for Magnetic Particle Examination of Steel Forgings
ASTM A668/A668M	(2022) Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM A931	(2008; R 2013) Standard Test Method for Tension Testing of Wire Ropes and Strand
ASTM A1023/A1023M	(2021) Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes
ASTM E125	(1963; R 2013) Photographs for Magnetic Particle Indications on Ferrous Castings
ASTM E543	(2021) Standard Specification for Agencies Performing Non-Destructive Testing
ASTM E1417/E1417M	(2016) Standard Practice for Liquid Penetrant Testing
ASTM F436/F436M	(2019) Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
ASTM F3125/F3125M	(2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch

	Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 74	(2020) Specifications for Single Girder Cranes

ELECTRIFICATION AND CONTROLS MANUFACTURERS ASSOCIATION (ECMA)

ECMA 15	(2018) Cable-less Controls for Electric Overhead Traveling Cranes

MATERIAL HANDLING INDUSTRY OF AMERICA (MHI)

MHI MH27.1	(2009) Specifications for Underhung Cranes and Monorail Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 5	(2017) Industrial Control and Systems: Control Circuit and Pilot Devices
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 8	(2011) Crane and Hoist Controllers
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS (RCSC)

RCSC A348	(2020) RCSC Specification for Structural Joints Using High-strength Bolts

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J429	(2014) Mechanical and Material Requirements for Externally Threaded Fasteners
SAE J995	(2017) Mechanical and Material Requirements for Steel Nuts

U.S. AIR FORCE (USAF)

AFMAN 91-118	(2010) Safety Design and Evaluation Criteria for Nuclear Weapon Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.179	Overhead and Gantry Cranes
29 CFR 1910.306	Specific Purpose Equipment and Installations

U.S. NAVAL SEA SYSTEMS COMMAND (NAVSEA)

NAVSEA T9074-AS-GIB-010/271	(1999; Notice 1) Requirements for Nondestructive Testing Methods

UNDERWRITERS LABORATORIES (UL)

UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1004-1	(2012; Reprint Nov 2020) UL Standard for Safety Rotating Electrical Machines - General Requirements

1.2 DEFINITIONS

a. Bridge Crane: That part of an overhead crane system consisting of a girder, end trucks, walkway, and drive mechanism which carries the trolley(s) and travels along the runway rails parallel to the runway.

b. Crane Runway: The track system along which the crane operates horizontally, including track hangar rods, track connection devices, and runway structural supports.

c. Dead Loads: The loads on a structure which remain in a fixed position relative to the structure.

d. Girder: The principal horizontal beam of the crane bridge. It is supported by the crane end trucks. Normally the crane trolley mounted hoist is suspended from the girder below the crane.

e. Lifted Load: The load consisting of the rated load and the weight of lifting devices attached to the crane such as the load block, bucket, or other supplemental devices.

f. Pendant: A control for a hoist and a crane. The pendant hangs from the hoist or the crane by a cable at a height that is easy for the operator to reach.

g. Patented Track: A generic term referring to track built in accordance with MHI MH27.1 utilizing a composite track section incorporating a proprietary bottom flange shape. For this crane system, it is provided for the crane bridge girder and also the crane runway track, if under running.

h. Rated Load: The maximum working load suspended under the load hook.

i. Standard Commercial Cataloged Product: A product which is currently being sold, or previously has been sold, in substantial quantities to the general public, industry or Government in the course of normal business operations. Models, samples, prototypes or experimental units do not meet this definition. The term "cataloged" as specified in this section is defined as "appearing on the manufacturer's published product data sheets. These data sheets must have been published or copyrighted prior to the issue date of this solicitation and have a document identification number or bulletin number.

j. Trolley Load: The weight of the trolley and its associated equipment carried by the trolley wheels.

k. Under running (Underhung) Crane: An electric overhead traveling crane that is supported by crane end trucks suspended below the crane runway. The load is supported by hanging from the lower flange of a beam or patented track.

l. Top Running Crane: An overhead electric traveling crane that is supported by end trucks which run on top of supporting rails.

m. Operating Environments:

(1) General Purpose Service: This applies to most cranes and are, in large measure, the manufacturers' standard designs. Cranes should be classified as General Purpose Service if they are operating in routine environments.

(2) Ordnance/Explosives Handling: Cranes handling palletized or unpackaged ammunition, missiles, torpedoes, and other types of ordnance. Minimum requirement of CMAA service class D.

(3) Hazardous (Explosive) Environments: Cranes operating in hazardous environments as defined by the cognizant activity safety office must be equipped with electrical safety features that meet NEC Article 500. The activity safety office must identify the specific Class, Division, and Group, as well as the envelope that the hazard exists, to allow proper design and must list these in this section. Materials for mechanical components must be chosen to minimize the potential for sparking, typically bronze, stainless steel, or aluminum. Hazardous environments are split

into two groups: minimum anti-spark protection and maximum anti-spark protection.

(a) Minimum Anti-Spark Protection is used when only the load block enters the explosive area.

(b) Maximum Anti-Spark Protection is used when the hazardous area envelops the entire crane.

1.3 SYSTEM DESCRIPTION

[The requirements for the crane runway system and rail supporting structures are specified in Section 05 12 00 STRUCTURAL STEEL, and must conform to AISC 360.

]1.3.1 Crane Design Criteria

Cranes will operate in the given spaces and match the runway dimensions and rails indicated. Hook coverage, hook vertical travel, clear hook height, lifting capacity, and load test weight must not be less than that indicated.

1.3.1.1 General

Include the following: Number of cranes [_____], located in building identified as [_____], with the capacity expressed in [_____] tons pounds, for each overhead electric traveling (OET) crane. Also clearly locate and identify each hoist and system components.

1.3.1.2 Classification

Provide [top running] [under running] bridge overhead electric traveling crane (OET), with under running trolley mounted hoist, conforming to CMAA 74 service class [A] [B] [C] [D] for operation in an [indoor] [outdoor] environment, [general purpose] [ordnance handling] [hazardous area] service, meeting the requirements of ASME B30.16 and ASME B30.17, with an ambient temperature range of [_____] to [_____] degrees Fahrenheit. This crane must operate in an NEC Class [_____], Division [_____], Group [_____] hazardous area. Hazardous protection is required for the [full height of the crane] [18 inches above ground level] [_____]. The crane span must be [_____] feet with a vertical lift of [_____] feet and as specified herein.

The crane must be [pendant controlled] [radio controlled] and operate in the spaces and within the loading conditions indicated.[The pendant controller must be mounted on a separate festooned cable system from the trolley power supply.] The crane must operate on [_____]-volts AC, 60 Hz [_____], [single] [three] phase power source. Maximum crane wheel loads (without impact) due to dead, trolley, and lifted loads, with the trolley in any position, must not cause a more severe loading condition in the runway support structure than that produced by the design wheel loads and spacing indicated.

1.3.1.3 Rated Capacity and Speeds

Provide crane with a rated capacity of [_____] tons pounds. Lower load block or assembly of hook, swivel bearing sheaves, pins, and frame suspended by the hoisting ropes are not considered part of the rated capacity.

Rated (maximum) speeds plus or minus 10 percent (in feet/min) for the main hoist, bridge, and trolley at the rated load are specified in the table below. The minimum speed must not exceed the values listed.

Rated Speeds feet/min		
Description	Minimum	Maximum
Main Hoist	[_____]	[_____]
Trolley	[_____]	[_____]
Bridge	[_____]	[_____]

1.4 VERIFICATION OF DIMENSIONS

The Contractor is responsible for the coordination and proper relation of their work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overhead Electric Crane System; G[, [_____]]

Complete Schematic Wiring Diagram; G[, [_____]]

Control System and Network Drawings; G[, [_____]]

SD-03 Product Data

Gear Reducers; G[, [_____]]

Hoist Brakes; G[, [_____]]

Travel Brakes; G[, [_____]]

Couplings; G[, [_____]]

Load Block and Hook; G[, [_____]]

Hoist and Trolley Units; G[, [_____]]

Bridge End Trucks; G[, [_____]]

Crane Bridge Girder; G[, [_____]]

End Stops; G[, [_____]]

Bumpers; G[, [_____]]

[Crane Runway System; G[, [_____]]

] Motors; G[, [_____]]

Enclosures; G[, [_____]]

Circuit Breakers; G[, [_____]]

Disconnect Switch; G[, [_____]]

Contactors and Relays; G[, [_____]]

Fuses; G[, [_____]]

Variable Frequency Drives; G[, [_____]]

Limit Switches; G[, [_____]]

Resistors; G[, [_____]]

[Radio Control System; G[, [_____]]

][Pendant Push-Button Station; G[, [_____]]
]

Pendant Conductor System; G[, [_____]]

Crane Controllers; G[, [_____]]

[Control Parameter Settings; G[, [_____]]

][Pilot Devices; G[, [_____]]

][Warning Devices; G[, [_____]]

][Floodlights; G[, [_____]]

] Runway Conductor System; G[, [_____]]

Bridge Conductor System; G[, [_____]]

Overload Protection; G[, [_____]]

Load Indicating Device; G[, [_____]]

Painting System; G[, [_____]]

Control System and Network; G[, [_____]]

SD-05 Design Data

Load and Sizing Calculations; G[, [_____]]

SD-06 Test Reports

[Hook Proof Test; G[, [_____]]

][Hook Non-Destructive Test (NDT); G[, [_____]]

] Post-Erection Inspection; G[, [_____]]

Operational Tests; G[, [_____]]

Hook Tram Measurement; G[, [_____]]

Load Tests; G[, [_____]]

SD-07 Certificates

[Wire Rope; G[, [_____]]

][Load Chain; G[, [_____]]

] Crane Runway System; G[, [_____]]

Hazardous Material; G[, [_____]]

Loss of Power Test; G[, [_____]]

Coupling Alignment Verification Record; G[, [_____]]

Overload Test; G[, [_____]]

Brake Adjustment Record; G[, [_____]]

Compliance with Listed Standards; G[, [_____]]

Contractor Hazardous Environment; G[, [_____]]

Hoist Manufacturer Hazardous Environment; G[, [_____]]

Public Domain Software; G[, [_____]]

Software and Services; G[, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

SD-11 Closeout Submittals

Disabled Ports, Connectors, and Interfaces; G[, [_____]]

Network-Capable Control Devices; G[, [_____]]

Control System Access Control; G[, [_____]]

Control System Account Management; G[, [_____]]

Patch Management and Updates; G[, [_____]]

Malware Detection and Protection; G[, [_____]]

Wireless Technology Provisions; G[, [_____]]

Control System Inventory; G[, [_____]]

Evaluation Status of Hardware and Software; G[, [_____]]

1.6 QUALITY ASSURANCE

1.6.1 Manufacturer Qualification

Overhead Electric Crane System, including sub-system components manufactured by vendors, must be designed and manufactured by a company with a minimum of 10 years of specialized experience in designing and manufacturing the type of overhead crane required to meet requirements of the Contract Documents.

The crane design must be accomplished by, or directly supervised by, a registered professional engineer (PE). PE licensing must be by a board or agency authorized to license and register professional engineers. The PE may be a Contractor's regular employee or a consultant. The PE's review and attestation of specification compliance and professional responsibility must be signified by his or her PE original seal and dated signature on the final drawings. The professional engineers must only undertake and perform work under this contract in the branch(s) of engineering in which they are licensed.

1.6.2 Pre-Delivery Inspections

Contractor is responsible for performance of quality control inspections, testing, and documentation. Submit all crane test data recorded on appropriate test record forms suitable for retention for the life of the crane.

1.6.2.1 Inspection of Steel Castings

Visually inspect [and test]load-carrying steel castings[using the magnetic-particle inspection method][using ultrasonic testing].[Reference allowable degree of discontinuities to ASTM E125, and relationship to service loads and stresses, critical configuration, location and type.] All load bearing components, couplings, shafts, and gears, in the hoist drive train must be rolled or forged steel, except brake drums which may be ductile iron. Methods of repairing the discontinuities is subject to review by the Contracting Officer.

1.6.2.2 Inspection of Hook Assembly

Inspect hook [by a magnetic-particle type inspection][and X-rayed][and tested ultrasonically] prior to delivery. Furnish documentation of hook inspection to Contracting Officer prior to field operational testing. As part of the acceptance standard, linear indications[greater than 1/16 inch] are not allowed. Welding repairs of hook are not permitted. A hook showing linear indications, damage or deformation is not acceptable.

[1.6.2.2.1 Hook Non-Destructive Test (NDT)

Magnetic-particle inspect the hook over the entire area in accordance with ASTM A275/A275M. Acceptance standard is no defects. A defect is defined as a linear indication that is greater than [1/8 inch][1/16 inch] long. For hooks of non-magnetic material, NDT shall be liquid penetrant (PT) method in accordance with ASTM E1417/E1417M. For PT testing of hooks containing stainless steels, titanium, or nickel based alloys, total halogens and Sulphur used in the NDT process shall be controlled as specified in NAVSEA T9074-AS-GIB-010/271.

Inspect each hook and shank over the entire surface area by magnetic particle inspection.

a. Procedure: Conduct magnetic particle inspection in accordance with ASTM A275/A275M with the following restrictions: Do not use DC yokes (including switchable AC/DC yokes used in the DC mode) or permanent magnet yokes. Do not use automatic powder blowers or any other form of forced air other than from a hand-held bulb for the application or removal of dry magnetic particles. Remove arc strikes. Equipment ammeters must have an accuracy of plus or minus 5 percent of full scale (equipment ammeter accuracy other than that stated is acceptable provided the MT procedure states that a magnetic field indicator is used to establish and verify adequate field strength for all aspects of the inspection.)

b. Acceptance Criteria: Defects found on the hook will result in rejection of defective items for use on furnished hoist. For this inspection, a defect is defined as a linear indication for which the largest dimension is greater than 1.5 mm 1/16 inch.

c. Test Report: Submit a test report of the magnetic particle inspection of each hook provided the Contracting Officer for approval prior to final acceptance of hoist installation. Certify test reports by the testing organization. The performing organization must provide a written statement of certification to ASTM E543, current within one year of the date the NDT was performed. The NDT procedures including technique sheets specific to the types, shapes, and size of the parts being examined must adequately describe the orientation of the hooks within the magnetizing equipment. The performing organization must have the NDT procedures and its technique sheet used for testing of the hook reviewed and approved by an independent Level III examiner. Submit the (Level III examiner) approved procedures, technique sheets, and certification to the Contracting Officer with the test report.

]1.6.2.3 Hook Proof Test

Proof test the load hook per ASME B30.10. Perform the proof test prior to Hook NDT.

1.6.3 Drawings: Overhead Electric Crane System

a. Submit drawings showing the general arrangement of all components in plan, elevation, and end views. Show all major features of the crane including: hook approaches on all four sides, clearances and principal dimensions, assemblies of hoist, trolley and bridge drives, motor nameplate data, overcurrent protective device ratings, and electrical schematic drawings. Include weights and centers of gravity of major components.

b. Submit shop drawings of all fabricated components. Shop drawing quality must be equivalent to the contract drawings accompanying this solicitation. Drawings must be reviewed, signed and sealed by a licensed professional engineer.

c. Provide integral schedule of crane components on each drawing. The schedule must provide a cross reference between manufacturer data and shop drawings. Components listed on the schedule of crane components must include total quantity, description, original manufacturer, and part number. Distributing agents will not be acceptable in lieu of the original manufacturer.

d. Provide control system and network drawings. Network diagram must show equipment locations, names, models, and IP addresses on network communications schematic for all Programmable Logic Controllers (PLCs), Remote Terminal Unit (RTU), Supervisory Controller, and Other Network-Capable Devices. In addition, the drawings shall consist of all software block, flow, and ladder diagrams.

1.6.4 Design Data: Load and Sizing Calculations

Submit complete list of equipment and materials, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Submit calculations reviewed, signed, and sealed by a registered professional engineer verifying the load cases, sizing of the bridge girder, end trucks, travel drives, motors, overcurrent protection, and conduit. Provide a list of all codes and standards, design assumptions, equations, specified efficiencies, limits, factors of safety, component ratings, and sources of values used. Include free body diagrams or sketches of each load case.[Include seismic analysis of crane.]

1.6.5 Certificates

All certifications shall be dated and shall bear the original signature (above the printed name) of the authorized representative of the Contractor or the manufacturer of the items or equipment being certified. Each certification shall clearly identify the crane, the drives, components, and location (as applicable) to which it applies:

[a. Submit a Wire Rope Certification with the wire rope manufacturer's certification that the rope meets the published breaking strength or the actual breaking strength of a sample taken from the reel and tested. Certification shall be traceable to the hoist, crane, and reel.

][a. Submit a Load Chain Certification from either the load chain manufacturer or the hoist manufacturer that the chain samples taken and tested meet the chain manufacturer's designed minimum breaking load, and the load chain has been proof tested with a load at least equivalent to one and a half times the hoist rated load divided by the number of chain parts (lines) supporting the load. Certification shall be traceable to the hoist.

] b. Submit a Crane Runway System Certificate stating that the new crane will operate properly on the runway. For runways provided by Contractor, include statement certifying runway has been aligned in accordance with CMAA 74 or MHI MH27.1, as applicable. If runway is existing and if the crane(s) cannot operate without restriction, the Contractor shall indicate crane limitations.

c. Submit a Hazardous Material Certificate that the crane does not contain hazardous material including asbestos, lead, cadmium, chromium, PCBs, or elemental mercury. Products required for the designing and manufacturing of cranes must not contain the prohibited materials.

d. Submit a Loss of Power Test Certificate stating that a test may be performed in which power is removed from the crane while the hoist, bridge, and trolley are in operation to simulate a loss of power.

e. Submit a Certificate of the Coupling Alignment Verification Record.

f. Submit an Overload Test Certificate stating that the crane can be periodically load tested to 125 percent (plus 0 minus 5 percent) of rated load.

g. Submit an Overload Test Certificate stating that the crane can be periodically load tested to 125 percent (plus [0] [_____] minus [5] [_____] percent) of rated load.

h. Submit a Certificate of the Brake Adjustment Record. Provide a brake adjustment record and installation/maintenance manuals for each brake on the crane. Each brake measurement must have a tolerance traceable to the associated brake manual or documentation provided by the brake manufacturer, location of measurements, and the actual brake setting. Changes made to settings of the brake, at any time, will void the record.

i. Submit a Certificate of Compliance with Listed Standards.

j. Provide a Contractor Hazardous Environment Certificate stating that the new crane and all associated components excluding the hoist are designed for operation in the hazardous environment specified in the Classification section.

k. Provide a Hoist Manufacturer Hazardous Environment Certificate from the hoist manufacturer stating that the hoist is designed for operation in the hazardous environment specified in the Classification section.

l. The Contractor shall provide a Public Domain Software Certificate declaring that public domain software (e.g., freeware, shareware) is not used in the system.

m. The Contractor shall provide a certificate stating that all Software and Services that are not required for operation and/or maintenance of the product have been removed. The software/services to be removed are identified in paragraph SOFTWARE AND SERVICES.

1.6.6 Welding Qualifications and Procedure

Welding must be in accordance with qualified procedures using AWS D14.1/D14.1M as modified. Written welding procedures must specify the Contractor's standard dimensional tolerances for deviation from camber and sweep and not exceed those specified in AWS D14.1/D14.1M, MHI MH27.1 and CMAA 74. Welders and welding operators must be qualified in accordance with AWS D1.1/D1.1M or AWS D14.1/D14.1M.

1.7 CRANE SAFETY

Comply with the mandatory and advisory safety requirements of ASME B30.10, ASME B30.16, ASME B30.17, ASME HST-4 or ASME HST-1, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306, and all applicable provisions of 29 CFR 1910 and NFPA 70. Where personal fall arrest anchorages are provided, design anchorages in accordance with ASSP Z359.

[1.7.1 Nuclear Safety Analysis

Nuclear certification, testing, and rules of construction must be in accordance with 29 CFR 1910.147 and ASME NUM-1. Air Force Nuclear certified hoists must meet requirements of AFMAN 91-118. Submit analysis and test reports to Contracting Officer for approval.

]PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide materials and equipment which are standard products of manufacturers regularly engaged in the fabrication of complete and totally functional cranes including necessary ancillary equipment. Material will be free from defects and imperfections that might affect the serviceability and appearance of the finished product. All material must be new and unused.

2.1.2 Nameplates

Secure nameplates to each major component of equipment with the manufacturer's name, address, type or style, model or catalog number, and serial number. Provide two bridge identification plates, one for each side of the bridge. Provide noncorrosive metal identification plates with letters which are easily read from the floor, showing a separate number such as BC-1, BC-2, for each bridge crane.

2.1.3 Capacity Marking

Mark the rated capacity in ton pounds units on each side of the crane on the bridge girder. Capacity marks must be large enough to be clearly visible from the floor. Individual hoist units must have their rated capacity clearly marked on their bottom block, and additionally labeled on the hoist body. Rated capacity must include all accessories below the hook, such as load bars, magnets, and grabs, as part of the load to be handled.

2.1.4 Safety Warnings

Affix labels in a readable position to each lift block or control station in accordance with ASME B30.16 and ASME B30.17. Submit safety warnings, diagrams and other instructions suitably framed and protected for display as indicated by the Contracting Officer as follows:

Design and locate the word "WARNING" or other legend to bring the label to the attention of the operator. Provide durable type warning labels and display the following information concerning safe-operating procedures: Cautionary language against lifting more than the rated load; operating the hoist when the hook is not centered under the hoist; operating hoist with twisted, kinked or damaged rope; operating damaged or malfunctioning hoist; operating a rope hoist with a rope that is not properly seated in its hoist drum groove; lifting people; lifting loads over people; and removing or obscuring the warning label.

2.2 STRUCTURAL REQUIREMENTS

Structural requirements must be in accordance with CMAA 74 and MHI MH27.1, as applicable. Structural steel materials must conform to the standards permitted in CMAA 74, MHI MH27.1, and AISC 360. Skewing and other applicable lateral loads must be considered in the design.

2.2.1 Structural Connections

High-strength bolted structural connections must be designed and installed in accordance with RCSC A348. Bolts must be of ASTM F3125/F3125M Grade A325/A325M or Grade A490/A490M material. Galvanized bolts are not acceptable.

Welded connections for the crane must be performed in accordance with AWS D14.1/D14.1M. Welded connections to the building must be performed in accordance with AWS D1.1/D1.1M. Allowable stress values must comply with CMAA 74.

2.2.2 Crane Bridge Girder

Provide a bridge girder of rolled steel shape conforming to CMAA 74 or patented track conforming to MHI MH27.1, as applicable. For ordnance handling cranes, the bridge girder must be of patented track. Intermittent ("skip") welds on bridge girder elements (e.g. web and flange interfaces) are prohibited. If the girder is notched to fit over the end trucks, reinforce the girder ends with vertical and horizontal stiffeners. Splices in the unsupported length of the girder are prohibited.

For patented track girder, submit manufacturer's standard published tables that verify the crane bridge girder is sized in compliance with all specification requirements. When standard published tables are not available, provide calculations for the strength design and deflection of the bridge. Patented track girder must be of welded steel construction and fabricated by a manufacturer regularly engaged in the production of this type of beam.

2.2.3 Bridge End Trucks

Provide bridge end trucks conforming to ASME B30.17 and CMAA 74 or MHI MH27.1, as applicable. Configure end trucks with a feature that limits end truck movement to one inch in the event of wheel or shaft failure.

2.2.4 End Stops and Bumpers

Fit bridge girders with structural steel end stops. Locate stops to permit maximum trolley travel. Fit bridge end trucks and trolley frames with shock-absorbing bumpers capable of decelerating and stopping the bridge and trolley within the limits stated by 29 CFR 1910 and CMAA 74 or MHI MH27.1, as applicable. Ensure bumpers and end stops conform to ASME B30.17. Bumpers must fully engage end stops. Mount bumpers so that there is no direct shear on mounting bolts (if any) upon impact. Bumpers must provide adequate clearance between the crane and surrounding structure when compressed to preclude damaging equipment. When more than one crane is located and operated on the same runway, bumpers shall be provided on their adjacent ends or on one end of one crane. Fit the other end of the end-truck with a structural steel stop to engage the bumpers of the adjacent crane. Ensure bridge bumpers are properly aligned with runway end stops. Metal to metal contact at the bumper to end stop connection is not permitted.

[2.2.5 Crane Runway System

a. Provide the complete runway track suspension system that is required to hang the crane runway track at its indicated location from the structural supports indicated on the drawings. Provide runway and support structure for under running crane of rolled steel shapes conforming to CMAA 74 or patented track girders conforming to MHI MH27.1.

b. For rolled steel shapes, locate splices under structural support members.

c. For patented track girders, perform splices as necessary in accordance with the manufacturer's recommendations and requirements. Align ends of lower T-section to minimize the horizontal gap on the running surface to not greater than 1/16 inch and not greater than a vertical difference of 1/32 inch for the wheel running surface alignment for a smooth crossing by the wheels. Splice assemblies must be from the same manufacturer as the patented track and located under structural support members. Submit manufacturer's standard published tables that verify the crane runway track is sized in compliance with all specification requirements. When standard published tables are not available, provide calculations for the strength design and deflection of the beams.

d. Runway support structure must be designed, fabricated, and installed such that runway rails meet the alignment tolerances of CMAA 74 or MHI MH27.1, as applicable. Provide means to allow for vertical adjustment of the runway track both before and after the system has been put in operation so that track can be erected and maintained level. Brace runway to restrain the track against damaging lateral and longitudinal movements. Where the runway track is suspended from hanger rods, provide means preventing the hanger rod nuts from backing off the rods. Allowable stress in hanger rods is 20 percent of the minimum specified ultimate strength of the material used.

][2.2.6 Seismic Forces

Perform a seismic analysis as a part of the design of the crane in accordance with ASCE 7-16[or ASME NUM-1]. The seismic analysis must be included in the CMAA 74 or MHI MH27.1 extraordinary load case (Case 3), as applicable.

For project locations beyond the scope of ASCE 7-16, a widely accepted design standard may be used for seismic analysis.

][2.2.7 Additional Provisions for Outside Service

Seal weld structural members on outdoor cranes. Provide crane bridges with parking brakes which will sufficiently hold the crane against a wind pressure of 5 psf for in-service conditions. Provide crane bridge with manually-operated pin locks at each rail, designed to securely anchor the crane against a wind pressure of 30 psf for out-of-service conditions. Design members to prevent the collection of water on crane.

]2.3 MECHANICAL REQUIREMENTS

Provide steel shafts, gears, keys, and couplings. Cast iron and aluminum used to support components of the hoist power transmission train must be ductile. Gray cast iron load bearing parts are prohibited.

All mechanical components must be accurately aligned and positively secured to maintain the alignment. Parts must not be forced into position to obtain apparent alignment.

2.3.1 Threaded Fasteners

Fasten base-mounted and flange-mounted components and all mechanical connections subjected to calculable loads with lubricated SAE J429 Grade 5 fasteners, ASTM F436/F436M washers, and SAE J995 Grade 5 nuts. Match bolt and nut threads. Oversize tapping is not permitted. Bolt and nut threads must conform to ASME B18.2.2 and ASME B1.1. Bolts and screws may be installed into tapped holes provided that adequate thread engagement is provided to develop the full designed connection strength.

2.3.2 Hoist

Provide hoist conforming to ASME B30.16, ASME B30.17, and CMAA 74 service class [A] [B] [C] [D] or better, double reeved, except as modified and supplemented in this section. Standard commercial hoist and trolley units (packaged hoists) must be [electric wire rope hoist conforming to ASME HST-4] [electric chain hoist conforming to ASME HST-1] Duty Class [H1] [H2] [H3] [H4] or better. For custom hoist shafts, the fatigue design factor must be a minimum of 1.5.

Configure trolley such that the trolley frame contacts the trolley stops and prevents the trolley from dropping more than one inch in the event of an axle or wheel failure.

2.3.2.1 Hoist Brakes

a. Equip the hoist with two holding brakes, each with a minimum torque rating of 125 percent of the rated load hoisting torque.[Provide a brake configuration with [one electro-mechanical or thruster brake and one mechanical load brake that stops and holds 125 percent of the hoist's rated load and does not require the load to be raised before being lowered.][two electro-mechanical or thruster brakes.]][A mechanical load brake may be utilized in lieu of one of the hoist holding brakes provided it stops and holds 125 percent of the hoist's rated load and does not require the load to be raised before being lowered].

[b. For cranes with two electro-mechanical or thruster brakes, designate each brake as primary or secondary with the primary brake being the brake mounted closer to the motor. Provide the primary brake with a non-time delayed setting and secondary brake with an adjustable setting time delay, set between one to three seconds after the primary brake in any stopping condition. Do not use an uninterruptible power supply (UPS) to create the secondary brake time delay.

] c. Electro-mechanical or thruster brakes [must be adjustable to 50 percent of its rated capacity, and]must have an externally accessible means of manual release. On drives where the brakes are utilized as holding brakes only, torque adjustment is not required. The brakes must be equipped with a manual self-return to ON brake release and designed to permit inspection and adjustment without disassembly of the brake.

2.3.2.2 Load Block and Hook

a. The load block must be constructed of steel non-sparking materials and designed to prevent metal-to-metal contact of moving parts. The block must be fully enclosed, concealing the sheaves and wire ropes, except for wire rope slots and drain holes. The design must preclude the wire rope from being cut, pinched, crushed, or chafed in case of two-blocking. The block must be clearly marked with the capacity in pounds on both sides. The load block sheaves must be constructed of non-sparking materials. An insulated link must be provided on each hook block per the requirements of NAVSEA OP-5. Standard commercial blocks may be used at their published ratings when their published design factors are 5.0 or greater.

[b. Provide load block with a trunnion separate from the sheave pin. Bore the trunnion for swivel mounting of the hook and securely retain in the block side plates. The trunnion must rotate about its horizontal axis in holes bored in the side plates. Lock wire trunnion keeper bar fasteners.

] c. Provide an unpainted single barbed forged steel hook complying with ASTM A668/A668M and which conforms to ASME B30.10. Provide an unpainted single barbed hook of non-sparking material with a minimum material longitudinal elongation of 16 percent in 2 inches. Bronze clad hooks are prohibited. Hook dimensions must be as shown on the drawings. Fit hook with a safety latch designed to preclude inadvertent displacement of slings from the hook saddle. The hook and hook nut must be removable without unreeving of the hoist or disassembly of the block. Provide hook nut with a removable type set screw or other similar fastener, installed in a plane parallel to the longitudinal axis of the hook shank. Do not weld hook nut. Uniquely mark the hook in a permanent fashion that is traceable to the NDT certification. The nut must be marked to match the hook. The hook nut must be of non-sparking materials. Hook must be free to rotate through 360 degrees when supporting the test load up to 125 percent of the rated capacity. Upper hooks of hook suspended hoists shall be of non-sparking materials.

2.3.2.3 Wire Ropes [Load Chain]

[

a. Wire rope must conform to ASTM A1023/A1023M and be tested as required by ASTM A931. The wire rope must be in a double reeved configuration with the equalizing method perpendicular to the running sheaves. Provide wire rope with a minimum design factor of [5 to 1] [_____ to 1] based on the load experienced at rated capacity and minimum breaking strength of the wire rope.

[b. Provide hoisting ropes with improved plow steel, extra improved plow steel, or extra-extra improved plow steel, regular lay, bright, and uncoated with an independent wire rope, wire strand, or otherwise, steel core. Hot-dipped galvanized wire rope is not permitted.

] b. Provide stainless steel hoist ropes.

c. Hoisting rope end connections, other than drum connections, must be speltered sockets with forged steel terminals or swaged fittings installed in a fashion that provides 100 percent of the breaking strength of the wire rope. Anchor hoisting rope ends on the drum by means of swaged fittings or by clamping with hoisting rope ends neatly and securely seized with corrosion resistant wire. Provide proof of Wire Rope breaking strength. Wedge sockets or aluminum swages are not permitted on wire rope end connections.

]

[d. Provide a welded link load chain suitable for powered hoist service with no less than a 5.0 to 1 design factor based on the minimum breaking strength of the chain. Provide stainless steel load chain. The chain must be pitched and sized to pass over load sprockets without binding. Provide an equalizing method when the load is supported by more than one part of load chain. Provide the chain with a chain stop or dead end connection to prevent the load chain from running out of the hoist at its fully extended position. Provide chain hoists with 10 foot lift or more with a load chain bucket.

]2.3.2.4 Drum

Provide drum made of steel. Design the drum such that all hoisting rope is wound in a single layer and so that not less than two dead wraps of hoisting rope remain on each anchorage when the hook is in its extreme low position. Drum grooving must be machined right and left hand beginning at the ends and grooving toward the center of the drum. Minimum drum groove depth must be 0.375 times the rope diameter.

Provide minimum drum groove pitch either 1.14 times the rope diameter, or the rope diameter plus 1/8 inch, whichever is smaller. Minimum drum pitch diameter must be [16] [18] [20] times the rope diameter. Do not paint, coat or galvanize the surface of the drum which comes in contact with wire rope.

2.3.2.5 Sheaves

Provide steel sheaves. Machine or grind the grooves to contour and rim toughen, flame, or induction harden to not less than 320 BHN. Minimum pitch diameters must be [16] [18] [20] [24] times the rope diameter for running sheaves and no less than 12 times the rope diameter for equalizer sheaves. Provide sheave groove depth of not less than 1.5 times the hoisting rope diameter. Do not paint wire rope contact surfaces of sheaves.

2.3.3 Drives

Provide travel assemblies with at least one quarter of all wheels driven for the crane and a minimum of one driven wheel on each side of the flange. No 3-bearing shaft configurations are allowed. The travel drive arrangement will be the contractor's design of choice.

2.3.3.1 Bridge Drives

Outdoor cranes must have half of the total wheels driven. Acceleration and deceleration must meet the requirements specified in CMAA 74.[Provide bridge travel limit switches].

2.3.3.2 Trolley Drives

Provide a motor-driven trolley arrangement.[Provide trolley travel limit switches].

2.3.4 Travel Brakes

Provide brakes with an externally accessible means to manually release the brake. The brakes must be equipped with a manual self-return to ON brake release and designed to permit inspection and adjustment without disassembly of the brake.

2.3.4.1 Bridge Brake

Provide bridge drive with an end-mounted electro-mechanical brake conforming to the requirements of CMAA 74 [or non-freecoasting mechanical drive]capable of stopping the motion of the bridge within a distance in feet equal to 10 percent of the full load speed in feet per minute when traveling at full speed with a full load. Provide brakes with a minimum torque rating per CMAA 74 according to the applicable environment, but not sized larger than 150 percent of the drive motor rated torque.

2.3.4.2 Trolley Brake

Provide trolley drive with a non-coasting mechanical drive[or an end-mounted electro-mechanical brake conforming to the requirements of CMAA 74] capable of stopping the trolley within a distance in feet equal to 10 percent of the rated speed in feet per minute when traveling at rated speed with rated load. The electro-mechanical brakes must have a minimum torque rating per CMAA 74 according to the applicable environment, but not be sized larger than 150 percent of the motor torque.

2.3.5 Gearing

Provide gearing of the enclosed gear reducers type. Provide steel spur, helical, or herringbone type gears and pinions only. Gearing must conform to ANSI/AGMA 2001 and AGMA 908. Internal and external gear dimensional tolerances must conform to the applicable AGMA standard for tooth geometry and tolerances. Open-type gearing is not acceptable, except for final drives.

2.3.5.1 Gear Reducers

Gear reducers must be [integral components of standard hoists or hoist/trolley units of manufacturers regularly engaged in the design and manufacture of hoists or hoist/trolley units for Class A, B, or C cranes][or][standard items of manufacturers regularly engaged in the design and manufacture of gear reducers for Class D and E cranes]. Gear reducers must be designed, manufactured, and rated in accordance with ANSI/AGMA 6113 (ANSI/AGMA 6013) (for trolley drives only), as applicable. Except for final reduction, the gear reduction units must be fully enclosed in oil-tight housing.[Enclosed gearing must be selected for ["Industrial Duty"]["Mill Duty"].] Gearing must be designed to AGMA standards and operate in an oil bath. Operation must be smooth and quiet.

2.3.5.2 Open Gearing

Provide all gears and pinions with adequate strength and durability for the crane service class and manufactured to ANSI/AGMA 2015-1 Accuracy Grade A8 or better. Open gears must be enclosed with safety guards provided with openings with covers for inspection and access for grease lubrication.

2.3.6 Bearings

All bearings, except those subject only to small rocker motion, must be anti-friction type. Provide permanently lubricated and sealed bearings or provide grease lubricated bearings with means for relubrication through easily accessible lubrication fittings.

Fit all connections subject only to small rocking motion with manufacturer's standard bronze alloy bushings in the pivot pin bore, as applicable. Provide means for relubrication of grease lubricated bushings through easily accessible lubrication fittings or provide oil impregnated type bushings.

2.3.7 Couplings

Chain and continuous sleeve type couplings must not be used. Spline couplings are acceptable as installed on c, d, or p-face assemblies. Conventional couplings must not be loaded in the radial direction. Brake wheel or brake disc couplings (if used) must be compatible with the required coupling type. Flexible couplings must not be relied upon to compensate for inaccurate alignment. Ends of coupled shafts must be aligned within the recommended installation criteria of the coupling manufacturer.

2.3.8 Wheels

a. Top running trolley and bridge travel wheels are to be straight tread, double flanged, and sized in accordance with CMAA 74 recommendations for wheel sizing and flange to rail head clearances. Wheel material must be of rolled-to-shape or roll-forged steel. Provide wheels made from non-sparking material. Bronze wheels must have a minimum tread hardness of 225 BHN. Provide steel wheels with a minimum tread hardness of 320 BHN.

b. Under running wheels are to be flanged or provided with side guide rollers. Provide wheel sizing and flange-to-rail head clearances in accordance with MHI MH27.1 and CMAA 74 recommendations, as applicable. Wheel material is to be steel or ductile cast iron. Minimum tread hardness for underhung wheels that run on patented track is 375 BHN. Minimum tread hardness for wheels running on structural shapes is 320 BHN. Wheels are to be made of forged steel. Provide wheels of non-sparking material. The minimum tread hardness for bronze wheels is 225 BHN.

[2.3.9 Drip Pans

a. The crane must be designed to preclude leakage of lubricants onto the lifted loads or the floor. Equipment or components, which cannot be made leak-proof, must be fitted with unpainted corrosion resistant steel drip pans or must have the foundations seal welded to create a dam. Drip pans that utilize liquid sealant to prevent leakage of lubricants are not permitted.

b. The drip pans must be sized to hold the entire gear case fluid capacity, installed under all drive machinery, designed to permit easy removal of collected lubricant. A trolley floor designed to contain any lubricant drips may be used as fluid containment for any equipment that is mounted on it.

c. Provide drip pans fitted around the shank of the hook and extending outward to encompass all possible points of lubrication drips from the load block or wire rope and must be easily removable without disassembly of the hook or load block and shall not interfere with the crane structure during testing of the upper limits.

]2.4 ELECTRICAL REQUIREMENTS

The design, selection, rating, and installation of the electrical portions of the crane and its accessories must conform to the requirements of NEMA ICS 3,NEMA ICS 8, the applicable ASME HST standard, and NFPA 70, and other requirements specified herein.

The crane manufacturer must furnish and install all electrical equipment on the crane conforming to NEMA ICS 6, including motors, conforming to NEMA MG 1, electrically released brakes, switches, crane controllers, panels, operating station, wiring system, cables, and crane electrification.

2.4.1 Motors

Motors must meet all applicable requirements of NEMA MG 1 and UL 1004-1. All motors must have a minimum of a 60 [30] [60] [_____] minute duty rating and be Totally Enclosed Non Ventilated (TENV), Totally Enclosed Fan Cooled (TEFC), or Totally Enclosed Blower Cooled (TEBC).[Provide inverter duty motors for Open Loop Variable Frequency Drives (VFD).][Provide vector duty motors for Closed Loop VFDs.][Provide [two] [single] speed AC squirrel cage induction type motors for the bridge and trolley drives.][Provide two speed, AC squirrel cage induction type motor for the hoist.] Provide motors with a minimum of Class F insulation. Provide motor overload protection utilizing a thermal sensitive device embedded in its windings. Provide motors painted to manufacturer's standard for "wash-down" service. Motors located outdoors must be furnished with anti-condensation heaters that remain energized when the mainline contactor is deenergized.

2.4.2 Controls

[a. Provide static reversing, variable frequency drives (VFD) for the [bridge,] [trolley][and][hoist] electric controls.[Provide static reversing, VFD, speed regulated, closed loop, flux vector electric controls for the hoist[s]. For feedback, provide hoist motors with encoders. The hoist controller must enable the drive motor to develop full torque continuously at zero speed. The hoist secondary brake shall be controlled separate from the primary and connected to different output (within the drive) from the primary brake.] VFD controllers must meet NEMA ICS 8, Part 8 and at a minimum, provide under-voltage protection, electronic instantaneous over current protection, DC bus over voltage protection, and be able to withstand output line to line shorts without component failure. Select bridge and trolley drives such that the continuous rating of the controller is not less than the motor full load current. Select hoist drives such that the continuous rating of the controller is not less than 125 percent 100 percent of the motor full load current. All hoist drives must have a motor over-torque limit to lock out the hoist and prevent gross overload of the associated hoist. Provide dynamic braking for each electric drive that is sized per VFD manufacturer's requirements. Submit VFD Control Parameter Settings.

b. Provide speed control which is infinitely variable for each function, controlled via [radio control system][and][pendant pushbutton station].[Provide controls designed such that the maximum speed of each function will be limited to 25 percent of rated speed when a slow speed switch is actuated on the controller[s].[Energize a yellow/amber light/indicator while in slow speed mode.]]

c. The [hoist][,] [trolley][,] and [bridge] brakes must set after the associated controller decelerates the drive motor to a controlled stop. The hoist, trolley, and bridge, controllers must be sized to provide sufficient starting torque to initiate motion of that crane drive mechanism from standstill with 0 to 125 percent of rated load on the hook. The hoist controller must prove torque before release of the brakes and enable the drive motor to develop full torque continuously at zero speed. Motors must operate smoothly at all speeds without torque pulsations and must only be energized within the frequency range of 50-60 Hz at rated speed.[The hoist control system may utilize overspeed up to 120hz, unloaded only, if the drivetrain equipment has all been balanced and is rated for the resulting speed.]

][d. Provide [one][two]-speed magnetic controls for the [bridge drive][,] [trolley drive][,][and][hoist] drive. Controllers must meet the requirements of NEMA ICS 8. Ensure that an energized drive motor initially rotates only in the direction selected by the operator by activating the corresponding direction; i.e., is not overhauled. For AC squirrel cage motor controllers, the requirements of NEMA ICS 2, Part 2, for general-purpose controllers, must be met.

[e. Provide the bridge and trolley motor control systems with a drift point between OFF and the first speed control point in each direction.

]]f. The use of definite purpose contactors is prohibited. If IEC contactors are used, the application cannot exceed the contactor manufacturer's AC3 ratings for the contactor at a minimum.

g. On hoist function roll-up must be less than 1/8 inch measured at the hook block and roll-back must not occur over the entire load range.

h. Use of Uninterruptible Power Supplies (UPS) is prohibited. Feed control circuits from a single phase, air cooled, double wound transformer with a grounded metal screen between the primary and secondary windings of the transformer.

i. Provide a main line contactor. Energization of the main line contactor must be controlled by the POWER-OFF/POWER-ON switch/pushbutton on all controllers. Upon actuation of the POWER-OFF pushbutton; power to all drive motors, brakes, and controls must be removed. The mainline contactor must not be able to be energize while the POWER-OFF pushbutton is actuated. The POWER-OFF pushbutton circuitry must be independent of all controls or any other electronic devices.

2.4.3 Protection

Protection must not be less than that required by NEMA ICS 3, NEMA ICS 8, CMAA 74, NFPA 70, UL 1004-1, UL 943, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306 and all applicable provisions of 29 CFR 1910. Provide disconnect switch or enclosed type circuit breaker readily accessible to the crane operator for the crane disconnect. Provide an On/Off button that removes power from the motors, brakes and control circuit on all [operator control stations][and][radio controllers]. Provide for lockout/tagout of all hazardous energy sources. Provide product data for all circuit breakers and fuses.

2.4.4 Resistors

Provide resistors with natural convection cooling sized as recommended by the VFD OEM and fabricated of corrosion resistant metal; the use of "wire wound" type resistors is prohibited for segments of 8 ohms or less. Mount resistors in substantial, ventilated enclosures constructed entirely of non-combustible materials. When mounted outdoors provide stainless steel resistor enclosures. Provide resistors with terminals fitted in the coolest position in the enclosure.

[2.4.5 Transients and Harmonics Protection

a. Provide contactors and relays with appropriate Metal Oxide Varistors (MOV) or resistor-capacitor (R-C) surge absorbers installed across the respective coil.

b. Provide transient protection for electronic drive controllers that is either internal to the drive or via an MOV connected line-to-ground close to the line terminals of the drive.

c. Provide line reactors rated for continuous duty operation based upon the motor nameplate amperes. With motors of 50 horsepower or greater, harmonics protection must be provided by an isolations transformer or as recommended by the VFD OEM. For a drive motor branch circuit that exceeds 150 feet in length, a reactor must also be connected in series with the controller load (output) terminals to provide standing wave protection or as otherwise recommended by the VFD or motor OEM.

]2.4.6 Limit Switches

a. Limit switches must be rated for the NEC Hazardous Classifications specified in the Classification section of this specification.

b. Provide primary upper and lower geared limit switches. Geared limits must allow reversing direction to back out of the limit without resetting. The lower limit switch must be set such that there are a minimum of two wraps of rope on the hoist drum.

c. Provide a backup mechanical hook block activated upper limit switch wired independent of the directional controllers and the primary upper limit switch that removes power from the hoist motor, hoist brake and hoist controls conforming to NEMA ICS 5. The backup limit must require hoist resetting prior to operation of the hoist in any direction.

d. For chain hoists, the upper hoist limit switch must be wired to remove all power from the hoist drive motor and brake(s) independent of the microprocessor drive. A two-position spring-returned bypass switch must be provided that allows for resetting of the final limit switch prior to resuming operation. During resetting of the final limit, the hoist must operate in the lowering direction only.

[e. Travel limit switches must be provided for the [bridge][and][trolley] motion to slow the crane to [25 percent] [_____] of its rated speed [[10] [_____] feet before the bridge end stops][and][[5] [_____] feet from the trolley end stops]. Limit switches must be mounted rigidly in a manner so as to protect the switch from misalignment or damage. The target/trip arm must be large enough to provide interception given a misalignment were to occur.

]2.4.7 Operator Controls

[a. Provide crane equipped with a [pendant pushbutton station][radio control system].

][b. Provide crane equipped with both a pendant pushbutton station and a radio control system. Provide a selector switch to allow the use of only one of the two available control stations on the pendant controller.

] c. If VFD controls are not provided, provide directional contactors with both mechanical and electrical interlocks.

d. Operator controls must be rated for the NEC Hazardous Classifications specified in the Classification section of this specification.

[2.4.7.1 Pendant Pushbutton Station

The cranes must be controlled from a pendant pushbutton station suspended from [the trolley] [an independent festooned messenger track system, operating the length of the bridge]. Provide multiconductor flexible cords for pendant pushbutton stations with No. 16 AWG minimum conductors. Provide a method of strain relief to protect the electrical conductors from damage. Locate the pendant pushbutton station [4 feet] [_____] above the finished floor. Pushbutton pendant station must have its elements legibly marked and arranged vertically, in order, in accordance with CMAA 74.[Provide [one speed] [two speed] [3-step infinitely variable] [2-step infinitely variable] pendant pushbuttons for control of the [hoist] [bridge][and][trolley].] Provide pendant pushbuttons for control that spring return to the OFF position. Voltage in the pendant pushbutton station must not exceed 150 Volts AC or 300 Volts DC.[Provide a maintained two-position selector switch for slow speed selection.] The pendant must be rated for the NEC Hazardous Classifications specified in the Crane Design Criteria "Classification" Section.

[2.4.7.1.1 Pendant Conductor System

Provide a festoon type pendant conductor system. The festoon cables must be flat cables suspended from carriers riding on an I-beam or C-track. The pendant controller must be capable of traveling the entire length of the bridge and move independently of the trolley. Festoon loops must not extend below the high hook position.

][2.4.7.1.2 Radio Control System

Provide each system with a [belly box] [handheld] [______] type portable transmitter unit [and an identical back-up transmitter unit].[Provide each transmitter with an adjustable belt or harness to support it when worn by the operator]. Only one transmitter at a time can control the crane and there must be no interference from one crane's controller affecting operation of the other cranes in the building. Each transmitter must include: individual [infinitely variable spring return joystick motion control levers] [push button controls] for each hoist, trolley, and bridge; a maintained contact, keyed switch, marked ON-OFF, for portable transmitter unit power; indication of Battery Power, and indication of Transmitting Status; a red emergency STOP mushroom pushbutton;[and]a floodlight on/off pushbutton[and a maintained slow speed selector switch]. The transmitters and all controls must each be clearly and permanently labeled with functionality and direction. Directions for controllers must be in accordance with CMAA 74 recommendations. The remote radio control system must be designed to meet the requirements of NEMA ICS 8, Part 9 and ECMA 15. Each radio remote control lever must be in the OFF position before the associated crane function can begin. The system frequency must be within the unlicensed FCC Part 15 range. Each control unit must maintain a continuous status signal to the associated receiver during operation.

There must be no significant loss in systems efficiency and function at the end of eight hours of continuous battery use. Provide a contact monitoring board with the crane radio system receiver.

]]2.4.8 Electrification Systems

2.4.8.1 Runway Conductor System

[a. Provide a rigid runway Conductor Bar System for the runway conductor system, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. Provide electrification system with three power conductors and an equipment grounding conductor. UV resistant. Steel (non-stainless) conductor bars are prohibited. The crane must be grounded through the runway electrification system. The grounded conductors must be a minimum of 70 square millimeters. Provide runway conductors sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. If there is any way the hook block or wire rope can swing into the runway electrification, provide a guard installed to prevent contact.

b. Provide two Collector Shoes (tandem design) for each conductor; each collector shoe must be rated for not less than the runway conductor sizing, so as to provide redundancy.

][c. Provide a Festoon System for the runway conductor system utilizing cables suspended from carriers riding on an I-beam or C-track for the crane, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. Provide electrification system with three power conductors and an equipment grounding conductor. Conductors must be fabricated from copper. The crane is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG. Provide conductors sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. Festooned cable loops must not extend low enough to come into contact with any obstructions.

][d. Provide a Cable Reel System for the runway conductor system, including all necessary cables and hardware to connect the cable reel to the floor level fused disconnect switch. The cable reel must have three power conductors and an equipment grounding conductor. The crane is required to be grounded through this conductor system. Conductors must be fabricated from copper, and sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. The grounded conductors must be a minimum of 2/0 AWG.

][e. Provide a totally enclosed flexible cable tray electrification system (cable chain) for the runway conductor system, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. The cable chain must have three power conductors and an equipment grounding conductor. The conductors must be selected so as to be of the longest length without splices. Conductors must be fabricated from copper, and sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. The crane is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG.

]2.4.8.2 Bridge Conductor System

[a. Provide Festoon System for the bridge conductor system utilizing cables suspended from carriers riding on an I-beam or C-track. Conductors must be fabricated from copper. A minimum of 20 percent of the festoon control circuit conductors for each electrification system must be spares at the time of crane acceptance. The trolley is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG. Festooned cable loops must not extend low enough to come into contact with any obstructions.

][b. Provide a Cable Reel System for the bridge conductor system. The cable reel must have an equipment grounding conductor, and all necessary control cables. A minimum of 20 percent of the festoon control circuit conductors for each electrification system must be spares at the time of crane acceptance. The trolley must be grounded through the cable reel connection and all conductors must be of copper construction. The grounded conductors must be a minimum of 2/0 AWG.

][c. Provide a totally enclosed flexible cable tray electrification system (cable chain) for the bridge conductor system. The cable chain must have three power conductors, an equipment grounding conductor, and all necessary control cables. The conductors must be selected so as to be of the longest length without splices and must be copper. A minimum of 20 percent of the control circuit conductors in the flexible cable tray system must be spares at the time of crane acceptance. The trolley is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG.

]2.4.9 Overload Protection[and Load Indicating Device]

a. Provide a capacity overload protective device for all hoist systems[using VFD drive capacity overload protection (separate from torque limiting feature of the VFD)][using the load indicating device (LID) described in the next paragraph]. Set hoist capacity overload protection at [_____]. Hoist capacity overload protection must be adjustable between 80 and 150 percent of hoist capacity. Provide a keyed override or other means to disable the hoist capacity overload protection when performing a load test. If a non-adjustable slip clutch is utilized, the OEM factory setting is acceptable and must be identified.

[b. Provide an LID for the [main][and][auxiliary] hoist[s].[Provide [a display] [displays] installed on the underside of the bridge of each crane to provide load information from the load indicating system, to be displayed in pounds, for [both] the [main][and][auxiliary] hoist[s].][Provide [a display] [displays] installed in the cab of each crane to provide alarm circuits and continual load readout information from the load indicating system, to be displayed in pounds, for [both] the [main][and][auxiliary] hoist[s].] The display[s] must be large enough so that the operator can read the load value[s] [from the ground level][and][while seated in the operator's cab]. The load indicating system capacity is to be compatible with the maximum test load for each hoist. The accuracy of the load indicating system is to be such that the indicated load is not less than 100 percent of the actual load, and not more than 110 percent of the actual load. The load indicating system must be configured with a set point for an overload limit. Provide Tare (zero) functionality at each operator's station for [the] [each] load indicating system. Any load bearing components used in the LID system must be steel, have a minimum design factor of 5 to 1 based on ultimate tensile strength and a hardness not to exceed HRC 40. Precipitation hardened stainless steel load bearing elements must be aged hardened at a minimum temperature of 1025 degrees F.

][c. Initially, set the torque limiting capability of the VFD (that is separate from the capacity overload protective device) to 150 percent of the motor torque (amperage) necessary to hoist 100 percent load. It may be adjusted up only to avoid nuisance trips and adjusted down if possible while still avoiding nuisance trips.

]2.4.10 Enclosures

a. Provide enclosures for control panels, controls, and brakes in accordance with NEMA 250 and NEMA ICS 6, Classification Type [1 indoor, general purpose] [12 indoor without knockouts, general purpose] [2 indoor, drip-proof] [3 outdoor, dust-tight, rain-tight, sleet-resistant] [4X outdoor] [7 indoor Class I hazardous] [9 indoor Class II hazardous] [8 indoor/outdoor Class I hazardous] [_____]. Provide enclosures with listed drains to prevent accumulation of water within the enclosure. There must not be any condensation inside the control panels. If anti-condensation heaters are provided, these heaters must remain energized when the main line contactor is deenergized.

[b. Provide a non-resettable hour meter, connected across the main line contactor, readable from the exterior of the main control panel, to indicate the elapsed number of hours the crane is energized.

] c. Gaskets of enclosures and fixtures, and joints and contact surfaces of hazardous/explosive enclosures must be kept free of any paint to prevent damage during removal and reinstallation of gaskets of enclosures.

2.4.11 Warning Devices

[Provide a warning horn that is operable from a push button at the [pendant pushbutton] [radio control] station.] [Provide a warning [strobe] [rotating beacon] that is illuminated at all times during movement of the hoist, trolley, or bridge function.]

[2.4.12 Floodlights

Provide evenly spaced floodlights along the bridge. Select floodlights to provide an illumination level of 40 foot-candles at three feet above the finished floor. All lights must be vibration resistant and designed to prevent any material from falling from the fixture. Switch the floodlights from the [pendant pushbutton] [radio controlled] station.

][2.4.13 Pilot Devices

Provide Indicator Lights mounted in an enclosure on the bottom of the bridge with lights sized and positioned to be visible from the ground. The lights must be the dual-lamp type. Provide a white light to indicate that power is available to the crane and a blue light to indicate that the main contactor is energized. Light voltage must be 115 VAC. Provide nameplates that are legible from ground level. The nameplates must read, in their respective order, "POWER AVAILABLE" and "CRANE ENERGIZED". The POWER AVAILABLE light must be supplied by a separate, fused transformer for its energization.

]2.4.14 Wind Speed Indicating System

Provide a wind speed indicating device. The transmitter must be mounted on the highest unobstructed location.

[2.4.15 Electrical Outlets

Provide a minimum of [one] [_____] 120 VAC duplex outlet[s] on the crane, mounted [on] [in] the [outside of the control panel(s)] [trolley] [cab] [_____]. The circuit(s) supplying receptacles must incorporate ground-fault circuit-interrupter protection for personnel and be protected by a circuit breaker with a minimum rating of [15] [20] amps.

]2.4.16 Cyber Security of Control Systems

a. Provide the following for PLC, RTU, Supervisory Controller, or other network-capable (whether networked or not upon delivery) control devices as applicable:

   (1) Hardware list (Hardware list must include the following for each device):
      (a) Manufacturer
      (b) Model
      (c) Location
      (d) Key technical ratings (e.g. memory)
      (e) Serial number
      (f) MAC addresses
      (g) IP addresses

   (2) Software List (Software list must include the following for each device):
      (a) Manufacturer
      (b) Version/subversion
      (c) Location/device
      (d) Used network ports/protocols/services

   (3) List and discussion of all security features of Contractor hardware and software.

b. For every PLC, RTU, Supervisory Controller, or other network-capable control devices (whether networked or not upon delivery), deliver the following on CD/DVD:

   (1) Original firmware
   (2) Original firmware hash
   (3) SOP for application of firmware updates/patches
   (4) POC or website for firmware updates/patches
   (5) Count of interfaces and types
   (6) Protocols in use, per interface
   (7) Configuration file
   (8) SOP for configuration

2.4.16.1 Control System and Network

[a. Provide a rugged laptop type workstation (computer) complete with all compatible software (including software licenses), redundant physical back-up copies on CD/DVD of the installed software, and all necessary cables and special connectors to allow crane software to be troubleshot, checked and upgraded, and for the data recorder to be accessed and information retrieved. Equip the workstation with a CD/DVD drive and the associated CD/DVD burning software. The workstation must also be equipped with USB ports (2.0 and 3.0), an Ethernet port, and a serial port. Delivering the software on a USB (flash drive) device is prohibited.

b. The laptops must be designed for an industrial environment and must be shock resistant and weatherproof as a minimum. Provide the laptop with a built-in CD/DVD reader with the capability to burn CDs and DVDs including associated software to burn CDs and DVDs.

] c. The Contractor must provide all equipment, including software and hardware, necessary for testing, installation, and communicating/troubleshooting all systems provided with the crane (e.g. engine/generator, control system, LID, etc.). The Contractor must provide all crane specific operational software files (e.g. ladder logic, functional block programming, etc.) for their associated systems (e.g. control systems, LID, engine generator, etc.).

d. A single common networked design must not be used for the control systems. A network for an individual function may be used as long as a failure of the network does not affect any other function/network except as defined for specific safety interlocks (e.g. LMI system). A common crane network may be used in a monitoring mode for recording faults and trending and is encouraged. Failure of the monitoring system must not affect crane functions.

e. All provided hardware and software must be currently marketed products, not currently scheduled for end of life or obsolescence, to ensure system sustainability.

f. Ensure there is no remote access capability enabled as remote access capabilities are prohibited. Physically disable or remove all modem/network devices not required for operational purposes.

2.4.16.2 Software and Services

a. Remove all Software and Services not required for operation and/or maintenance of the product. If removal is not technically feasible, then disable software not required for the operation and/or maintenance of the product. Configure the product to allow the ability to re-enable ports and/or services if they are disabled by software. The removal of software or services may not impede the primary function of the product. If software that is not required cannot be removed or disabled, document a specific explanation and provide risk mitigating recommendations and/or specific technical justification. The software/service to be removed and/or disabled includes, but is not limited to:

(1) Cameras

(2) Games

(3) Device drivers for product components not procured/delivered

(4) Messaging services (e.g., email, instant messenger, peer-to-peer file sharing)

(5) Source code

(6) Software compilers in user workstations and servers

(7) Software compilers for programming languages that are not used in the control system

(8) Unused networking and communications protocols

(9) Unused administrative utilities, diagnostics, network management, and system management functions

(10) Backups of files, databases, and programs used only during system development

(11) All unused data and configuration files

(12) Remove and/or disable, through software, physical disconnection, or engineered barriers, all services and/or ports in the procured product not required for normal operation, emergency operations, or troubleshooting. This includes communication ports and physical input/output ports (e.g., USB docking ports, video ports, and serial ports).

b. Provide documentation showing all disabled ports, connectors, and interfaces for all network-capable devices. In addition, the documentation shall provide summary documentation of the procured product's security features and security-focused instructions on product maintenance, support, and reconfiguration of default settings.

c. For the evaluation status of hardware and software, the Contractor must provide information on Common Criteria or National Information Assurance Partnership (NIAP) or Federal Information Processing Standards (FIPS) evaluation status of hardware and software.

2.4.16.3 Access Control

a. The Contractor must configure each component of the procured product to operate using the principle of least privilege. This includes operating system permissions, file access, user accounts, application-to-application communications, and energy delivery system services.

b. Provide user accounts with configurable access and permissions associated with one or more organizationally defined user role(s), where roles are used.

c. Provide a system administration mechanism for changing user(s') role (e.g., group) associations.

d. The Contractor must document control system access control options by defining access and security permissions, user accounts, and applications with associated roles.

e. Provide recommended methods for the Acquirer to prevent unauthorized changes to the Basic Input/Output System (BIOS) and other firmware. If it is not technically feasible to protect the BIOS to reduce the risk of unauthorized changes, the Contractor must document this case and provide mitigation recommendations.

2.4.16.4 Control System Account Management

The Contractor must document all accounts (including, but not limited to, generic and/or default) that need to be active for proper operation of the procured product.

Remove or disable any accounts that are not needed for normal or maintenance operations, emergency, or troubleshooting of the energy delivery system.

2.4.16.5 Session Management

The Contractor may not allow multiple concurrent logins using the same authentication credentials, allow applications to retain login information between sessions, provide any auto-fill functionality during login, or allow anonymous logins.

Provide account-based and group-based configurable session-based logout and timeout settings (e.g., alarms and human-machine interfaces).

2.4.16.6 Authentication/Password Policy and Management

Provide a configurable account password management system that allows for, but is not limited to, the following:

a. Changes to passwords (including default passwords)

b. Selection of password length

c. Frequency of change

d. Setting of required password complexity

e. Number of login attempts prior to lockout

f. Inactive session logout

g. Screen lock by application

h. Comparison to a library of forbidden strings

i. Derivative use of the user name

j. Denial of repeated or recycled use of the same password

The Contractor must time stamp log files.

2.4.16.7 Logging and Auditing

Provide logging capabilities that cover the following events, at a minimum (as appropriate to their function):

a. Information requests and server responses

b. Successful and unsuccessful authentication and access attempts

c. Account changes

d. Privileged use

e. Application start-up and shutdown

f. Application failures

g. Major application configuration changes

2.4.16.8 Heartbeat Signals

The Contractor must identify heartbeat signals or protocols and recommend which should be included in network monitoring. At a minimum, a last gasp report from a dying component or equivalent shall be included in network monitoring.

The Supplier must provide packet definitions of the heartbeat signals and examples of the heartbeat traffic if the signals are included in network monitoring.

2.4.16.9 Patch Management and Updates

The Contractor must verify that procured products (including third-party hardware, software, firmware, and services) have appropriate updates and patches installed prior to delivery.

Provide documentation of the patch management program and update process (including third-party hardware, software, and firmware). This documentation must include resources and technical capabilities to sustain this program and process. Provide the Contractor's method or a recommendation for how the integrity of the patch is validated by the Acquirer as well as the Supplier's approach and capability to remediate newly reported zero-day vulnerabilities.

2.4.16.10 Malware Detection and Protection

a. The Contractor is required to implement at least one of the following:

(1) Provide a host-based malware detection capability that quarantines (instead of automatically deleting) suspected infected files. Provide an updating scheme for malware signatures. The Contractor must test and confirm compatibility of malware detection application patches and upgrades.

(2) If the Contractor is not providing the host-based malware detection capability, the Contractor must suggest malware detection products to be used and provide guidance on malware detection and configuration settings that will work with Contractor products.

b. The Contractor must validate that cybersecurity services running on the procured product (e.g., virus checking and malware detection) do not conflict with other such services running on the procured product.

c. For malware detection and protection, the Contractor must provide, or specify how to implement, the capability to automatically scan any removable media that is introduced to the product being acquired.

2.4.16.11 Physical Security

Provide lockable or locking enclosures or rooms for energy delivery systems and system components (e.g., servers, clients, and networking hardware) and for the systems used to manage and control physical access (e.g., servers, lock controllers, and alarm control panels). Provide a method for tamper detection on lockable or locking enclosures. If a physical security and monitoring system is used, tamper detection must be compatible. The Contractor must ensure that physical security features do not hamper the crane system operations. Provide the tools and instructions for making changes to locks, locking codes, keycards, and any other keyed entrances.

2.4.16.12 Wireless Technology

For wireless technology provisions, the Contractor must document:

a. Specific protocols and other detailed information required for wireless devices to communicate with the control network, including other wireless equipment that can communicate with the Contractor-supplied devices.

b. Use, capabilities, and limits for the wireless devices.

c. Power and frequency requirements of the wireless devices (e.g., microwave devices meet the frequency requirements of Generic Requirements [GR]-63 Network Equipment Building System [NEBS] and GR-1089).

d. Range of the wireless devices and verify that the range of communications is minimized to both meet the needs of the Acquirer's proposed deployment and reduce the possibility of signal interception from outside the designated security perimeter.

e. Wireless technology and associated devices compliance with standard operational and security requirements specified in applicable wireless standard(s) or specification(s) (e.g., applicable IEEE standards, such as 802.11).

f. Configuration control options that enable varying of the security level of the devices.

2.4.16.13 Control System Inventory

Provide the complete control system inventory. The Control System Inventory must include the following attributes, in tabular format, as applicable:

General Information	Location Information	Hardware Details	Operating System and Platform	Network Information (Actual Function, not potential function)
Unique ID	Facility Name	Device Type	Embedded OS (Yes/No)	MAC Address(es)
Barcode or Identifier	NFAID	Device Sub-Type	OS Contractor	IP Address(es)
Region	Commodity	Device Function	Operating System (O/S)	Upstream Device

Installation	Floor	Manufacturer	O/S Version	Protocols In Use
Special Area (Option DNA1)	Room	Product Line	Platform Contractor	Host Name
	Location	Model No.	Platform Product Line	
	System Type	Serial No.	Platform	
	Functional System or Equipment Control	Remote Connectivity: (Wired / Wireless / None)	Platform Version	
		Network Type Used: (Serial / Ethernet / Both / None)		

2.5 PAINTING SYSTEM

a. Remove all grease, oil, and surface debris by solvent wiping or detergent/water scrubbing, prior to blast cleaning. Prepare surfaces to be coated by abrasive blasting to SSPC SP 6/NACE No.3, Commercial Blast Cleaning, or in accordance with the coating manufacturer's requirements, whichever is more stringent.

b. Use a painting system appropriate for the conditions provided in the Crane Design Criteria section. Paint exposed portions of the crane [and crane runway system] using a [three][_____]-coat system as follows: [zinc-rich primer consisting of a minimum of 77 percent zinc by weight in the dry film, an anticorrosive epoxy intermediate coat, and an aliphatic polyurethane top coat][_____]. All paint products must be supplied by a single manufacturer and free of chromates, lead, and mercury. Apply each coat in accordance with manufacturer's instructions and requirements. Ensure each coat is smooth, even, and free of runs, sags, orange peel, and other defects. Desired color of finish coat is [brilliant yellow][_____]. Submit product data for painting system.

c. Coat faying surfaces of bolted connections per RCSC A348, but do not apply finish paint.

d. Paint the load block [brilliant yellow] [_____] with black diagonal striping. Paint, coatings, or galvanizing on the following items or areas is not acceptable: hoist wire ropes, hooks, hook nuts, running bearing surfaces (including sheaves and wheel treads), grease fittings, or other items not normally painted.

e. Factory paint electrical and mechanical equipment in accordance with the manufacturer's best standard practice (for the specified environment).

2.6 IDENTIFICATION PLATES

Furnish and install identification plates. Provide non-corrosive metal identification plates with clearly legible permanent lettering giving the manufacturer's name, model number, serial number, capacity in both kilogram and pound units printed in different colors, and other essential information or identification.

2.6.1 Markings on Crane, Trolley, and Hook

To avoid operation of the crane in the wrong direction, affix the appropriate directions (NORTH, SOUTH, EAST, and WEST) with arrows on both sides of the bridge and both sides of trolley, as applicable. Markings must be visible by the operator and from the loading point. Labels on the controls must have corresponding directional (NORTH, SOUTH, EAST, and WEST) markings. Markings must agree with the markings on controller. Do not indicate directional arrows on controller.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, and before performing any work, verify all dimensions in the field. The Contractor is responsible for the coordination and proper relation of the contracted work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

[3.2 SHOP ASSEMBLY AND TESTS

Shop assemble major components as completely as possible, except for reeving of drums and sheaves. Functionally test the crane system at the construction facility prior to shipment. The Government reserves the right to inspect the crane for compliance with this specification and to witness the functionality tests. Notify the Contracting Officer [14] [_____] days prior to starting testing operations.

]3.3 ERECTION AND INSTALLATION

Perform the entire crane system erection in accordance with manufacturer's instructions under the full-time supervision of the manufacturer's representative.

3.3.1 Mechanical Alignment

Align motors, couplings, brakes, gear boxes, and drive components in accordance with manufacturer's instructions. Complete the Coupling Alignment Verification Record.

3.3.2 Electrical Adjustments

Adjust control system in accordance with manufacturer's instructions. Store a copy of all Control Parameter Settings (PLC, VFD). Provide the final settings and configurations data on the Complete Schematic Wiring Diagram, including but not limited to, timer settings, resistor tap settings, potentiometer settings, test-point voltages, supply voltages, motor voltages, motor currents. Provide the test conditions such as ambient temperature, motor load, date performed and person performing the adjustments as part of the Operational Tests report.

3.3.3 Field Welding

Perform welding indoors, where possible. Surface of parts to be welded must be free from rust, scale, paint, grease, and other foreign matter. Minimum preheat and interpass temperatures must conform to the requirements of AWS D14.1/D14.1M.

3.3.4 Field Painting

Perform painting indoors, where possible. Field painting (including touch-up) must conform to the requirements of the coating manufacturer and as specified in paragraph PAINTING SYSTEM.

3.4 FIELD QUALITY CONTROL

3.4.1 Post-Erection Inspection

After erection, the Contractor[, the Activity Crane Inspector/Test Director,] and the Contracting Officer must jointly inspect the crane bridge and hoist systems and components to verify compliance with specifications and approved submittals. Notify the Contracting Officer [_____] days before the inspection. Provide for approval a report of the inspection indicating the crane is considered ready for operational tests.

3.4.2 Operational Tests

Check the clearance envelope of the entire crane prior to picking or traversing any load to ensure there are no obstructions. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the crane is operational.[The Contractor must furnish test weights, operating personnel, instruments, and other apparatus necessary to conduct field tests on each crane. Solid weights must be measured using calibrated equipment traceable to National Institute of Standards and Technology (NIST) with a minimum accuracy of plus or minus two percent.]

3.4.2.1 No-Load Test

Raise and lower each hook through the full range of normal travel at rated speed for three complete cycles. Raise and lower each hook, testing other speeds of the crane. Verify proper operation of hoist limit switches. Operate the bridge and trolley in each direction the full distance between end stops. Operate through the entire speed range and verify proper brake operation. Verify correct operation of all indication and ancillary devices.

3.4.3 Test Data

Record test data on appropriate test record forms suitable for retention for the life of the crane. Record operating and startup current measurements for hoist, trolley, and bridge motors using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) must be justified or appropriate adjustments performed. In addition, note, investigate, and correct any high temperatures or abnormal operation of any equipment or machinery. Record hoist, trolley, and bridge speeds during each test cycle.

3.4.4 Hook Tram Measurement

Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus 1/64 inch). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening from the base measurement is cause for rejection.

3.4.5 Load Tests

Perform the following tests, as specified below.

Test loads used in this section are defined as the following:

Wire rope run-in load: 25 - 50 percent of rated load.

Rated load test: [100 percent (plus 0 minus 10)] [100 percent (plus [_____] minus [_____])] of rated load.

Overload test: [125 percent (plus 0 minus 5)] [125 percent (plus [0] [_____] minus [5] [_____])] of rated load.

3.4.5.1 Wire Rope Run-In

The primary purpose of this procedure is to exercise the newly installed wire rope.

Place the load on the hook. Start at ground level and hoist up to one foot below upper limit at slow speed. Hoist down to lower limit at slow speed. Repeat hoisting and lowering of the load for approximately 10 hoisting cycles, increasing the speed for each cycle. During this test, the capacity overload lockout should not activate.

3.4.5.2 Rated Load Test

3.4.5.2.1 Hoist

a. Static Load Test: With the trolley in the center of the bridge span, raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the load and hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes. Verify that maximum beam and girder deflections do not exceed CMAA 74 and MHI MH27.1 design limits, as applicable.

   For hoists with primary and secondary holding brakes, raise the test load and release the secondary holding brake while testing the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage secondary holding brake and release the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage the primary holding brake. Recheck proper operation of time delay and ensure smooth positive stopping.

b. Hoist Mechanical Load Brake (if present): Raise test load approximately 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

c. Raise and lower test load through the full lift range and visually observe smooth control and acceleration between points. Completely stop the machinery at least once in each direction to ensure proper brake operation.

d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet. While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.2.2 Trolley

Operate the trolley (if space is available) the full distance of the bridge rails in each direction with a test load on the hook. Check proper functioning through the range of speeds. Verify proper brake action.

3.4.5.2.3 Bridge

With a test load on the hook, operate the bridge for the full length of the runway (if space is available) in one direction with the trolley at the far end of the bridge, and in the opposite direction with the trolley at the opposite end of the bridge. Use extreme caution. Check proper functioning through the range of speeds. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

3.4.5.2.4 Trolley Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed of trolley travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the trolley stops and that the brake sets properly. Measure the distance required for the trolley to stop.

3.4.5.2.5 Bridge Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed of bridge travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the bridge stops and that the brake sets properly. Measure the distance required for the bridge to stop.

3.4.5.3 Overload Test

3.4.5.3.1 Hoist

Disconnect or adjust the overload limit device to allow the hoist to lift the test load. Verify proper operation of the overload limit device after it is reconnected.

a. Static Load Test: With the trolley in the center of the bridge span, raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the load and hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes.

For hoists with primary and secondary holding brakes, raise the test load and release the secondary holding brake while testing the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage secondary holding brake and release the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage the primary holding brake. Recheck proper operation of time delay and ensure smooth positive stopping.

b. Raise and lower test load and visually observe smooth control. Stop the load during raising and lowering to verify that the brakes holds the load.

c. Hoist Mechanical Load Brake (if present): Raise test load approximately 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet. While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.3.2 Trolley

Operate the trolley the full distance of the bridge rails in each direction with a test load on the hook (one cycle) through the range of speeds. Verify proper brake action.

3.4.5.3.3 Bridge

With a test load on the hook, operate the bridge for the full length of the runway in one direction with the trolley at the extreme end of the bridge, and in the opposite direction with the trolley at the opposite extreme end of the bridge (one cycle). Check proper functioning through the range of speeds. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

3.5 MANUFACTURER'S FIELD SERVICE REPRESENTATIVE

Furnish a qualified experienced manufacturer's field service representative to supervise the crane installation, assist in the performance of the on-site testing, and instruct personnel in the operational and maintenance features of the equipment.

3.6 OPERATION AND MAINTENANCE MANUALS

Provide [two] [_____] hard copies of operation and [two] [_____] hard copies of maintenance manuals for the equipment furnished along with an electronic copy (PDF) of each on a Compact Disc. Provide one complete set prior to performance testing and final copies upon acceptance. Provide operation manuals that detail the step-by-step procedures required for system startup, operation, and shutdown. Include the manufacturer's name, model number, parts list, and brief description of all equipment and basic operating features. List in the maintenance manuals routine maintenance procedures, including weekly, monthly, semi-annual, and annual required maintenance items, possible breakdowns and repairs, and troubleshooting guides. Also include as-built drawings, piping and equipment layout, design calculations, Control Parameter Settings and printouts of any software, and simplified wiring and control diagrams of the system as installed. Secure approval of operation and maintenance manuals prior to the field training course.

[3.7 FIELD TRAINING

Conduct a training course for [_____] operating and maintenance staff[and provide a copy of the training material to each participant]. Provide a training period consisting of a total of [_____] hours of normal working time and starting after the system is functionally completed but prior to final acceptance. Cover all pertinent points involved in operating, starting, stopping, and servicing the equipment, including all major elements of the Operation and Maintenance Manuals. Demonstrate in course instructions all routine maintenance operations such as lubrication, general inspection, and [_____].

][3.8 FINAL ACCEPTANCE

Final acceptance of crane system will not be given until Contractor has successfully completed all testing operations, corrected all material and equipment defects, made all proper operation adjustments, and removed paint or overspray on wire rope, hook, and electrical collector bars.

] -- End of Section --

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SECTION 41 22 13.16

GANTRY CRANES
04/08, CHG 1: 02/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 2011	(2014B) Cylindrical Wormgearing Tolerance and Inspection Methods
AGMA ISO 10064-6	(2010A) Code of Inspection Practice - Part 6: Bevel Gear Measurement Methods
AGMA ISO 17485	(2008A; Supplement 2008) Bevel Gears - ISO System of Accuracy (Including Supplement - Tolerance Tables 2008)
ANSI/AGMA 2001	(2004D; R 2010) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
ANSI/AGMA 2015-1	(2001A; R 2014) Accuracy Classification System - Tangential Measurements for Cylindrical Gears
ANSI/AGMA 6013	(2006A; R 2016) Standard for Industrial Enclosed Gear Drives

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-6 2021; Addenda AS-BF 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B30.2	(2017) Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)
ASME B30.10	(2019) Hooks

ASME B30.11	(2010) Monorails and Underhung Cranes - Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings
ASME B30.16	(2022) Overhead Underhung and Stationary Hoists
ASME B30.17	(2020) Overhead and Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoists)
ASME HST-1	(2012) Performance Standard for Electric Chain Hoists
ASME HST-4	(2021) Performance Standard for Overhead Electric Wire Rope Hoists
ASME NOG-1	(2020) Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)
ASME NUM-1	(2016) Rules for Construction of Cranes, Monorails, and Hoists with Bridge or Trolley or Hoist of the Underhung Type.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D14.1/D14.1M	(2019) Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment

ASTM INTERNATIONAL (ASTM)

ASTM A159	(1983; R 2020) Standard Specification for Automotive Gray Iron Castings
ASTM A275/A275M	(2018) Standard Practice for Magnetic Particle Examination of Steel Forgings
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A490	(2014a) Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A668/A668M	(2022) Standard Specification for Steel

	Forgings, Carbon and Alloy, for General Industrial Use
ASTM A931	(2008; R 2013) Standard Test Method for Tension Testing of Wire Ropes and Strand
ASTM A1023/A1023M	(2021) Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes
ASTM B438	(2021) Standard Specification for Bronze-Base Powder Metallurgy (PM) Bearings (Oil Impregnated)
ASTM B439	(2021) Standard Specification for Iron-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated)
ASTM B633	(2019) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM E125	(1963; R 2013) Photographs for Magnetic Particle Indications on Ferrous Castings
ASTM E543	(2021) Standard Specification for Agencies Performing Non-Destructive Testing
ASTM F436	(2011) Hardened Steel Washers
ASTM F959/F959M	(2017a) Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch and Metric Series

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 70	(2015) Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes
CMAA 74	(2020) Specifications for Single Girder Cranes

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 5	(2017) Industrial Control and Systems: Control Circuit and Pilot Devices

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 8	(2011) Crane and Hoist Controllers
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.179	Overhead and Gantry Cranes
29 CFR 1910.306	Specific Purpose Equipment and Installations

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1004-1	(2012; Reprint Nov 2020) UL Standard for Safety Rotating Electrical Machines - General Requirements
UL 1449	(2021) UL Standard for Safety Surge Protective Devices

1.2 DEFINITIONS

a. Crane Bridge: That part of an overhead crane system consisting of girder(s), end trucks, end ties, walkway, and drive mechanism which carries the trolley(s) and travels along the runway rails perpendicular to the gantry runway.

b. Crane Runway: The track system along which the crane operates horizontally, including track, track hangar rods, track connection devices, and runway structural supports.

c. Dead Loads: The loads on a structure which remain in a fixed position relative to the structure.

d. Girder: The principal horizontal beam of the crane gantry. It is supported by the crane end legs. Normally the crane trolley is mounted on top of the girder, and the hoist is suspended from the trolley to below the crane girder; however,the trolley and cab may also be suspended from the girder.

e. Live Load: A load which moves relative to the structure under consideration.

f. Pendant: A control for a hoist and/or a crane. The pendant hangs from the hoist or the crane by a cord at a height that is easy for the operator to reach.

g. Rated Load: For the purpose of this specification the rated load is defined as the maximum working load suspended under the load hook.

h. Standard Commercial Cataloged Product: A product which is currently being sold, or previously has been sold, in substantial quantities to the general public, industry or Government in the course of normal business operations. Models, samples, prototypes or experimental units do not meet this definition. The term "cataloged" as specified in this section is defined as "appearing on the manufacturer's published product data sheets. These data sheets must have been published or copyrighted prior to the issue date of this solicitation and have a document identification number or bulletin number.

i. Top Running Crane: An electric overhead traveling (OET) crane that runs on rails on top of support beams (bridge girders); or OET with equal or unequal legs supporting a girder, trolley, hoist (and cab)which travels horizontally on legs. The load is supported by the entire cross-section of the beam in bridge cranes. The load is carried by the cross-section of the beam supported by movable legs for a gantry crane, distributing the load to the legs, wheels, and gantry track.

j. Trolley Mounted Hoist: A combined unit consisting of a wheeled trolley that provides horizontal motion along the gantry girder, and a hoist suspended from the trolley, that provides lifting and lowering of a freely suspended load.

k. Under running (Underhung) Crane: An electric overhead traveling crane that is supported by crane end trucks suspended below the crane runway. The load is supported by hanging from the lower flange of a beam.

1.3 SYSTEM DESCRIPTION

The requirements for the crane runway and rail supporting structures are specified in Section 05 12 00 STRUCTURAL STEEL.

[1.3.1 Load and Sizing Calculations

Submit complete list of equipment and materials, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Submit calculations verifying the sizing of the gantry girder, end trucks and travel drives.[Include seismic analysis of gantry girder and end trucks.]

]1.3.2 OET Design Criteria

Cranes will operate in the given spaces and match the runway dimensions and rails indicated. Hook coverage, hook vertical travel, clear hook height, lifting capacity, and load test weight shall not be less than that indicated.

1.3.2.1 General

Include the following: Number of cranes [_____], located in building identified as [_____], the required span, and the rated capacity expressed in [_____] tons pounds, for each OET. Also clearly locate and identify each multiple girder hoist and system components.

1.3.2.2 Classification

Provide crane designed and constructed to[CMAA 70 Class [_____], [_____] service][CMAA 74 [Duty Class A][Duty Class B] [Duty Class C] service] requirements for operation in[indoor][outdoor][hazardous][non-hazardous] environment with[multiple girder hoist system][electric chain hoist conforming to ASME HST-1][electric wire rope hoist conforming to ASME HST-4].

1.3.2.3 Rated Capacity and Speeds

Provide crane conforming to[CMAA 70][CMAA 74] with rated capacity of [_____] tons pounds.[Provide auxiliary hoist with [_____] tons pounds capacity.] Lower load block or assembly of hook, swivel bearing sheaves, pins and frame suspended by the hoisting ropes are not considered part of the rated capacity. Rated speeds (in fpm) for the hoist,[hoist micro-drive, gantry micro-drive, trolley micro-drive,] gantry and trolley at the rated load are as follows:

Rated Speeds [meters per second] [feet per minute]			
Description	Minimum	Maximum	[Micro-drive]
Main Hoist	[_____]	[_____]	[[_____].]
[Auxiliary Hoist]	[_____]	[_____]	[[_____].]
Trolley	[_____]	[_____]	[[_____].]
Gantry	[_____]	[_____]	[[_____].]

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a

code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overhead Electric Traveling (OET) Crane(s); G[, [_____]]

Crane Runway System; G[, [_____]]

Complete Schematic Wiring Diagram; G[, [_____]]

Description of operation.

SD-03 Product Data

OET Design Criteria; G[, [_____]]

Overhead Electric Traveling (OET) Crane(s); G[, [_____]]

Load and Sizing Calculations; G[, [_____]]

Festoon System; G[, [_____]]

Runway Electrification System; G[, [_____]]

Variable Frequency Drives; G[, [_____]]

Bumpers; G[, [_____]]

End Stops; G[, [_____]]

[Spare Parts; G[, [_____]]

] Framed Instructions; G[, [_____]]

SD-06 Test Reports

Acceptance Testing; G[, [_____]]

SD-07 Certificates

Overload Test Certificate

No Hazardous Material; G[, [_____]]

Loss of Power Test; G[, [_____]]

Crane Runway System; G[, [_____]]

Certificate of Compliance; G[, [_____]]

Including listed Standards.

Wire Ropes; G[, [_____]]

Including Manufacturer's Certificate of Breaking Strength.

Hook NDT Reports; G[, [_____]]

NDT Vendor Certification; G[, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer Qualification

Overhead Electric Traveling (OET) Crane(s) shall be designed and manufactured by a company with a minimum of 10 years of specialized experience in designing and manufacturing the type of overhead crane required to meet requirements of the Contract Documents.

1.5.2 Pre-Delivery Inspections

Contractor is responsible for performance of quality control inspections, testing and documentation of steel castings, hook assembly and nuclear safety as follows. Submit all crane test data recorded on appropriate test record forms suitable for retention for the life of the crane. Visually inspect and test load-carrying steel castings ASTM A668/A668M using the magnetic-particle inspection method per ASTM A275/A275M. Reference allowable degree of discontinuities to ASTM E125, and relationship to service loads and stresses, critical configuration, location and type. Methods of repairing the discontinuities is subject to review by the Contracting Officer.

1.5.3 Certificates

Submit an Overload Test Certificate stating that the crane can be periodically load tested to 125 percent (plus 5 to minus 0) 131.25 percent of rated load. Also submit the following certificates:

a. stating that No Hazardous Material, including, but not limited to asbestos, cadmium, chromium, lead, elemental mercury, or PCB'c, is contained within system or components.

b. stating that the system is safe to perform a Loss of Power Test

c. stating that the Crane Runway System conforms to the requirements as specified herein and as specified in Section 05 12 00 STRUCTURAL STEEL.

d. Certificate of Compliance with Listed Standards

e. Provide manufacturer's Wire Ropes Breaking Strength certification that each rope meets the published breaking strength, or actual breaking strengths, of samples taken from reels and tested. Certifications shall be traceable to the crane and to the hoist to which the wire rope is installed. Wire rope must conform to ASTM A1023/A1023M. and ASTM A931.

f. Hook NDT Reports

1.5.4 NDT Vendor Certification

Provide certification that the NDT vendor meets the requirements of ASTM E543. Provide the NDT report to the Government which is traceable to the unique ID number on the hook and nut.

a. Submit for review the NDT vendor's procedures, including technique sheets specific to the types, shapes, and sizes of the parts being examined (e.g., shank hook, eye hook, duplex hook, eye bar, nut).

b. For the magnetic particle method, adequately describe the procedures for the orientation of the hooks, nuts, or pins with the magnetizing equipment. Procedures shall bear the approval of an independent Level III examiner.

c. Prior to performing any operational testing of the cranes, inspect the hook and hook nut by the magnetic particle method (MT) over their entire surface area[in accordance with NAVSEA Technical Publication T9074-AS-GIB-010/271]. ASTM A275/A275M may be used with the following restrictions:

  1. Do not use DC yokes (including switchable AC/DC yokes used in the DC mode) and permanent magnet yokes;

  2. Do not use automatic powder blowers or any other form of forced air other than from a hand-held bulb for the application or removal of dry magnetic particles;

  3. Remove all arc strikes;

  4. Equipment ammeters shall have an accuracy of plus/minus 5 percent of full scale (equipment ammeter accuracy other than that stated is acceptable provided the MT procedure states that a magnetic field indicator is used to establish and verify adequate field strength for all aspects of the inspection).

  5. If NDT cannot be performed on surfaces inside holes, visually inspect those surfaces to the maximum extent practical. Acceptance criterion is "no linear indications greater than 1/16 inch".

1.5.5 Overhead Electric Traveling (OET) Crane(s)

a. Submit shop drawings detailing all OET Design Criteria, showing the general arrangement of all components in plan, elevation, and end views; hook approaches on all four sides, clearances and principal dimensions, assemblies of hoist, trolley and gantry drives, and complete schematic wiring diagram with description of operation, and Runway Electrification System. Include weights of components and maximum gantry wheel loads and spacing.

b. Provide shop drawings whose quality is equivalent to the contract drawings accompanying this solicitation.

c. Provide integral schedule of crane components on each drawing. Provide maximum wheel loads (without impact) and spacing imparted to the crane runway system track beams. Indicate the crane speeds along the runway, the trolley speeds along the gantry girder, and the hoist lifting speeds; all speeds indicated are speeds with hoist loaded with rated crane capacity load.

[1.5.6 Welding Qualifications and Procedures

Perform welding in accordance with qualified procedures using AWS D14.1/D14.1M as modified. Written welding procedures shall specify the Contractor's standard dimensional tolerances for deviation from camber and sweep not exceeding those specified in AWS D14.1/D14.1M. Welders and welding operators shall be qualified in accordance with AWS D1.1/D1.1M or AWS D14.1/D14.1M. Allowable stress values shall comply with CMAA 70.

]1.5.7 Safety Requirements

Comply with the mandatory and advisory safety requirements of ASME B30.10, ASME B30.11,ASME B30.16, ASME B30.17, ASME B30.2, ASME HST-1, ASME HST-4, NFPA 70, 29 CFR 1910, 29 CFR 1910.179, and 29 CFR 1910.306. Nuclear certification, testing, and rules of construction shall be in accordance with 29 CFR 1910.147, and [ASME NOG-1 top running type cranes][ASME NUM-1 for underhung type cranes]. Submit analysis and test reports to Contracting Officer for approval.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect all delivered and stored equipment from the weather, humidity, temperature variations, dirt and dust, and other contaminants.

[1.7 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified and/or as recommended by the manufacturer, after approval of the detail drawings and not later than [_____] months prior to the date of beneficial occupancy. Include in data a complete list of parts and supplies, with current unit prices and source of supply. Furnish and deliver one set of manufacturer's recommended spare parts to the site. Suitably package the spare parts for long-term protection and storage. Legibly label the packaging to identify the spare parts. Also include a list of the furnished spare parts in the Maintenance manual.

]PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide materials and equipment which are standard products of manufacturers regularly engaged in the fabrication of complete and totally functional cranes including necessary ancillary equipment.

2.1.2 Nameplates

Secure nameplates to each major component of equipment with the manufacturer's name, address, type or style, model or catalog number, and serial number. Provide two gantry identification plates , one for each side of gantry. Provide noncorrosive metal identification plates with letters which are easily read from the floor, showing a separate number such as BC-1, BC-2, for each gantry crane.

2.1.3 Prohibited Use of Asbestos Products

Materials and products required for designing and manufacturing cranes shall not contain asbestos.

2.1.4 Capacity Plates

Two capacity plates indicating the crane capacity in tons pounds are required, one secured to each side of gantry. Fabricate each capacity plate with a steel backing plate and exterior quality/fade-resistant stick-on labels with letters large enough to be easily read from the floor. Place capacity plates in a location visible to pendant operator's position after the crane has been installed.

2.1.5 Safety Warnings

Affix labels in a readable position to each lift block or control pendant in accordance with ASME B30.16, ASME B30.2 and ASME B30.17. Submit safety warnings, diagrams and other framed instructions suitably framed and protected for display as indicated by the Contracting Officer as follows:

a. Design and locate the word "WARNING" or other legend to bring the label to the attention of the operator. Provide durable type warning labels and display the following information concerning safe-operating procedures:

   Cautionary language against lifting more than the rated load; operating the hoist when the hook is not centered under the hoist; operating hoist with twisted, kinked or damaged rope; operating damaged or malfunctioning hoist; operating a rope hoist with a rope that is not properly seated in its hoist drum groove; lifting people; lifting loads over people; and removing or obscuring the warning label.

b. To avoid operation of the crane in the wrong direction, affix the appropriate directions, with arrows, NORTH, SOUTH, EAST and WEST on the bottom of the girder where they can be easily seen by the operator. Labels on the controls shall have corresponding direction (NORTH, SOUTH, etc.). Markings shall agree with the markings on control pendant. Do not indicate directional arrows on control pendant.

2.2 STRUCTURAL MATERIALS

2.2.1 Bolts, Nuts and Washers

Utilize corresponding lockwashers with high-strength bolted connections ASTM F436, nuts ASTM A563, etc., conforming to requirements of AISC 325. Bolts, nuts and washers ASTM F959/F959M shall conform to ASTM A325 bolts or ASTM A307. Galvanized bolts are not acceptable. Do not use ASTM A490 bolts.

2.2.2 Gantry Girder or Girders

Provide[welded structural steel box section][wide flange beam, standard I-Beam, reinforced beam or section fabricated from rolled plates and shapes] gantry girders.

2.2.3 Gantry Rails or Bars

Trolley runway rails, crane girders and other sections shall be straight and true. When loaded with motor driven cranes the deflection of rails shall not exceed 1/888 of the span. Calculate the deflection with the worst case of two loaded gantry cranes located adjacent each other. Make all rail joints flush and true without misalignment of running tread and design to minimize vibration. The gap between adjacent rail ends and the vertical misalignment of running treads shall not exceed 0.0625 inch. Level the gantry rail to a plus-or-minus 1/8 inch at all rail support joints.[Fasten upper gantry rail to[top cover plate][wide flange] or centered on flange or offset near web plate for welded box sections, complete with welded clips.] Bolt gantry rail joints using standard joint bars. Stagger rail joints. Provide a positive stop at gantry rail ends to prevent creep.

2.2.4 End Ties and Gantry Girder End Connections

Use welded steel box sections for end ties. Provide full depth diaphragms at girder connections and jacking points. Provide horizontal gusset plates at the elevation of top and bottom end tie flanges for connection to girder ends. Make end connections with high-strength bolts per AISC 325. Use body-bound bolts fitted in drilled and reamed holes to maintain the crane square.

2.2.5 Gantry End Trucks

Provide[rotating][fixed axle] type end trucks fabricated of structural tubes or from structural steel to provide a rigid box section structure. Provide jacking pads for removal of wheel assemblies.

[2.2.6 Trolley Frame

Provide trolley frame consisting of two structural steel side frames or trucks welded together with one or more structural steel load girts to form a one-piece unit. Provide pads for the use of jacks or wedges when changing truck wheels.

]2.2.7 End Stops and Bumpers

Fit crane runways and gantry girders with structural steel end stops. Fit gantry end trucks and trolley frames with shock-absorbing, [spring][or][hydraulic] type bumpers capable of decelerating and stopping the gantry and/or trolley within the limits stated by OSHA and MHI CMAA. Provide trolley end stops of sufficient strength to withstand the impact of a fully loaded trolley moving at 50 percent of maximum rated travel speed. When two gantry cranes are on the same runway, fit one crane with shock-absorbing bumpers on each face of each end-truck, and the other crane shall have shock-absorbing bumpers as per above on one face only of each end-truck which is the opposite face of the adjacent crane. Fit the other face of the end-truck with a structural steel stop to engage the bumpers of the adjacent crane. Provide gantry bumper stops as specified in Section 05 12 00 STRUCTURAL STEEL. Locate stops to permit maximum gantry and trolley travel.

[2.2.8 Footwalks

The location and construction of footwalks shall conform to ASME B30.2. A full-length structural platform is required on the driver's side of the gantry. Provide[checkered steel][non-slip] flooring for platform, double member handrail and a suitable toe-guard, with 30 inch clearance in front of control equipment. Minimum 15 inch clearance is required in front of gantry machinery.[To give access to the opposite side of the trolley, gantry conductors, or other equipment, mount a footwalk a minimum of twice the length of the trolley on the opposite side of the crane. Provide a cross-over footwalk over an end tie between the two girder footwalks.] Mate the drive side footwalk with the crane access platform. Make the length of the drive side footwalk[adequate to provide access to the trolley and provide sufficient room for mounting control cabinets][along the entire length of the gantry]. Provide safety handrails for footwalks.

]2.2.9 Runway Rails

Provide runway rail size as specified in Section 05 12 00 STRUCTURAL STEEL.

[2.2.10 Operator's Cab

[2.2.10.1 Design

Design and construct operator's cab in accordance with[CMAA 70][CMAA 74][and ASME B30.2]. Locate cab access to facilitate entry and exit by crane operator. Provide space near cab entrance for storage of a carbon-dioxide, dry chemical, or equivalent hand fire extinguisher.

][2.2.10.2 Cab Construction

Provide a[standing][seated] type[fixed cab mounted on gantry][trolley mounted cab] of the[enclosed][open] type for[outdoor][indoor] use, and designed to provide a clear view of the operating floor and hook for operator.[Provide cab with a suitable[heating][heating and air conditioning] unit]. Locate cab on the [_____] of the[gantry][trolley] with the operator facing [_____].

]][2.2.11 Additional Provisions for Outside Service

Seal weld structural members on outdoor cranes. Provide crane gantries with parking brakes which will sufficiently hold the crane against a wind pressure of 5 psf for in-service conditions. Provide crane gantries with manually-operated pin locks at each rail, designed to securely anchor the crane against a wind pressure of 30 psf for out-of-service conditions.

]2.3 MECHANICAL EQUIPMENT

2.3.1 Variable Frequency Drives

2.3.1.1 Gantry Drives

Provide Variable Frequency AC (VFAC) [either the A-1 or][A-4] gantry drive arrangement as specified in[CMAA 70][CMAA 74], consisting of a single electric motor mechanically connected through gear reduction and drive shafts to the drive wheels or separate drive motors at each end of gantry. Perform acceleration and deceleration meeting the requirements specified in this section. Gears shall conform to applicable AGMA standards. Provide gear reducers that are oil tight and fully enclosed with pressure or splash type lubrication. Gantry-travel limit-switches are optional.

2.3.1.2 Trolley Drives

Provide complete trolley drive arrangement with a minimum of two wheels driven by an integral electric motor. Drive mechanism shall run in totally enclosed oil bath. Limit switches are optional for drive mechanism. Provide acceleration and deceleration controls meeting the requirements specified in this section.

[2.3.1.3 Micro-Drives

Provide the following crane motions with a separate micro-drive: [main hoist,] [auxiliary hoist,] [trolley drive][and][gantry drive]. The micro-drives are used to precisely position loads. Provide each micro-drive with an electric motor, gear reducer, magnetic coupling clutch and necessary controls. Connect the output shaft of the reducer to an extension of the primary drive high-speed shafting with a magnetic coupling clutch. Coupling shall normally be disengaged and become engaged only if the micro-drive is required. Provide electrical clutch components, required for proper operation, conforming to the requirements specified in paragraph ELECTRICAL COMPONENTS. Provide magnetic coupling type clutches which engage and disengage the micro-drives from the high speed shafts of the main drive arrangement. The clutch shall be engaged by electromagnet and released by springs. Provide clutch ratings not less than 150 percent of the micro-motor rated torque as amplified by the intervening gearing. Provide clutch enclosures to facilitate easy access for wear inspection of the friction elements and visual examination of the clutch assemblies.

]2.3.2 Gearing

Provide enclosed gear reducers type gearing. Gears and pinions shall be spur, helical, or herringbone type only, and be forged, cast or rolled steel. Open-type gearing is not acceptable, except for final drives. Provide gears and pinions with adequate strength and durability for the crane service class and manufactured to ANSI/AGMA 2001 Quality Class 6 or better precision per [AGMA ISO 10064-6] [AGMA ISO 17485] [AGMA 2011] [ANSI/AGMA 2015-1].

2.3.2.1 Gear Reducers

Provide gear reducers which are [standard items of manufacturers regularly engaged in the design and manufacture of gear reducers for Class D and E cranes][or][integral components of standard hoists or hoist/trolley units of manufacturers regularly engaged in the design and manufacture of hoists or hoist/trolley units for Class A, B or C cranes]. Provide gear reducers designed, manufactured and rated in accordance with ANSI/AGMA 6013 (for trolley drives only), as applicable. Except for final reduction, provide the gear reduction units with fully enclosed in oil-tight housing. Design gearing to AGMA standards and to operate in an oil bath. Operation shall be smooth and quiet.

2.3.2.2 Open Gearing

Provide gears and pinions possessing adequate strength and durability for the crane service class and manufactured to ANSI/AGMA 2001 quality class 6 or better precision per [AGMA ISO 10064-6] [AGMA ISO 17485] [AGMA 2011] [ANSI/AGMA 2015-1]. Enclose open gears with safety guard removable covers over openings for inspection and access for grease lubrication.

2.3.3 Hoist Brakes

a. General: In addition to the requirements of CMAA 70, provide shoe, disc, or conical type brakes with thermal capacity suitable for class and service specified in this section. Shoe, disc, and conical brakes shall be spring-set and electrically-released by a continuously rated direct acting magnet. Provide brakes which are self-aligning and easily adjusted for torque setting and lining wear. Use brake lining material which is asbestos free. Provide cast iron brake wheels conforming to ASTM A159 or the manufacturer's standard high-strength ductile cast-iron brake wheels, provided that the material exhibits wear characteristics in the form of powdered wear particles and is resistant to heat-checking. Provide disc brakes totally enclosed and having multiple discs with stationary releasing magnets. Brake torque shall be easily adjustable over a 2:1 torque range.

b. Gantry Brakes:[Provide gantry braking system with a spring-applied and electrically-released single shoe, disc, or conical brake for each gantry drive motor.] Braking system which automatically sets when controls are released or power is interrupted. Make provisions to facilitate easy brake adjustment. Provide brakes with a torque rating of at least 50 percent of gantry drive motor rated torque.

2.3.4 Wheels

Furnish wheels manufactured of rolled or forged steel.[Wheel treads and flanges shall be rim toughened to between 320 and 370 Brinell hardness number.] Provide double-flanged [gantry][gantry and trolley]wheels. Trolley and gantry wheels shall have straight treads. Equip wheels with self-aligning double-row spherical roller-bearings of capacity as recommended by bearing manufacturer for design load of trolley or gantry.

2.3.5 Bearings

All bearings, except those subject to a small rocker motion, shall be anti-friction type. Provide a means for lubrication for bearings not considered lifetime lubricated by the manufacturer. Equip equalizer sheaves with sintered oil-impregnated type bushings in accordance with ASTM B438 or ASTM B439.

[2.3.6 Anti-Drip Provisions

Design cranes to preclude leakage of lubricants onto the lifted loads, floor, or external grounds. Fit all equipment and components which cannot be made leak-proof with suitable drip pans. Provide drip pans manufactured of steel and designed to permit removal of collected lubricant.

]2.4 ELECTRICAL COMPONENTS

[2.4.1 Explosion Proof Requirements

Provide equipment and wiring in locations indicated conforming to NFPA 70 for Class [I] [II] [III], Division [1] [2] hazardous locations. Provide equipment suitable for[Group [_____]][operating temperature of [_____] degrees F]. Provide wiring and equipment in locations indicated of the classes, groups, divisions, and suitable for the operating temperature as specified.

]2.4.2 Control Systems

Provide a separate controller for each motor; however, use a duplex controller two motor gantry drives. Provide overload protection in conformance with the requirements of NEMA ICS 2 and mechanically and electrically interlock contactors that are used for starting, stopping, and reversing.

2.4.2.1 Travel Motion Control System

Provide AC inverter duty, totally enclosed non-ventilated (TENV), squirrel cage induction type bridge and trolley drive motors.

2.4.2.2 Drive Control System

Provide static reversing, adjustable frequency controllers conforming to[NEMA ICS 3][,][NEMA ICS 8] for the [hoist][trolley][and bridge]infinitely variable electric drives. Provide dynamic braking. Provide two step infinitely variable speed control for the bridge and trolley functions, controlled via pendant pushbuttons. The trolley, and bridge brakes shall set after associated controller decelerates motor to a controlled stop. Size the bridge and trolley controllers to provide sufficient starting torque to initiate motion of that crane drive mechanism from standstill with 0 to 131.25 percent of rated load on the hook and not produce any hook rollback. Drive motors shall run smoothly, without torque pulsations at the lowest speed, and be energized at a frequency not exceeding 60 HZ.

2.4.3 Power Sources

2.4.3.1 System Supply Voltage

Design cranes to be operated from a [_____] volt,[three-phase, 60 Hz, alternating current][direct current] system power source. Design energy isolating devices for such machine or equipment to accept a lockout device in accordance with NFPA 70.

2.4.3.2 Transformers

Provide dry type transformers and carry full load continuously at rated voltage and frequency without exceeding an average temperature rise of 115 degrees C above an ambient temperature of 40 degrees C. Provide transformer with totally enclosed case finished with manufacturer's standard coating system. Fully encapsulate transformers, except for those specifically designed for use as an isolation transformer for static power conversion units.

2.4.4 Motors

2.4.4.1 General Requirements for Motors

a. Provide motors designed specifically for crane and hoist duty. Provide drain holes at low points near each end; inspection and service covers with gaskets; and hardware which is corrosion-resistant. Provide motors conforming to the requirements of NFPA 70[,] [NEMA MG 1]and UL 1004-1.

[b. Motor heaters shall energize when mainline contactor is de-energized, and water heaters de-energize when mainline contactor is de-energized. Provide motors 20 HP and larger with a suitable heater to prevent condensation during long periods of inactivity. Provide motor heater which is an integral component of the hoist and motor manufacturer.

] c. Provide one embedded thermal sensitive device in hoist motor windings. Device and associated circuitry shall serve as an alarm activating an amber signal or pilot light visible to control stations when motor temperatures become excessive. Establish set point below the Class B insulation temperature limit. Thermal-sensitive device and associated circuits shall be self-restoring (automatic reset). Two-speed, two-winding motors with a solid-state control are not allowed for creep-speed use.

2.4.4.2 Gantry and Trolley Drive Motors

Provide [ac crane type] [dc industrial type] [800 Series dc mill type] [[single-speed; single-winding] [two-speed; two-winding]] [NEMA design B squirrel cage ac type rated] [wound rotor ac induction type] [ac type designed for ac adjustable frequency operation] [dc series wound type] [dc shunt-wound type] gantry and trolley drive motors.

2.4.4.3 Motor Enclosures

Provide motor enclosures which are [totally enclosed, non-ventilated (TENV)] [totally enclosed, fan cooled (TECH)] [totally enclosed, air-over frame (TAO)] [drip-proof] [drip-proof forced ventilation] conforming to NEMA 250.

2.4.4.4 Motor Insulation and Time Rating

Provide motors with [Class F] [Class H] rated insulation based on an [105] [125] degree C motor temperature rise above 40 degrees C ambient, with frame size selection based on continuous ratings.

[2.4.4.5 Micro-Motors

Micro-motors for gantry [and trolley] drives shall be [direct current industrial type, shunt wound motors] [industrial type, single-speed; single-winding; ac squirrel cage motor] and conform to the requirements of NEMA MG 1. Provide totally enclosed micro-motor , fan cooled (TEFC), with Class F or H insulation. Motor voltage rating shall comply with system supply voltage rating specified.

]2.4.5 Electric Hydraulic Brakes

[2.4.5.1 Travel Brakes

Provide electric-hydraulic [gantry][trolley] brakes which are dc shunt magnet type equipped with hydraulic actuators manually-operated with a foot-operated master control unit in the operator's cab, and electrically released with the operation of the mainline contactor POWER-OFF pushbutton or power failure. Provide remote control bleeders operable by pushbutton and foot pedal except for power-assisted brake systems. Remote control bleeders shall be complete with pushbutton clearly labeled and located in operator's cab where the operator can easily depress the pushbutton and pump the brake simultaneously. In lieu of the combination electric-hydraulic brakes, separate hydraulic and electric brakes may be provided. Design hydraulic brake system to ensure equal pressure at each brake cylinder.

][2.4.5.2 Hoist Brake Time Delay

Provide one of the hoist holding brakes with a time-delay setting (from 1 to 3 seconds). Initiate the time-delay upon releasing the control pushbutton or returning the master switch to OFF. Operation of mainline POWER-OFF pushbutton or power failure shall result in each hoist brake's setting without any time-delay.

]2.4.5.3 Automatic Stop System

Provide fail-safe spring set electrically-controlled brakes when power is interrupted. Release brakes with a mainline contactor POWER-OFF pushbutton or a master switch for the associated drive. Brakes shall automatically stop when there is a power failure. Design electric system to be mechanically released. Provide enclosures for electrical-controlled brake components conforming to NEMA ICS 6 Type [_____]. Provide direct current shunt magnetic shoe brakes with an electrical forcing circuit for rapid release of brake. Circuit each shunt coil brake for both conductors to open simultaneously when the brake is de-energized.

2.4.6 Controls

2.4.6.1 Control Panels

Fabricate control panels of solid sheet steel designed and constructed to conform to requirements of NEMA ICS 6 Type [_____]. [Provide thermostatically-controlled heaters to keep control enclosure temperatures at or above 0 degrees C in each static crane control panel.][Control panel heaters shall be energized when mainline contactor is de-energized, and be de-energized when mainline contactor is energized to prevent anti-condensation.]Hinge and equip control panel doors with gaskets and fitted with key-lock handle design, complete with a single key to open all locks. Provide a non-resettable hour meter, connected across the main line contactor, readable from the exterior of the main control panel, to indicate the elapsed number of hours the crane is energized.

2.4.6.2 Drift Point

Provide trolley and gantry main control systems with a drift point between OFF and first speed control point in each direction or have a separate pushbutton.

[2.4.6.3 Micro-Drive Motor and Clutch Control

Design micro-drive system such that when micro-drive is selected at control station, all main motors are disconnected, and all micro-drive clutches energized. Operation of micro-drive motors shall be from crane control station. Provide micro-motor control systems with single-speed in each direction by means of an electrically-operated, full-magnetic, [reduced][full] voltage type starter. Do not apply power to any micro-motor unless all clutches are fully engaged. If a clutch disengages during operation of micro-motors, the mainline contactors shall open and all brakes shall set. Prevent application of power to any main motor with any clutch engaged. Provide a transfer switch at crane control station to allow transfer from either mode of operation to the other only when all brakes have been set for not less than 5 seconds. Provide a single CLUTCH-ENGAGED green pilot light [at the pendant station][in the cab] when all clutches are energized; also provide individual CLUTCH ENGAGED pilot lights on drive control panels.

][2.4.7 Cab Control Station

2.4.7.1 General

Accomplish crane control by a [gantry-mounted][trolley-mounted] cab control. Provide spring-return to "OFF" for master switch operating handles, with [distinct drift point detents,][distinct speed-point intents,] and OFF position latching. Provide NEMA Type 1 master switch enclosures. Provide POWER-OFF pushbutton with a red mushroom head and a green or black POWER-ON pushbutton. Provide the following cab master switches:

a. Main Hoist - up/down.

[b. Aux Hoist - up/down.

] c. Gantry - [_____] [_____].

d. Trolley - [_____] [_____].

e. POWER-OFF.

f. POWER-ON.

2.4.7.2 Cab Indications

Provide red pilot lights to indicate excessive hoist motor temperature. Provide a white pilot light to indicate that power is available on load side of crane disconnect switch. Provide a blue pilot light to indicate that the main contactor is energized.[Supply a minus 300 to plus 300 Dc voltmeter to monitor the main rectifier output voltage, and provide a selector switch to select the voltage to be monitored.][Provide a red pilot light to indicate the rail clamps are set.][Provide a single-toggle switch to operate crane floodlights.][Provide a single green pilot to indicate all micro-drive clutches are engaged.]

[2.4.7.3 Cab Controls

Provide cab with a 2-position key-operated switch to allow transfer of control from cab to [pendant][radio control] station and a red pilot light mounted in cab to indicate that the control has been transferred to other station. Selection of one operating station shall lock out the controls of other stations.[Also provide a 2-position switch to raise and lower the pendant station.]

][2.4.7.4 Cab Heating & Ventilating [& Air-Conditioning]

Provide thermally-insulated cab with [air-conditioner][and electric heater]. Provide a filter unit to pressurize the cab with filtered outside air. Provide air filter which is a standard commercial type capable of removing airborne dust and located where it can be readily cleaned or changed. Provide adjustable thermostat to control [air conditioner][with][heater]. The unit shall meet the Energy Efficient requirements of ASHRAE 90.1 - IP. Keep the cab interior at 65 degrees F in winter with [_____] degrees F ambient temperature and [_____] degrees F in summer with [_____] degrees F dry bulb and [_____] degrees F wet-bulb ambient temperatures. Provide corrosion-resistant material or protection against corrosion for all other hardware and components. Mount motor compressor assembly on vibration isolators.

]][2.4.8 Pendant Control Station

[2.4.8.1 General

Provide NEMA Type [1] [3R] [7] [9] [12] pendant control station. Hold physical size of pendant to a minimum. Provide a separate cable of corrosion-resistant chain consisting of minimum 1/8 inch wire. Attach pendant station to [underside of crane gantry footwalk][an auxiliary girder] and hang vertically with bottom of pendant at 40 inches above floor. Do not support weight of pendant by control cable.

]2.4.8.2 Operating Pushbuttons

Provide heavy-duty, dust-and-oil-tight type operating pushbuttons with distinctly-felt operating positions which meet requirements of NEMA ICS 2. Pendant control buttons shall be momentary pushbuttons. Provide recessed type pushbuttons (except the POWER-OFF button) to avoid accidental operation. Make diameter of buttons a size which will make operation possible with a thumb while holding the pendant with same hand. Provide nameplates adjacent to each pushbutton. Provide barriers on pendant between various pushbutton functions, except on elements mounted in junction box. In a multi-speed application, provide dual-position pushbuttons that have a definite click-detent position for each speed. Design and manufacture pushbuttons not to hang up in control case. Include with the pendant a separate set of pushbuttons for each motion and for POWER-ON POWER-OFF. Provide the following pushbuttons:

POWER-OFF.

POWER-ON.

Hoist-up.

Hoist-down.

[Gantry]-[_____].

[Gantry]-[_____].

Trolley-[_____].

Trolley-[_____].

2.4.8.3 Light Indicators

Provide pilot lights meeting heavy-duty requirements of NEMA ICS 5. Provide one red pilot light to indicate excessive hoist motor temperature on pendant station. Provide a blue pilot light to indicate that the main contactor is energized, and a white pilot light to indicate that power is available on the load side of crane disconnect switch. Provide a bright red mushroom head for the POWER-OFF pushbutton. Provide a 2-position selector switch to select between normal and micro-drive.[Provide a single green pilot light to indicate all [micro-drive]clutches are engaged.]

[2.4.8.4 Pendant Drive Control

Provide a 3-position momentary contact spring-return to OFF toggle switch to control the motorized trolley for pendant.

][2.4.8.5 Transfer of Control Stations

Provide pendant with a green pilot light to indicate that control has been transferred to pendant station from cab with key lock-out.

]][2.4.9 Radio Remote Control, Infrared Remote Control

2.4.9.1 General

Equip crane with a complete digital radio remote-control system to permit full control of crane from a portable wireless transmitter. Provide a system which is the use-proven product of a manufacturer regularly engaged in design and manufacture of crane radio remote-control systems. Provide a "fail-safe" designed system so that the failure of any component or loss of signal will cause all crane motors to stop. The system shall permit complete, independent and simultaneous operation of all crane functions.[Set system frequency in the 72MHz-76MHz band.][Frequencies shall conform to FCC Part 15.] Include transfer relays in receiver if crane is also cab or pendant controlled.

2.4.9.2 Transmitter

Provide portable transmitter complete with an adjustable belt or harness. Crane motion switches shall spring-return to OFF. Provide transmitter with two spare batteries and battery charger to permit continuous operation. Provide a key-lock with the key removable in the OFF position only to control transmitter operation. Provide a blue signal light mounted on crane visible from floor to indicate the main contactor is energized. Make POWER-OFF toggle-switch bright red. Provide the transmitter with the following controls:

Hoist-up/down.

Gantry-[_____].

Trolley-[_____].

POWER-ON.

POWER-OFF.

]2.4.10 Protection

2.4.10.1 Main Line Disconnect

Provide a main line disconnect consisting of a combination circuit breaker (50,000 AIC) and non-reversing starter, starter without overloads (mainline contactor) in NEMA Type [_____] enclosure. Control circuit of mainline disconnect shall cause all crane motions to stop upon mainline undervoltage, overload, control circuit fuse failure, or operation of POWER OFF pushbutton. Equip mainline disconnect with energy isolating devices designed to accept lockout devices.

2.4.10.2 Isolation Transformer

Provide an SCR drive type isolation transformer specifically designed for cranes, with a continuous rating which will exceed that required of the sum of rated full-load full-speed KVA of hoist plus 50 percent of rated full-load full-speed KVA of trolley and gantry motors plus the rated KVA of controls. Multiply the total KVA by 1.05 (efficiency factor). Connect the isolation transformer to the load side of mainline disconnect of the transformer. Supply crane dc static control electric power distributed on the crane through this isolation transformer.

2.4.10.3 Surge Protection

Provide surge suppressors meeting the requirements of UL 1449. Provide three metal oxide varistors on the line side of each SCR drive isolation transformer to provide transient over-voltage protection.

2.4.10.4 Circuit Breakers

Provide circuit breakers meeting the requirements of UL 489.

2.4.10.5 Overloads

[Provide alternating current circuit overload relays of the ambient compensated, automatic reset, inverse time type located in all phases individual motor circuits. Arrange overload relays to de-energize the associated motor on an overload condition.] [Provide an automatically reset inverse time-trip running overload relay for each dc motor circuit. Provide an automatically reset instantaneous trip overload relay in each dc motor circuit or for a pair of series-connected motors. Arrange overload relays to de-energize the associated motor on an overload condition.] [Alternating current adjustable frequency-control motor overload-protection shall be electronic and protected by inverse time and current versus output frequency which will allow less current for a given amount of running time when frequency (speed) is lower than rated.] [Provide electronic direct current variable voltage control motor overload-protection.]

2.4.11 Limit-Switches

Provide heavy-duty quick-break double-pole double-throw type gear limit switches conforming to NEMA ICS 2. The geared limit-switch interruption of a motion in one direction shall not prevent the opposite motion. Geared limit-switches shall reset automatically. Provide NEMA Type [1] [4] limit switch housings. Provide limit-switches to interrupt power to the primary [and micro-drive]control systems. Provide a geared limit switch to limit upward travel at an upper limit and a geared limit switch to limit downward travel at a lower limit. Provide also a block activated mechanical limit switch that removes power from the brake, motor and control drive simultaneously.

2.4.11.1 Gantry and Trolley Travel Limit-Switches

Provide runway (track-type) limit-switches for crane gantry and trolley motions to stop the gantry and trolley motions, respectively. Install limit-switch actuators on building and trolley frame to actuate the limit-switches and stop the crane gantry or trolley prior to contacting the trolley frame bumpers. Locate trip mechanism for trolley motion on crane runway to trip the switch before the bumper contacts the stop. Locate trip mechanism for gantry motion on crane runway to trip switch before bumper contacts the stop. When the switch is tripped, permit the switch opposite travel in the direction of stop and to automatically reset.

[2.4.11.2 Rail Clamp Limit-Switches

When rail clamps are set, furnish each rail clamp with a limit-switch designed to interrupt the primary [and micro-drive]control circuits to gantry drive. Provide a red pilot light at control station to indicate the rail clamps are set.

]2.4.12 Wiring

Perform wiring complying with Article 610 of NFPA 70. Number or tag wires at connection points. Make all splices in boxes or panels on terminals boards or standoff insulators. Base motor loop, branch circuit and brake conductor selection on NFPA 70 for 194 degrees F conductor rating on indoor cranes, and for 164 degrees F conductor rating on outdoor cranes. Provide Type SRML conductors in the vicinity of resistors and conductors connected to resistors.

2.4.13 Electrification

2.4.13.1 Main Power Electrification

Main power electrification system shall provide power to crane starter/disconnect circuit breaker.

2.4.13.2 Crane Runway Conductors

[Provide covered conductor bar type crane runway conductor system designed and manufactured to meet UL requirements. Provide rigid or flexible self-closing type protective cover designed to cover all live conductors and shaped to prevent accidental contact with conductors. Provide heavy-duty sliding shoe type collectors compatible with the electrification system. Provide two tandem designed collector heads for each conductor rail to provide redundancy.] [Provide festooned type crane runway conductor system consisting of a support rail, cables, junction boxes, cable cars and accessories. Hardware shall be corrosion-resistant or protected against corrosion. Festoon storage area shall not restrict the crane travel at the ends of runway.]

2.4.13.3 Gantry Span Conductors

Provide[festooned type consisting of a support rail, electrical cables, junction boxes, cable cars and accessories][rigid conductor/collector type located within enclosure] gantry span conductor system. Do not allow cable loops to drop below the hook high position. Furnish corrosion resistant, outdoor crane gantry festoon, system hardware.

[2.4.13.4 Pendant Festoon System

Provide pendant festoon system consisting of a support rail, cables, junction boxes, cable cars and accessories. Do not allow cable loops to drop below the hook high position. Provide pendant control car with NEMA Type [1] [3R] [12] junction box. Pendant festoon shall be[towed by trolley][independent of trolley motion]. Furnish corrosion resistant, outdoor crane, pendant festoon system hardware.

][2.4.13.5 Pendant Drive System

Provide pendant festoon system with a motor-drive system capable of driving the pendant control car at [_____] fpm. Control of pendant motor drive shall be from the pendant.

][2.4.13.6 Pendant Retraction System

[Provide pendant control car with an electric-powered cable reel so that the pendant station will retract fully.][Provide a wire-rope hoist to hoist the pendant station. Pendant and pendant drop-cable shall be retractable to approximately 1/3 of drop cable length.]Control retraction system from cab.

]2.4.14 Special Requirements

2.4.14.1 Warning Horn

Provide a solid-state electronic warning horn on the crane. Accompany any gantry or trolley motion by a continuous series of alternating tones.[The warning horn shall not sound when the crane is in the micro-drive mode.]

2.4.14.2 Accessory Power

Use three-phase 208Y/120 volt ac power supplied via a circuit breaker and isolation transformer from the line side of the main line disconnect for [lighting,] [heaters,] [and accessory circuits] on the crane. Provide the circuit breaker with a NEMA Type [1] [3R] [12] enclosure. The enclosure shall have provisions to lock the breaker in the OFF position. Provide each circuit breaker pole with individual thermal and magnetic trip elements and the enclosure cover with a button for mechanically tripping the circuit breaker. Supply three-phase 480 volt delta primary and 208Y/120 volt wye secondary general lighting transformer from the accessory circuit breaker and feed a 208Y/120 volt UL listed circuit breaker panelboard and a heater circuit breaker/combination starter. Provide a panelboard to supply branch circuits for utilization of various accessories such as [receptacles,] [lighting,] [panel internal lighting,] [motor heaters and control enclosure which meets NEMA requirements]. Transformer and panelboard shall have the same NEMA classification as the circuit breaker.

2.4.14.3 Receptacles

Provide single-phase, 120-volt 15-amp, grounded, duplex type receptacles complete with metal weather-proof enclosure with self-closing weatherproof receptacle cover. Provide a receptacle on the trolley at each end of the front gantry walkway in the vicinity of gantry travel drive motors and in the cab. Provide several receptacles in the vicinity of the control equipment equally spaced every 10 feet. Breakers used to protect circuits supplying the receptacles for outside cranes shall incorporate ground fault current interruption feature and meet the requirements of UL 943.

2.4.14.4 Lighting

Provide control panels with a 120-volt lamp fixture with an unbreakable lens and switch. Provide floodlights to illuminate the work area under the crane and drum area on crane, controlled from crane control station. Provide metal halide industrial floodlight luminaries. Totally enclose each floodlight, vapor-tight design, gasketed and provided with a heat-resistant and impact-resistant glass lens. Space and attach floodlights to underside of crane to provide uniform lighting.

[2.4.14.5 Anti-Condensation Heaters

Equip motor and control panels with anti-condensation heaters. Provide thermostatically-controlled heaters in each static-control panel to keep control enclosure temperatures at or above 0 degrees C. Provide NEMA Type [1] [3R] [12] enclosure for circuit breaker combination magnetic starter. Equip magnetic starter with manually-reset overload relays and interlock with the mainline disconnect so that anti-condensation heaters are de-energized when the mainline contactor is energized and the magnetic starter is energized when the mainline contactor is de-energized.

][2.4.14.6 Wind Indication and Alarm

Provide a wind-indicating device with an adjustable alarm trip point.

Provide alarm trip with time-delay for wind gusts. Adjustable trip shall actuate an oscillating blue light and bell mounted near [_____]. Provide ability to cut off bell alarm from the[pendant station][cab].

][2.4.14.7 Electrically-Driven Oil Pump Alarm

Provide electrically -driven lubricating pump complete with an audible alarm and red light for indication of pump malfunction. Make location of alarm the factory standard location.

]2.4.15 Load-Limit System

Provide a load-limit visual/audible system for the main hoist to inform the operator that the preset load has been exceeded. Provide a load-limit system consisting of a load-cell, load-sensing electronics, overload indicator lights, overload alarm bell and alarm cut-out switch. Mount load cell to receive the load from equalizing sheave pin or upper block sheave pin. The alarm setpoint shall be adjustable.

2.4.15.1 Load-Sensing Electronics

Provide NEMA Type [1] [3R] [12] enclosures for load sensing electronics. Alarm setpoint shall be adjustable.

2.4.15.2 Alarm and Indicator Light

Provide an overload alarm light to indicate a load greater than the preset maximum. Indicate overload alarm with a red light and clearly labeled "OVERLOAD". Also provide a bell to indicate when an overload condition exists. Make provisions to turn off the bell from[pendant station][cab] [_____].

2.4.16 Fungus Resistance

Coat electrical connections such as terminal connections, circuit connections, components and circuit elements with fungus-resistant varnish. Do not treat components and elements which are inherently inert to fungi or hermetically sealed. Do not treat elements whose operation will be adversely affected with the application of varnish.

2.5 ELECTROMAGNETIC INTERFERENCE SUPPRESSION

2.5.1 Shielded Cable

Provide shielded type pendant and festooned cables of braided tinned-copper. Ground each cable shielding with a single connection to equipment grounding conductor.

2.5.2 EMI/RFI Shielded Boxes

2.5.2.1 General

Boxes designed to house electronic and electrical control equipment, instruments, metering equipment, etc., in installations where electromagnetic compatibility and/or system security is required shall protect interior components from stray radio frequency (RF) fields and contain RF signals produced by interior components.

2.5.2.2 Construction

Design Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) shielded boxes to meet UL 50 Type 12 and Type 13. Construct the shielded boxes of [16] [14] gauge steel with seams continuously welded and ground smooth, without holes and knockouts. Cover gasket shall be a combination of woven plated steel mesh and oil-resistant gasket which will provide an EMI/RFI seal as well as an oil-tight, dust-tight and water-tight seal between cover and body. Attach gasket to cover with oil-resistant adhesive. Provide stainless steel cover clamps and screws which are quick and easy to operate on three sides of hinged cover for positive clamping.

2.5.2.3 Attenuation

Design EMI/RFI shielded boxes to provide maximum shielding of electric and magnetic components of radiated RF energy. Provide RF filters to suppress conducted radio frequency in cables and conductors. Provide shielded boxes with attenuation greater than 60 db at 14.5 KHz to greater than 100 db at 1 MHz for magnetic fields and greater than 100 db from 14.5 KHz to 430 MHz for electric fields.

2.5.2.4 Finish

Provide zinc-plated EMI/RFI shielded boxes in accordance with ASTM B633 SC3/Type II to provide corrosion-resistant conductive surfaces for gasket contact area and conduit entries. Match the finish coat with the crane finish.

[2.5.3 Hoist Drum Grounding

Provide a copper ring/collector assembly to ground each drum. Provide electrically-bonded ring to drum. Collector shall be stationary and connected to equipment grounding conductor system with a No. 8 AWG copper wire.

]PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, and before performing any work, verify all dimensions in the field and submit a letter describing the results of this verification including discrepancies to the Contracting Officer and crane manufacturer. The Contractor is responsible for the coordination and proper relation of the contracted work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

3.2 ERECTION

Perform the entire crane erection in accordance with manufacturer's instructions under the full-time supervision of the manufacturer's representative. Provide a written certificate from crane manufacturer indicating the crane is erected in accordance with manufacturer's recommendations before testing the completed installation.

3.2.1 Shop Assembly

Shop assemble major crane components as completely as possible. Match mark disassembled parts and tag electrical connections after complete no-load shop testing. Protect all parts and equipment at site from weather, damage, abuse and loss of identification. Erection procedures shall ensure that the crane is erected without initial stresses, forced or improvised fits, misalignments, nicks of high-strength structural steel components, stress-raising welds and rough burrs. Clean and repaint damaged surfaces after crane is erected. Provide all necessary grease and oil of approved quality and grade for the initial servicing and field test.

3.2.2 Mechanical Alignment

Align motors, couplings, brakes, gear boxes and drive components when reinstalled in accordance with manufacturer's instructions.

3.2.3 Electrical Alignment

Align control system in accordance with manufacturer's instructions. Store a copy of the final alignment data in control panel door, including but not limited to, timer settings, resistor tap settings, potentiometer settings, test-point voltages, supply voltages, motor voltages, motor currents and test conditions such as ambient temperature, motor load, date performed and person performing the alignment.

3.2.4 Welding

Qualify or pre-qualify welders, welding operations and welding procedures in accordance with AWS D14.1/D14.1M. Perform welding indoors. Surface of parts to be welded shall be free from rust, scale, paint, grease or other foreign matter. Minimum preheat and interpass temperatures shall conform to the requirements of AWS D14.1/D14.1M. Perform welding in accordance with written procedures which specify the Contractor's standard dimensional tolerances for deviation from camber and sweep. Such tolerances shall not exceed those specified in accordance with AWS D14.1/D14.1M. Allowable stress ranges shall be in accordance with CMAA 70. Perform welding of girders and beams conforming to AWS D14.1/D14.1M.

3.2.5 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the facility, shall conform to SSPC SP 6/NACE No.3 and as specified in Section 09 90 00 PAINTS AND COATINGS. Paint gantry crane including gantry, trolley, hoist and all attached items in accordance with the manufacturer's standard practice. Paint the complete crane of one color. Paint gantry rail, supports and bracing in accordance with Section 09 90 00 PAINTS AND COATINGS. **Do not paint** items such as surfaces in contact with the rail wheels, wheel tread, hooks, wire rope, surfaces on the electrical collector bars in contact with the collector shoes and nameplates.[Coordinate the requirements of explosion proof cables with cable manufacturer.]

3.3 ACCEPTANCE TESTING

3.3.1 General

Provide all personnel necessary to conduct the required testing, including but not limited to, crane operators, riggers, rigging gear and test weights. Perform testing in the presence of Contracting Officer or his designated representative. Notify the Contracting Officer [_____] days prior to testing operations. Operate all equipment and make all necessary corrections and adjustments prior to the testing operations witnessed by

Contracting Officer. A representative of the Contractor responsible for procuring and installing hoist equipment shall be present to direct the field testing. Use compact test loads and permit a minimum of 50 percent of vertical lift. Test loads shall be minus 0 percent to plus 5 percent of the required weight, and be verified prior to testing. Test weights required are [_____], [_____] and [_____] pounds. Do not perform operational testing until after building interior has been painted. Furnish [three] [_____] copies of all test reports to Contracting Officer.

3.3.1.1 Test Sequence

Test crane in accordance with applicable paragraphs of this procedure in the sequence provided. Verify clearance envelope is clear to ensure there are no interferences.

3.3.1.2 Test Data

Record operating and startup current measurements for coils, hoist, trolley, and gantry motors using the appropriate instrumentation. Record speed measurements as required by facility evaluation tests (normally at 100 percent load). Compare recorded values with design specifications or manufacturer's recommended values. Abnormal differences shall be justified in the remarks and appropriate adjustments performed. Note any high temperatures or abnormal operation of any equipment or machinery, investigate and correct. Record hoist, trolley and gantry speeds during each test cycle.

3.3.1.3 Equipment Monitoring

Monitor improper operation or poor condition of safety devices, electrical components, mechanical equipment and structural assemblies during the load test. Report defects observed to be critical during the testing period immediately to the Contracting Officer and suspend the testing operations until the defects are corrected. During each load test and immediately following each load test, make the following inspections:

a. Inspect for evidence of bending, warping, permanent deformation, cracking or malfunction of structural components.

b. Inspect for evidence of slippage in wire rope sockets and fittings.

c. Check for overheating in brake operation; check for proper stopping. Test all safety devices including emergency stop switches and POWER-OFF pushbuttons and inspect separately to verify proper operation of the brakes. When provided, inspect all safety accessories including warning horn, lighting, gauges, warning lights and accuracy of wind indicating device and alarm.

d. Check for abnormal noise or vibration and overheating in machinery drive components.

e. Check wire rope sheaves and drum spooling for proper reeving and operation, freedom of movement, abnormal noise or vibration.

f. Check electrical drive components for proper operation, freedom from chatter, noise, overheating, and lockout/tag-out devices for energy isolation.

g. Inspect gears for abnormal wear patterns, damage, or inadequate lubrication.

h. Verify that locations of crane capacity plates are visible from pendant operator's position.

[3.3.2 Trolley Travel

Operate trolley the full distance of gantry rails exercising all primary drive [and micro-drive]speed controls in each direction. Verify brake operation in each direction. In slow speed [or micro-drive,]trolley bumpers shall contact trolley stops located on the gantry girders. In slow speed, test the proper operation (interrupt power, automatic reset) of the trolley limit-switches at both limits of trolley motion.

]3.3.3 Gantry Travel

Operate gantry in each direction the full distance of runway exercising all primary drive [and micro-drive]speed controls. Verify brake operation in each direction.[In slow speed the proper operation (interrupt power, automatic reset) of the gantry, test limit-switches at both limits of gantry motion.] In slow speed [or micro-drive]the crane gantry bumpers shall contact the runway rail stops.

3.3.4 Gantry Crane Tests

3.3.4.1 Dynamic Load Tests

a. Trolley Dynamic Load Test: While operating the trolley the full distance of gantry rails in each direction with test load on the hook (one cycle), test proper functioning of all primary drive and micro-drive speed control points and proper brake action.

b. Gantry Dynamic Load Test: With test load on hook, operate gantry for the full length of runway in both directions with trolley at each extreme end of gantry. Verify proper functioning of all primary drive and micro-drive speed control points and brake action. Binding of the gantry end trucks indicates a malfunction requiring adjustment.

3.3.4.2 Trolley and Gantry Loss of Power Test

A test load of 100 to 105 percent of rated load shall be raised clear of any obstructions on operating floor. Starting at a safe distance from walls or other obstructions, select a slow speed using the trolley and gantry primary drive. While maintaining a safe distance to obstructions, disconnect the main power source and verify brakes have set and that the equipment stops within the distance recommended by manufacturer.

3.3.5 Overload Tests

After the operational tests, test gantry crane system and all functions of gantry crane at 125 percent of rated load. With the trolley in the center of the bridge span, raise the test load approximately 1 foot and hold the load for 10 minutes. Verify the load does not move. Verify the girder deflection is within specifications.

3.3.6 Acceleration and Deceleration Tests

Test the acceleration and deceleration of gantry and trolley with approximately 10 percent of rated load at lowest possible location of hook. Operate gantry and trolley to run up to high speed and then stop without jarring or swinging the load.

3.3.7 Grounding Test

Test hoist to determine that the hoist, including hook and pendant, are grounded to building during all phases of hoist operation. Test the grounding of gantry and trolley with approximately 10 percent of rated load on hook. Test grounding between hoist hook and the structure's grounding system.

3.3.8 Adjustments and Repairs

Perform adjustments and repairs under the direction of the Contracting Officer at no additional cost to the Government, until satisfactory conditions are maintained, and contract compliance is affected. After adjustments are made to assure correct functioning of the components, repeat pertinent testing.

3.4 SCHEMATIC DIAGRAMS

Store schematic diagrams for equipment where indicated on drawings.

3.5 MANUFACTURER'S FIELD SERVICE REPRESENTATIVE

Furnish a qualified experienced manufacturer's field service representative to supervise the crane installation, assist in the performance of the on site testing, and instruct personnel in the operational and maintenance features of the equipment.

3.6 OPERATION AND MAINTENANCE MANUALS

Provide [six] [_____] copies of operation and [six] [_____] copies of maintenance manuals for the equipment furnished. One complete set prior to performance testing and the remainder upon acceptance. Detail in the operation manuals the step-by-step procedures required for system startup, operation and shutdown. Include the manufacturer's name, model number, parts list, and brief description of all equipment and basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Also include piping and equipment layout and simplified wiring and control diagrams of the system as installed. Secure approval of operation and maintenance manuals prior to the field training course.

3.7 FIELD TRAINING

Conduct a training course for the operating staff. Provide a training period consisting of a total of [_____] hours of normal working time and starting after the system is functionally completed but prior to final acceptance. Cover all pertinent points involved in operating, starting, stopping, and servicing the equipment, including all major elements of the Operation and Maintenance Manuals. Demonstrate in course instructions all routine maintenance operations such as lubrication, general inspection, and [_____]. Give Contracting Officer at least 2 weeks advance notice of field training.

3.8 FINAL ACCEPTANCE

Final acceptance of crane system will not be given until Contractor has successfully completed all testing operations, corrected all material and equipment defects, made all proper operation adjustments, and removed paint or overspray on wire rope, hook and electrical collector bars.

-- End of Section --

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SECTION 41 22 13.55

BRIDGE CRANES, UNDER RUNNING, AIRCRAFT HANGAR
02/22 CHG 1: 05/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360 (2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B30.10 (2019) Hooks

ASME B30.16 (2022) Overhead Underhung and Stationary Hoists

ASME B30.17 (2020) Overhead and Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoists)

ASME B30.30 (2019) Ropes

ASME HST-4 (2021) Performance Standard for Overhead Electric Wire Rope Hoists

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding Code - Steel

AWS D14.1/D14.1M (2019) Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment

ASTM INTERNATIONAL (ASTM)

ASTM A1023/A1023M (2021) Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes

ASTM E543 (2021) Standard Specification for Agencies Performing Non-Destructive Testing

ASTM E1417/E1417M	(2016) Standard Practice for Liquid Penetrant Testing
ASTM F436/F436M	(2019) Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
ASTM F3125/F3125M	(2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

BRITISH STANDARDS INSTITUTE (BSI)

BS ISO 4309	(2017) Cranes - Wire Ropes - Care and Maintenance, Inspection and Discard

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 70	(2015) Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes
CMAA 74	(2020) Specifications for Single Girder Cranes

ELECTRIFICATION AND CONTROLS MANUFACTURERS ASSOCIATION (ECMA)

ECMA 15	(2018) Cable-less Controls for Electric Overhead Traveling Cranes

MATERIAL HANDLING INDUSTRY OF AMERICA (MHI)

MHI MH27.1	(2009) Specifications for Underhung Cranes and Monorail Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA NEIS 1	(2015) Standard for Good Workmanship in Electrical Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 5	(2017) Industrial Control and Systems: Control Circuit and Pilot Devices
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 8	(2011) Crane and Hoist Controllers

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS (RCSC)

RCSC A348	(2020) RCSC Specification for Structural Joints Using High-strength Bolts

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J429	(2014) Mechanical and Material Requirements for Externally Threaded Fasteners
SAE J995	(2017) Mechanical and Material Requirements for Steel Nuts

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-W-410	(2022; Rev J) Wire Rope and Strand

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.179	Overhead and Gantry Cranes
29 CFR 1910.306	Specific Purpose Equipment and Installations

U.S. NAVAL SEA SYSTEMS COMMAND (NAVSEA)

NAVSEA T9074-AS-GIB-010/271	(1999; Notice 1) Requirements for Nondestructive Testing Methods

UNDERWRITERS LABORATORIES (UL)

UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1004-1	(2012; Reprint Nov 2020) UL Standard for

Safety Rotating Electrical Machines - General Requirements

1.2 DEFINITIONS

a. Crane Bridge: That part of an overhead crane system consisting of a girder, end trucks, walkway, and drive mechanism which carries the trolley(s) and travels along the runway rails parallel to the runway.

b. Crane Runway: The track system along which the crane operates horizontally, including track hangar rods, track connection devices, and runway structural supports.

c. Dead Loads: The weight of all effective parts of the bridge structure, the machinery parts, and the fixed equipment supported by the structure.

d. Crane Bridge Girder: The principal horizontal beam of the crane bridge structure. It is supported by the crane end trucks. Typically, for single girder cranes the trolley mounted hoist is suspended from the girder below the crane.

e. Lifted Load: The load consisting of the rated load and the weight of lifting devices attached to the crane such as the load block, bucket, or other supplemental devices.

f. Original Equipment Manufacturer (OEM): the Company that produced the part or original equipment.

g. Packaged Hoist: A commercially designed and mass produced hoist characterized by the motor, gearing, brake(s), and drum contained in a single package often connected by the use of c, d, or p-face flanges.

h. Patented Track: A generic term referring to track built in accordance with MHI MH27.1 utilizing a composite track section incorporating a proprietary bottom flange shape. For this crane system, it is provided for the crane bridge girder and also the crane runway track, if under running.

i. Pendant: A control for a hoist and a crane. The pendant hangs from the hoist or the crane by a cable at a height that is easy for the operator to reach.

j. Rated Load: The maximum working load suspended under the load hook.

k. Standard Commercial Cataloged Product: A product which is currently being sold, or previously has been sold, in substantial quantities to the general public, industry or Government in the course of normal business operations. Models, samples, prototypes or experimental units do not meet this definition. The term "cataloged" as specified in this section is defined as "appearing on the manufacturer's published product data sheets." These data sheets must have been published or copyrighted prior to the issue date of this solicitation and have a document identification number or bulletin number.

l. Trolley Load: The weight of the trolley and its associated equipment carried by the trolley wheels.

m. Under running (Underhung) Crane: An electric overhead traveling crane that is supported by crane end trucks suspended below the crane runway. The load is supported by hanging from the lower flange of a beam or patented track.

n. Hazardous (Explosive) Operating Environment: Locations where fire or explosion hazards may exist due to flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, or ignitable fibers/flyings. Cranes operating in hazardous environments as defined by the cognizant activity safety office must be equipped with electrical safety features that meet NFPA 70 Article 500. The activity safety office must identify the specific Class and Division, as well as the envelope that the hazard exists, to allow proper design and must list these in this section. Materials for mechanical components must be chosen to minimize the potential for sparking, typically bronze, stainless steel, or aluminum. Hazardous environments are split into two groups: minimum anti-spark protection and maximum anti-spark protection.

(1) Minimum Anti-Spark Protection is used when only the load block enters the explosive area. Anti-spark protection is required for the pendant controller, hook, hook block, and wire rope.

(2) Maximum Anti-Spark Protection is used when the hazardous area envelops the entire crane. In addition to the minimum anti-spark protections, the entire crane and runway components must also be protected against sparking.

1.3 SYSTEM DESCRIPTION

[The requirements for the structures supporting the crane runway are specified in Section 05 12 00 STRUCTURAL STEEL, and must conform to AISC 360.

]1.3.1 Crane Design Criteria

Cranes will operate in the given spaces and match the runway dimensions and rails indicated. Hook coverage, hook lift, clearances, lifting capacity, and load test weight must not be less than that indicated. Provide loaded hook coverage to the maximum extent possible in the Aircraft Maintenance Bay.

1.3.1.1 General

Include the following: Number of cranes [_____], located in Hangar identified as [_____],[bay [_____],] with the capacity expressed in [_____] tons pounds, for each crane. Also clearly locate and identify each hoist and system components.

1.3.1.2 Classification

Provide under running, single girder electric bridge crane(s), with under running trolley mounted hoist, conforming to MHI MH27.1, CMAA 70, and CMAA 74 service class [C] [D], as applicable. The crane(s) must be designed for operation in an indoor environment, hazardous area service, meeting the requirements of ASME B30.16 and ASME B30.17, with an ambient temperature range of [_____] to [_____] degrees Fahrenheit. This crane must operate in an NFPA 70 Class [I] [_____], Division [2] [1] [_____], Group [D] [_____] hazardous area. Hazardous protection is required from the floor level to[5 feet above wing upper surface and engine enclosures][10 feet above the aircraft][30 feet above the aircraft surface]. The crane span must be [_____] feet with a vertical lift of [_____] feet and as specified herein.

The crane must be [pendant controlled] [radio controlled] and operate in the spaces and within the loading conditions indicated. Provide a crane, including hooks and hoisting ropes, that in all operating configurations is able to clear the vertical lift fabric door maintenance catwalk or other obstructions.[The pendant controller must be mounted on a separate festooned cable system from the trolley power supply.] The crane must operate on [_____]-volts AC, 60 Hz [_____], [single] [three] phase power source. Maximum crane wheel loads (without impact) due to dead, trolley, and lifted loads, with the trolley in any position, must not cause a more severe loading condition in the runway support structure than that produced by the design wheel loads and spacing indicated.

1.3.1.3 Rated Speeds

Provide the crane with rated (maximum) speeds within plus or minus 10 percent (in feet/min) for the main hoist, bridge, and trolley at the rated load as specified in the table below. The minimum speed must not exceed the values listed.

Rated Speeds feet/minute		
Description	Minimum	Maximum
Main Hoist	[_____]	[_____]
Trolley	[_____]	[_____]
Bridge	[_____]	[_____]

1.4 VERIFICATION OF DIMENSIONS

The Contractor is responsible for the coordination and proper relation of their work to the building structure and to the work of all trades. Coordinate with the crane support structure design, where applicable, to provide the desired crane operating envelope (i.e., hook envelope and hook height). Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overhead Electric Crane System; G[, [_____]]

Complete Schematic Wiring Diagram; G[, [_____]]

Control System and Network Drawings; G[, [_____]]

SD-03 Product Data

Hoist Brakes; G[, [_____]]

Travel Brakes; G[, [_____]]

Load Block and Hook; G[, [_____]]

Hoist and Trolley Units; G[, [_____]]

Hoisting Rope; G[, [_____]]

Bridge End Trucks; G[, [_____]]

Crane Bridge Girder; G[, [_____]]

End Stops; G[, [_____]]

Bumpers; G[, [_____]]

[Crane Runway System; G[, [_____]]

] Motors; G[, [_____]]

Enclosures; G[, [_____]]

Circuit Breakers; G[, [_____]]

Contactors and Relays; G[, [_____]]

Fuses; G[, [_____]]

Variable Frequency Drives; G[, [_____]]

Limit Switches; G[, [_____]]

Resistors; G[, [_____]]

[Radio Control System; G[, [_____]]

][Pendant Push-Button Station; G[, [_____]]

] Pendant Conductor System; G[, [_____]]

Crane Controllers; G[, [_____]]

[Control Parameter Settings; G[, [_____]]

][Pilot Devices; G[, [_____]]

][Warning Devices; G[, [_____]]

][Floodlights; G[, [_____]]

] Runway Conductor System; G[, [_____]]

Bridge Conductor System; G[, [_____]]

Overload Protection; G[, [_____]]

Painting System; G[, [_____]]

Control System and Network; G[, [_____]]

SD-05 Design Data

Load and Sizing Calculations; G[, [_____]]

SD-06 Test Reports

[Hook Proof Test; G[, [_____]]

][Hook Non-Destructive Test (NDT); G[, [_____]]

] Post-Erection Inspection; G[, [_____]]

Operational Tests; G[, [_____]]

Hook Tram Measurement; G[, [_____]]

Load Tests; G[, [_____]]

SD-07 Certificates

Wire Rope; G[, [_____]]

Crane Runway; G[, [_____]]

Hazardous Material; G[, [_____]]

Loss of Power Test; G[, [_____]]

Overload Test; G[, [_____]]

Brake Adjustment Record; G[, [_____]]

Contractor Hazardous Environment; G[, [_____]]

Public Domain Software; G[, [_____]]

Software and Services; G[, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals, Data Package 3; G[, [_____]]

SD-11 Closeout Submittals

Network-Capable Control Devices; G[, [_____]]

Disabled Ports, Connectors, and Interfaces; G[, [_____]]

Evaluation Status of Hardware and Software; G[, [_____]]

Control System Access Control; G[, [_____]]

Control System Account Management; G[, [_____]]

Patch Management and Updates; G[, [_____]]

Malware Detection and Protection; G[, [_____]]

Wireless Technology Provisions; G[, [_____]]

Control System Inventory; G[, [_____]]

1.6 QUALITY ASSURANCE

1.6.1 Manufacturer Qualification

Overhead Electric Crane System, including sub-system components manufactured by vendors, must be designed by, or directly supervised by, a registered professional engineer (PE). PE licensing must be by a board or agency authorized to license and register professional engineers. The PE may be a Contractor's regular employee or a consultant. The PE's review and attestation of specification compliance and professional responsibility must be signified by their PE original seal and dated signature on the final drawings. The professional engineers must only undertake and perform work under this contract in the branch(s) of engineering in which they are licensed.

1.6.2 Pre-Delivery Inspections

Contractor is responsible for performance of quality control inspections, testing, and documentation.

1.6.2.1 Hook Proof Test

Proof test custom designed or non-ferrous load hooks per ASME B30.10. Perform the proof test prior to Hook NDT.

1.6.2.2 Inspection of Hook Assembly

Inspect hook[by liquid penetrant type inspection][and X-rayed][and tested ultrasonically] prior to delivery. Furnish documentation of hook inspection to Contracting Officer prior to field operational testing. As part of the acceptance standard, linear indications greater than [1/16 inch] [_____] are not allowed. Welding repairs of hook are not permitted. A hook showing linear indications, damage or deformation is not acceptable.

[1.6.2.2.1 Hook Non-Destructive Test (NDT)

For hooks of non-magnetic material, NDT must be liquid penetrant (PT) method in accordance with ASTM E1417/E1417M. Acceptance standard is no defects. A defect is defined as a linear indication that is greater than[1/16 inch][1/8 inch] long. For PT testing of hooks containing stainless steels, titanium, or nickel based alloys, total halogens and Sulphur used in the NDT process must be controlled as specified in NAVSEA T9074-AS-GIB-010/271.

Inspect each hook and shank over the entire surface area by magnetic particle inspection.

a. Acceptance Criteria: Defects found on the hook will result in rejection of defective items for use on furnished hoist. For this inspection, a defect is defined as a linear indication for which the largest dimension is greater than 1/16 inch.

b. Test Report: Submit a test report of the inspection of each hook provided the Contracting Officer for approval prior to final acceptance of hoist installation. Certify test reports by the testing organization. The performing organization must provide a written statement of certification to ASTM E543, current within one year of the date the NDT was performed. The performing organization must have the NDT procedures and its technique sheet used for testing of the hook reviewed and approved by an independent Level III examiner. Submit the (Level III examiner) approved procedures, technique sheets, and certification to the Contracting Officer with the test report.

]1.6.3 Drawings: Overhead Electric Crane System

a. Submit drawings showing the general arrangement of all components in plan, elevation, and end views. Show all major features of the crane including: hook approaches on all four sides, clearances and principal dimensions, hoist, trolley and bridge drives, motor nameplate data, overcurrent protective device ratings, and electrical schematic drawings. Include weights and centers of gravity of major components (e.g., bridge girder, trolley/hoist).

b. Submit shop drawings of all fabricated components. Shop drawing quality must be equivalent to the contract drawings accompanying this solicitation. Drawings must be reviewed, signed, and sealed by a licensed professional engineer.

c. Provide Bill of Material for crane components on each drawing. The schedule must provide a cross reference between manufacturer data and shop drawings. Components listed on the schedule of crane components must include total quantity, description, original manufacturer, and part number. Distributing agents will not be acceptable in lieu of the original manufacturer.

d. Provide control system and network drawings. Network diagram must show equipment locations, names, models, and IP addresses on network communications schematic for all Programmable Logic Controllers (PLCs), Remote Terminal Unit (RTU), Supervisory Controller, and Other Network-Capable Devices. In addition, the drawings must consist of all software block, flow, and ladder diagrams.

1.6.4 Design Data: Load and Sizing Calculations

Submit complete list of equipment and materials, including manufacturer's descriptive data, technical literature, and performance charts and curves. Submit calculations reviewed, signed, and sealed by a registered professional engineer verifying the load cases, sizing of the bridge girder, end trucks, travel drives, motors, overcurrent protection, and conduit. Provide a list of all codes and standards, design assumptions, equations, specified efficiencies, limits, factors of safety, component ratings, and sources of values used. Include free body diagrams or sketches of each load case.[Include seismic analysis of crane.]

1.6.5 Certificates

All certifications must be dated and bear the original signature (above the printed name) of the authorized representative of the Contractor or the manufacturer of the items or equipment being certified. Submit certifications that clearly identify the crane, the drives, components, and location (as applicable) to which it applies:

a. Wire Rope Certification with the wire rope manufacturer's certification that the rope meets the published breaking force or the actual breaking force of a sample taken from the reel and tested. Certification must be traceable to the hoist, crane, and reel.

b. Crane Runway Certificate stating that the new crane will operate properly on the runway. For runways provided by Contractor, include statement certifying runway has been aligned in accordance with MHI MH27.1.

c. Hazardous Material Certificate that the crane does not contain hazardous material including asbestos, lead, cadmium, chromium, PCBs, or elemental mercury. Products required for the designing and manufacturing of cranes must not contain the prohibited materials.

d. Loss of Power Test Certificate stating that a test may be performed in which power is removed during operation without any detrimental effects to the crane.

e. Overload Test Certificate stating that the crane can be periodically load tested to 125 percent (plus 0 minus 5 percent) of rated load. Overload Test Certificate stating that the crane can be periodically load tested to 125 percent (plus [0] [_____] minus [5] [_____] percent) of rated load.

f. Certificate of the Brake Adjustment Record. Provide a brake adjustment record and installation/maintenance manuals for each brake on the crane. Each brake measurement must have a tolerance traceable to the associated brake manual or documentation provided by the brake manufacturer, location of measurements, and the actual brake setting. Changes made to settings of the brake, at any time, will void the record.

g. Contractor Hazardous Environment Certificate stating that the new crane and all associated components excluding the hoist are designed for operation in the hazardous environment specified in the Classification section.

h. Public Domain Software Certificate declaring that public domain software (e.g., freeware, shareware) is not used in the system.

i. Certificate stating that all Software and Services that are not required for operation and/or maintenance of the product have been removed. The software/services to be removed are identified in SOFTWARE AND SERVICES.

1.6.6 Welding Qualifications and Procedure

Welding must be in accordance with qualified procedures using AWS D14.1/D14.1M as modified. Written welding procedures must specify the Contractor's standard dimensional tolerances for deviation from camber and sweep and not exceed those specified in AWS D14.1/D14.1M and MHI MH27.1. Welders and welding operators must be qualified in accordance with AWS D1.1/D1.1M or AWS D14.1/D14.1M.

1.7 CRANE SAFETY

Comply with the mandatory and advisory safety requirements of ASME B30.10, ASME B30.16, ASME B30.17, ASME HST-4, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306, and all applicable provisions of 29 CFR 1910 and NFPA 70.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide materials and equipment which are standard products of manufacturers regularly engaged in the fabrication of complete and totally functional cranes including necessary ancillary equipment. Material will be free from defects and imperfections that might affect the serviceability and appearance of the finished product. All material must be new and unused.

2.1.2 Nameplates

Secure nameplates to each major component of equipment with the manufacturer's name, address, type or style, model or catalog number, and serial number. Provide two bridge identification plates, one for each side of the bridge. Provide noncorrosive metal identification plates with letters which are easily read from the floor, showing a separate number such as BC-1, BC-2, for each bridge crane.

2.1.3 Capacity Marking

Mark the rated capacity in ton pounds units on each side of the crane on the bridge girder. Capacity marks must be large enough to be clearly visible from the floor. Individual hoist units must have their rated capacity clearly marked on their lower block, and additionally labeled on the hoist body.

2.1.4 Safety Warnings

Affix labels in a readable position to each lift block or control station in accordance with ASME B30.16 and ASME B30.17. Submit safety warnings, diagrams and other instructions suitably framed and protected for display as indicated by the Contracting Officer as follows:

Design and locate the word "WARNING" or other legend to bring the label to the attention of the operator. Provide durable type warning labels and display the following information concerning safe-operating procedures: Cautionary language against lifting more than the rated load; operating the hoist when the hook is not centered under the hoist; operating hoist with twisted, kinked or damaged rope; operating damaged or malfunctioning hoist; operating a rope hoist with a rope that is not properly seated in its hoist drum groove; lifting people; lifting loads over people; and removing or obscuring the warning label.

2.2 STRUCTURAL REQUIREMENTS

Structural requirements must be in accordance with MHI MH27.1. Structural steel materials must conform to the standards permitted in MHI MH27.1 and AISC 360. Skewing and other applicable lateral loads must be considered in the design.

2.2.1 Structural Connections

High-strength bolted structural connections must be designed and installed in accordance with RCSC A348. Bolts must be of ASTM F3125/F3125M Grade A325/A325M or Grade A490/A490M material. Galvanized bolts are not acceptable.

Welded connections for the crane must be performed in accordance with AWS D14.1/D14.1M. Welded connections to the building must be performed in accordance with AWS D1.1/D1.1M. Allowable stress values must comply with MHI MH27.1.

2.2.2 Crane Bridge Girder

Provide a crane bridge girder of patented track conforming to MHI MH27.1. Intermittent ("skip") welds on bridge girder elements (e.g., web and flange interfaces) are prohibited. If the girder is notched to fit over the end trucks, reinforce the girder ends with vertical and horizontal stiffeners. Splices in the unsupported length of the girder are prohibited.

Submit manufacturer's standard published tables that verify the crane bridge girder is sized in compliance with all specification requirements. When standard published tables are not available, provide calculations for the strength design and deflection of the bridge. Patented track girder must be of welded steel construction and fabricated by a manufacturer regularly engaged in the production of this type of beam.

2.2.3 Bridge End Trucks

Provide bridge end trucks conforming to ASME B30.17 and MHI MH27.1. Configure end trucks with a feature that limits end truck movement to one inch in the event of wheel or shaft failure.

2.2.4 End Stops

Fit the crane bridge girders with structural steel end stops. Locate stops to permit maximum trolley travel. Design end stops in accordance with MHI MH27.1 and ASME B30.17. Provide a system in which the travel wheels do not contact the end stops. End stops must be designed to absorb the maximum kinetic energy and impact force developed by the bumper contact. Provide end stops compatible with trolley bumpers and designed to bolt to the crane bridge girder.

2.2.5 Bumpers

Fit bridge end trucks and trolley frames with shock-absorbing bumpers capable of decelerating and stopping the bridge and trolley within the limits stated by ASME B30.17. Ensure bumpers conform to ASME B30.17. Bumpers must fully engage end stops. Mount bumpers so that there is no direct shear on mounting bolts (if any) upon impact. Bumpers must provide adequate clearance between the crane and surrounding structure when compressed to preclude damaging equipment (clearance requirements are defined in 29 CFR 1910.179). When more than one crane is located and operated on the same runway, bumpers must be provided on their adjacent ends or on one end of one crane. Fit the other end of the end-truck with a structural steel stop to engage the bumpers of the adjacent crane. Ensure bridge bumpers are properly aligned with runway end stops. Metal to metal contact at the bumper to end stop connection is not permitted.

[2.2.6 Crane Runway System

a. Provide the complete runway track suspension system that is required to hang the crane runway track at its indicated location from the structural supports indicated on the drawings. Provide runway and support structure for underrunning crane of patented track girders conforming to MHI MH27.1.

b. Splice assemblies must be from the same manufacturer as the patented track and located under structural support members. Submit manufacturer's standard published tables that verify the crane runway track is sized in compliance with all specification requirements. When standard published tables are not available, provide calculations for the strength design and deflection of the beams.

c. Runway support structure must be designed, fabricated, and installed such that runway rails meet the alignment tolerances of MHI MH27.1. Provide means to allow for vertical adjustment of the runway track both before and after the system has been put in operation so that track can be erected and maintained level. Brace runway to restrain the track against damaging lateral and longitudinal movements. Where the runway track is suspended from hanger rods, provide means preventing the hanger rod nuts from backing off the rods. Allowable stress in hanger rods is 20 percent of the minimum specified ultimate strength of the material used.

d. The lower T-section ends of the runway must be aligned to minimize the horizontal gap on the running surface to not greater than 1/16 inch and not greater than a vertical difference of 1/32 inch for the wheel running surface alignment for a smooth crossing by the wheels. Provide splices located directly under structural support members. When runways are suspended, bracing preventing damaging lateral or longitudinal movement is required. Loads transmitted to the building through the suspension must have the review and approval of the building engineer of record (EOR) prior to installation.

e. Design, fabricate, and install new runway end stops in accordance with MHI MH27.1 and ASME B30.17. End stops must be designed to absorb the maximum kinetic energy and impact force developed by the bumper contact. Provide end stops compatible with end truck bumpers, designed to bolt to the runway support girders, and maximize bridge travel.

][2.2.7 Seismic Forces

Perform a seismic analysis as a part of the design of the crane in accordance with ASCE 7-16. The seismic analysis must be included in the MHI MH27.1 extraordinary load case (Case 3).

For project locations beyond the scope of ASCE 7-16, a widely accepted design standard may be used for seismic analysis.

]2.3 MECHANICAL REQUIREMENTS

a. Provide steel shafts, gears, and keys.

b. Cast iron and aluminum used to support components of the hoist power transmission train must be ductile. Hoist speed reducers must be steel or ductile/malleable cast iron with a minimum elongation of 5 percent in 2.00 inches.

c. Provide steel or ductile/malleable cast iron brake housings of motor mounted disc brakes, brake lining backing plates, shoes and shoe holders. Provide spring-set shoe or pad linings of a non-asbestos material.

d. All mechanical components must be accurately aligned and positively secured to maintain the alignment. Parts must not be forced into position to obtain apparent alignment.

2.3.1 Threaded Fasteners

Fasten mechanical connections that are not part of a commercial packaged assembly with SAE J429 Grade 5 fasteners, ASTM F436/F436M washers, and SAE J995 Grade 5 nuts. Lubricate all mechanical fasteners unless otherwise specified by the original component manufacturer.

2.3.2 Hoist

Provide hoist conforming to ASME B30.16, ASME B30.17, and CMAA 74, double reeved, except as modified and supplemented in this section. Packaged hoist and trolley units (packaged hoists) must be electric wire rope hoist conforming to ASME HST-4 Duty Class [H3] [H4] or better.

Configure trolley such that the trolley frame contacts the trolley stops and prevents the trolley from dropping more than one inch in the event of an axle or wheel failure.

2.3.2.1 Hoist Brakes

a. Equip the hoist with two holding brakes, each with a minimum torque rating of 125 percent of the rated load hoisting torque. Provide a brake configuration with one electro-mechanical brake and one mechanical load brake that stops and holds 125 percent of the hoist's rated load and does not require the load to be raised before being lowered.

b. Electro-mechanical brakes [must be adjustable to 50 percent of its rated capacity, and]must have an externally accessible means of manual release. On drives where the brakes are utilized as holding brakes only, torque adjustment is not required. The brakes must be equipped with a manual self-return to ON brake release and designed to permit inspection and adjustment without disassembly of the brake. Double face mounted brakes are not permitted.

2.3.2.2 Load Block and Hook

Provide a load block constructed of non-sparking materials. Covering the exposed surfaces of the load block with bronze, stainless steel, or aluminum covers attached with similar fasteners is acceptable. The load block must be designed to prevent metal-to-metal contact of moving parts. The block must be fully enclosed, concealing the sheaves and wire ropes, except for wire rope slots and drain holes. The design must preclude the wire rope from being cut, pinched, crushed, or chafed in case of two-blocking. The block must be clearly marked with the capacity in pounds on both sides. Standard commercial blocks may be used at their published ratings when their published design factors are 5.0 or greater.

Provide an unpainted single barbed hook of non-sparking material. Bronze clad hooks are prohibited. The hook must be a standard commercial product with a published design factor of 5.0 or greater. Fit hook with a safety latch designed to preclude inadvertent displacement of slings from the hook saddle. The hook and hook nut must be removable without unreeving of the hoist or disassembly of the block. Provide a hook nut secured to the hook with a commercial standard removable and reusable means. Do not weld hook nut. Uniquely mark the hook in a permanent fashion that is traceable to the NDT certification. The nut must be marked to match the hook. The hook nut must be of non-sparking materials. Hook must be free to rotate through 360 degrees when supporting the test load up to 125 percent of the rated capacity. Upper hooks of hook suspended hoists must be of non-sparking materials.

2.3.2.3 Hoisting Rope

a. Wire rope must comply with ASME B30.30 and FS RR-W-410, ASTM A1023/A1023M, or BS ISO 4309 and have a rope classification appropriate for the usage. Wire ropes must be handled and seized in accordance with ASME B30.30. The wire rope must be in a double reeved configuration equalized with a sheave. Select wire rope minimum design factor in accordance with ASME B30.16. Provide proof of Wire Rope breaking force.

b. Provide stainless steel hoist ropes with an independent wire rope, wire strand, or otherwise, steel core.

2.3.2.4 Drum

Provide grooved drum made of steel. Design drum in accordance with ASME hoist performance standards. All hoisting rope is to be wound in a single layer and provided with no less than two dead wraps of hoisting rope remaining at each anchorage when the hook is in its extreme low position.

2.3.2.5 Sheaves

Provide sheaves constructed of non-sparking metals in the load block. Provide sheaves constructed of steel for the equalizer and in the upper sheave nest. Size sheaves in accordance with ASME HST-4 for the minimum pitch diameters of running and equalizer sheaves.

2.3.3 Travel Drives

Provide travel assemblies with a minimum of one driven wheel on each side of the web. No 3-bearing shaft configurations are allowed. The travel drive arrangement must consist of motor(s) driving through self-contained gear reduction units located at each driven wheel assembly.

2.3.3.1 Bridge Drives

Acceleration and deceleration must meet the requirements specified in CMAA 74.[Provide bridge travel limit switches.]

2.3.3.2 Trolley Drives

Provide a motor-driven trolley arrangement.[Provide trolley travel limit switches.]

2.3.4 Travel Brakes

Spring set brakes must be provided with an externally accessible means to manually release the brake. The brakes must be equipped with a manual self-return to ON brake release and designed to permit inspection and adjustment without disassembly of the brake.

2.3.4.1 Bridge Brake

Provide bridge drive with an end-mounted electro-mechanical brake conforming to the requirements of CMAA 74 or non-freecoasting mechanical drive capable of stopping the motion of the bridge within a distance in feet equal to 10 percent of the full load speed in feet per minute when traveling at full speed with a full load. Provide brakes with a minimum torque rating per CMAA 74 according to the applicable environment, but not sized larger than 150 percent of the drive motor rated torque.

2.3.4.2 Trolley Brake

Provide trolley drive with an end-mounted electro-mechanical brake conforming to the requirements of CMAA 74 or a non-coasting mechanical drive capable of stopping the trolley within a distance in feet equal to 10 percent of the rated speed in feet per minute when traveling at rated speed with rated load. Provide brakes for underrunning trolleys/carriers sized in accordance with ASME B30.17.

2.3.5 Wheels

Provide under running wheel sizing and flange-to-rail head clearances in accordance with MHI MH27.1 recommendations. The wheels must be compatible with their respective runway profile. Wheel material is to be steel or ductile cast iron; the use of plate steel is prohibited. Provide wheels of non-sparking material. Minimum tread hardness for underhung wheels (non-bronze) that run on patented track is 375 BHN. Bronze wheels must have sufficient size and hardness to withstand the intended loading and use.

[2.3.6 Drip Pans

a. The crane must be designed to preclude leakage of lubricants onto the lifted loads or the floor. Equipment or components, which cannot be made leak-proof, must be fitted with unpainted corrosion resistant steel drip pans or must have the foundations seal welded to create a dam. Drip pans that utilize liquid sealant to prevent leakage of lubricants are not permitted.

b. The drip pans must be sized to hold the entire gear case fluid capacity, installed under all drive machinery, designed to permit easy removal of collected lubricant. A trolley floor designed to contain any lubricant drips may be used as fluid containment for any equipment that is mounted on it.

c. Provide drip pans fitted around the shank of the hook and extending outward to encompass all possible points of lubrication drips from the load block or wire rope. The drip pans must be easily removable without disassembly of the hook or load block and cannot interfere with the crane structure during testing of the upper limits.

]2.4 ELECTRICAL REQUIREMENTS

a. The design, selection, rating, and installation of the electrical portions of the crane and its accessories must conform to the requirements of NEMA ICS 3, NEMA ICS 8, the applicable ASME HST standard, and NFPA 70, and other requirements specified herein.

b. All electrical components must be industrial grade, commercially available and comply with established national or internationally recognized approving organizations such as Underwriters Laboratories (UL) and Canadian Standards Association (CSA). All electrical components installed or operated in hazardous areas including but not limited to enclosures, junction boxes, disconnects, pendant controller, and electrification must be designed and rated for the NFPA 70 Hazardous Classifications specified in Classification section.

c. All electrical components must be located so they are easily accessible for inspection and maintenance without removing other parts, doors, or door center posts. Install electrical equipment and panel wiring in a neat and workmanlike manner in accordance with Electrical Construction Standard NECA NEIS 1. Each motion of the crane must be provided with a separate and independent variable frequency drive unit. The loss of any one function must not prevent the operation of other unaffected functions. Two independent relays, contactors, drive inputs, or other equivalent components/logic must be utilized for each function to provide directional control such that the failure of a single relay/contactor/component cannot result in motion in an unintended direction.

d. Disconnecting means for cranes must be in accordance with NFPA 70 Article 610.32. A permanent placard must be installed on the face of the main line disconnect that states "WARNING - THIS DOES NOT ISOLATE POWER TO LIGHTING, RECEPTACLES, AND ANCILLARY EQUIPMENT". Additionally, a lighting (ancillary equipment) disconnect must be provided, with lockout feature, as the isolation means for the lighting transformer and lighting circuit breaker panel, which must power the crane's ancillary equipment. It must feed 480 VAC to the primary side of the transformer directly from the runway conductors via tapping the line side of the main power disconnect. Provide individual disconnects, with lockout feature, capable of being locked in the open position for bridge lights and receptacles.

e. Unless otherwise specified, interconnecting wiring must be of copper stranded construction complying with Table 310.104(A) of NFPA 70. Interconnecting wiring containing asbestos in the insulation or outer covering are prohibited. Aluminum conductors must not be used. Aluminum connectors are allowed if they are rated for use with copper conductors (marked "AL/CU"). All conductors connected to or routed above resistors must have insulation shown in NFPA 70 Table 610.14(a) for 257 degrees F. For packaged hoists and hoist/trolleys, provide wiring sizes in accordance with NFPA 70 Table 610.14(a). Motor branch circuit conductors not part of a packaged hoist and hoist/trolley must be sized as to have an ampacity not less than 150 percent of the motor full load current rating and to be no smaller than 12 AWG. Conductors must be selected and de-rated based on maximum ambient temperature. Continuous loads such as utility, heating, lighting, and air conditioning must be multiplied by 2.25 to determine ampacity in order to permit application of NFPA 70 610.14 (A) for crane supply conductors. Wire-nuts are not permitted on splices. However, connections for lighting ballasts may be made using wire-nuts (if applicable).

f. Excluding conduit directly connected to dynamic breaking resistors, raceways must maintain a 12-inch clearance between the raceway and dynamic braking resistors. A separate grounding wire, sized in accordance with Section 250.122 of NFPA 70, must be routed with all ungrounded conductors. Only one equipment grounding conductor must be run in each conduit and be the largest size required for any circuit routed in that conduit. All wiring must be numbered or tagged at all connection points. Power conductors which are shielded such that their wire size cannot be easily determined must be labeled as to the conductor size. All unused conduit openings must be plugged.

g. When fiber optic cable is utilized, inspections and performance checks must be accomplished upon completion of on-site installation to ensure cable cleanliness and proper signal integrity. Testing and verification must be conducted by a knowledgeable fiber optics technician using specialized, calibrated equipment. Cables must be tested for signal loss/attenuation. The fiber optic system must also be tested using an Optical Time Domain Reflectometer (OTDR). Final attenuation and OTDR readings from each fiber optic cable run, including spares, must be documented as a baseline for future reference. All spare fiber optic cables must have protective covers over their ends to maintain cleanliness while not in use. When fiber optic cable is utilized the drive OEM's recommendations for encoders and optical to digital converters must be followed. All system components utilized for this purpose must have known compatibility prior to integration.

h. Power cables and low voltage signal cables may not be mixed in the same conduit.

i. The crane manufacturer must furnish and install all electrical equipment on the crane conforming to NEMA ICS 6, including motors, conforming to NEMA MG 1, electrically released brakes, switches, crane controllers, panels, operating station, wiring system, cables, and crane electrification.

2.4.1 Motors

Motors must meet all applicable requirements of NEMA MG 1 and UL 1004-1. All motors must have a minimum of a [60] [30] [_____] minute duty rating and be Totally Enclosed Non Ventilated (TENV), Totally Enclosed Fan Cooled (TEFC), or Totally Enclosed Blower Cooled (TEBC).[Provide inverter duty motors for Open Loop Variable Frequency Drives (VFD).][Provide [two] [single] speed AC squirrel cage induction type motors for the bridge and trolley drives.][Provide two speed, AC squirrel cage induction type motor for the hoist.] Provide motors with a minimum of Class F insulation. Provide motor overload protection utilizing a thermal sensitive device embedded in its windings.

2.4.2 Controls

a. Provide static reversing, variable frequency drives (VFD) for the [bridge,] [trolley][and][hoist] electric controls. VFD controllers must meet NEMA ICS 8, Part 8 and at a minimum, provide under-voltage protection, electronic instantaneous over current protection, DC bus over voltage protection, and be able to withstand output line to line shorts without component failure. Select bridge and trolley drives such that the continuous rating of the controller is not less than the calculated motor full load current based on CMAA 70 paragraph 5.2.9.1.1.1 and NFPA 70 Table 430.250. Select hoist drives such that the continuous rating of the controller is not less than 125 percent of the calculated motor full load current based on CMAA 70 paragraph 5.2.9.1.1.1 and NFPA 70 Table 430.250. All hoist drives must have a motor over-torque limit to lock out the hoist and prevent gross overload of the associated hoist. Provide dynamic braking for each electric drive that is sized per VFD manufacturer's requirements. Submit VFD Control Parameter Settings.

b. Provide speed control which is infinitely variable for each function, controlled via [radio control system][and][pendant pushbutton station].[Provide controls designed such that the maximum speed of each function will be limited to 25 percent of rated speed when a slow speed switch is actuated on the controller[s].[Energize a yellow/amber light/indicator while in slow speed mode.]]

c. The [hoist][,] [trolley][,] and [bridge] brakes must set after the associated controller decelerates the drive motor to a controlled stop. The hoist, trolley, and bridge, controllers must be sized to provide sufficient starting torque to initiate motion of that crane drive mechanism from standstill with 0 to 125 percent of rated load on the hook. The hoist controller must prove torque before release of the brakes and enable the drive motor to develop full torque continuously at zero speed. Motors must operate smoothly at all speeds without torque pulsations and must only be energized within the frequency range of 50-60 Hz at rated speed.[The hoist control system may utilize overspeed up to 120hz, unloaded only, if the drivetrain equipment has all been balanced and is rated for the resulting speed.]

d. The use of definite purpose contactors is prohibited. If IEC contactors are used, the application cannot exceed the contactor manufacturer's AC3 ratings for the contactor at a minimum.

e. On hoist function roll-up must be less than 1/8 inch measured at the hook block and roll-back must not occur over the entire load range.

f. Use of Uninterruptible Power Supplies (UPS) is prohibited. Feed control circuits from a single phase, air cooled, double wound transformer with a grounded metal screen between the primary and secondary windings of the transformer.

g. Provide a main line contactor. Energization of the main line contactor must be controlled by the POWER-OFF/POWER-ON switch/pushbutton on all controllers. Upon actuation of the POWER-OFF pushbutton; power to all drive motors, brakes, and controls must be removed. The mainline contactor must not be able to be energize while the POWER-OFF pushbutton is actuated. The POWER-OFF pushbutton circuitry must be independent of all controls or any other electronic devices.

2.4.3 Protection

Protection must not be less than that required by NEMA ICS 3, NEMA ICS 8, CMAA 74, NFPA 70, UL 1004-1, UL 943, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306 and all applicable provisions of 29 CFR 1910. All protection must be by circuit breakers or fuses. Motor branch circuits must be individually protected by inverse time circuit breakers capable of being locked in the open position. The means for locking must remain in place with or without the lock installed. Motor full load current from NFPA 70 Article 430, Part XIV (Tables) must be used to calculate the circuit breaker size.

Provide disconnecting means on the crane in accordance with NFPA 70 Article 610.32. Provide for lockout/tagout of all hazardous energy sources. Provide product data for all circuit breakers and fuses.

2.4.3.1 Conductors

a. The crane contractor is responsible for ensuring that all conductors from the load side of the existing floor level disconnect to the motor branch circuits have adequate overcurrent protection complying with one of the following:

   (1) Not be greater than the largest rating or setting of any branch circuit protective device plus the sum of the nameplate rating of all other loads per NFPA 70 Article 610.41(A).

   (2) Not be greater than the ampacity of all feeder conductors after all ampacity correction factors have been applied.

b. Conductors for brake coils must be protected by fuses or other protective devices. The device must be chosen to protect the brake circuit conductors from ground faults or short circuits.

2.4.4 Resistors

Provide resistors with natural convection cooling sized as recommended by the VFD OEM and fabricated of corrosion resistant metal; the use of "wire wound" type resistors is prohibited for segments of 8 ohms or less. Mount resistors in substantial, ventilated enclosures constructed entirely of non-combustible materials. Provide resistors with terminals fitted in the coolest position in the enclosure.

[2.4.5 Transients and Harmonics Protection

Provide contactors and relays with appropriate Metal Oxide Varistors (MOV) or resistor-capacitor (R-C) surge absorbers installed across the respective coil.

Provide transient protection for electronic drive controllers that is either internal to the drive or via an MOV connected line-to-ground close to the line terminals of the drive.

Provide line reactors rated for continuous duty operation based upon the motor nameplate amperes. With motors of 50 horsepower or greater, harmonics protection must be provided by an isolations transformer or as recommended by the VFD OEM. For a drive motor branch circuit that exceeds 150 feet in length, a reactor must also be connected in series with the controller load (output) terminals to provide standing wave protection or as otherwise recommended by the VFD or motor OEM.

]2.4.6 Limit Switches

a. Provide primary upper and lower geared limit switches. Geared limits must allow reversing direction to back out of the limit without resetting. The lower limit switch must be set such that there are a minimum of two wraps of rope on the hoist drum.

b. Provide a backup mechanical hook block activated upper limit switch wired independent of the directional controllers and the primary upper limit switch that removes power from the hoist motor, hoist brake and hoist controls conforming to NEMA ICS 5. The backup limit must require hoist resetting prior to operation of the hoist in any direction.

[c. Travel limit switches must be provided for the [bridge][and][trolley] motion to slow the crane to [25 percent] [_____] of its rated speed [[10] [_____] feet before the bridge end stops][and][[5] [_____] feet from the trolley end stops]. Limit switches must be mounted rigidly in a manner so as to protect the switch from misalignment or damage. The target/trip arm must be large enough to provide interception given a misalignment were to occur.

] d. Limit switches must be rated for the NFPA 70 Hazardous Classifications specified in the Classification section of this specification.

2.4.7 Operator Controls

[Provide crane equipped with a [pendant pushbutton station][radio control system].

][Provide crane equipped with both a pendant pushbutton station and a radio control system. Provide a selector switch to allow the use of only one of the two available control stations on the pendant controller.

] If VFD controls are not provided, provide directional contactors with both mechanical and electrical interlocks.

Operator controls must be rated for the NFPA 70 Hazardous Classifications specified in the CLASSIFICATION section of this specification.

[2.4.7.1 Pendant Pushbutton Station

The cranes must be controlled from a pendant pushbutton station suspended from [the trolley] [an independent festooned messenger track system, operating the length of the bridge]. Provide multiconductor flexible cords for pendant pushbutton stations with #16 AWG minimum conductors. Provide a method of strain relief to protect the electrical conductors from damage. Locate the pendant pushbutton station [4 feet] [_____] above the finished floor. Pushbutton pendant station must have its elements legibly marked and arranged vertically, in order, in accordance with CMAA 74.[Provide [one speed] [two speed] [3-step infinitely variable] [2-step infinitely variable] pendant pushbuttons for control of the [hoist] [bridge][and][trolley].] Provide pendant pushbuttons for control that spring return to the OFF position. Voltage in the pendant pushbutton station must not exceed 150 Volts AC or 300 Volts DC.[Provide a maintained two-position selector switch for slow speed selection.] The pendant must be rated for the NFPA 70 Hazardous Classifications specified in the Crane Design Criteria "Classification" Section.

[2.4.7.1.1 Pendant Conductor System

Provide a festoon type pendant conductor system. The festoon cables must be flat cables suspended from carriers riding on an I-beam or C-track. The pendant controller must be capable of traveling the entire length of the bridge and move independently of the trolley. Festoon loops must not extend below the high hook position.

][2.4.7.1.2 Radio Control System

Provide each system with a [belly box] [handheld] [_____] type portable transmitter unit[and an identical back-up transmitter unit].[Provide each transmitter with an adjustable belt or harness to support it when worn by the operator.] Only one transmitter at a time can control the crane and there must be no interference from one crane's controller affecting operation of the other cranes in the building. Each transmitter must include: individual [infinitely variable spring return joystick motion control levers] [push button controls] for each hoist, trolley, and bridge; a maintained contact, keyed switch, marked ON-OFF, for portable transmitter unit power; indication of Battery Power, and indication of Transmitting Status; a red emergency STOP mushroom pushbutton;[and]a floodlight on/off pushbutton[and a maintained slow speed selector switch]. The transmitters and all controls must each be clearly and permanently labeled with functionality and direction. Directions for controllers must be in accordance with CMAA 74 recommendations. The remote radio control system must be designed to meet the requirements of NEMA ICS 8, Part 9 and ECMA 15. Each radio remote control lever must be in the OFF position before the associated crane function can begin. The system frequency must be within the unlicensed FCC Part 15 range. Each control unit must maintain a continuous status signal to the associated receiver during operation. There must be no significant loss in systems efficiency and function at the end of eight hours of continuous battery use. The technical section of Form DD 1494 frequency allocation application (found on the NAVFAC/NCC website), addressing the Contractor's equipment, must be completed by the manufacturer of the radio control equipment being furnished under this contract.[For unlicensed radio control systems, Form DD 1494 must be submitted to the activity's frequency coordinator for information.][For licensed radio control systems, Form DD1494 must be submitted to the local frequency coordinator to initiate equipment approval for use in the geographical location.] The Contractor must receive approval from the Government for the frequency to be used (licensed or unlicensed) for the radio remote system prior to design approval. Forms may be submitted via the Equipment Location Certification Information Database (EL CID) on-line system in lieu of submitting Form DD 1494.

]]2.4.8 Electrification Systems

2.4.8.1 Runway Conductor System

[Provide a rigid runway Conductor Bar System for the runway conductor system, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. Provide electrification system with three power conductors and an equipment grounding conductor. The crane must be grounded through the runway electrification system. Provide runway conductors sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. If there is any way the hook block or wire rope can swing into the runway electrification, provide a guard installed to prevent contact.

Provide two Collector Shoes (tandem design) for each conductor; each collector shoe must be rated for not less than the runway conductor sizing, so as to provide redundancy.

][Provide a Festoon System for the runway conductor system utilizing cables suspended from carriers riding on an I-beam or C-track for the crane, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. Provide electrification system with three power conductors and an equipment grounding conductor. Conductors must be fabricated from copper. The crane is required to be grounded through this conductor system. Provide conductors sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. Festooned cable loops must not extend low enough to come into contact with any obstructions.

][Provide a Cable Reel System for the runway conductor system, including all necessary cables and hardware to connect the cable reel to the floor level fused disconnect switch. The cable reel must have three power conductors and an equipment grounding conductor. The crane is required to be grounded through this conductor system. Conductors must be fabricated from copper, and sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads.

][Provide a totally enclosed flexible cable tray electrification system (cable chain) for the runway conductor system, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. The cable chain must have three power conductors and an equipment grounding conductor. The conductors must be selected so as to be of the longest length without splices. Conductors must be fabricated from copper, and sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. The crane is required to be grounded through this conductor system.

]2.4.8.2 Bridge Conductor System

[Provide Festoon System for the bridge conductor system utilizing cables suspended from carriers riding on an I-beam or C-track. Conductors must be fabricated from copper. A minimum of 20 percent of the festoon control circuit conductors for each electrification system must be spares at the time of crane acceptance. The trolley is required to be grounded through this conductor system. Festooned cable loops must not extend low enough to come into contact with any obstructions.

][Provide a Cable Reel System for the bridge conductor system. The cable reel must have an equipment grounding conductor, and all necessary control cables. A minimum of 20 percent of the festoon control circuit conductors for each electrification system must be spares at the time of crane acceptance. The trolley must be grounded through the cable reel connection and all conductors must be of copper construction.

][Provide a totally enclosed flexible cable tray electrification system (cable chain) for the bridge conductor system. The cable chain must have three power conductors, an equipment grounding conductor, and all necessary control cables. The conductors must be selected so as to be of the longest length without splices and must be copper. A minimum of 20 percent of the control circuit conductors in the flexible cable tray system must be spares at the time of crane acceptance. The trolley is required to be grounded through this conductor system.

]2.4.9 Overload Protection

a. Provide a capacity overload protective device for all hoist systems using VFD drive capacity overload protection (separate from torque limiting feature of the VFD). Set hoist capacity overload protection at [100] [_____] percent of rated capacity. Hoist capacity overload protection must be adjustable between 80 and 150 percent of hoist capacity. Provide a keyed override or other means to disable the hoist capacity overload protection when performing a load test.

[b Initially, set the torque limiting capability of the VFD (that is separate from the capacity overload protective device) to 150 percent of the motor torque (amperage) necessary to hoist 100 percent load. It may be adjusted up only to avoid nuisance trips and adjusted down if possible while still avoiding nuisance trips.

]2.4.10 Enclosures

a. Provide enclosures for control panels, controls, and brakes in accordance with NEMA 250 and NEMA ICS 6, Classification Type [1 indoor, general purpose] [12 indoor without knockouts, general purpose] [2 indoor, drip-proof] [3 outdoor, dust-tight, rain-tight, sleet-resistant] [4X outdoor] [_____] [7 indoor Class I hazardous] [9 indoor Class II hazardous] [8 indoor/outdoor Class I hazardous], or all controls must be intrinsically safe as defined by NFPA 70 Article 504.

[b. Provide a non-resettable hour meter, connected across the main line contactor, readable from the exterior of the main control panel, to indicate the elapsed number of hours the crane is energized.

] c. Gaskets of enclosures and fixtures, and joints and contact surfaces of hazardous/explosive enclosures must be kept free of any paint to prevent damage during removal and reinstallation of gaskets of enclosures.

2.4.11 Warning Devices

[Provide a warning horn that is operable from a push button at the[pendant pushbutton][radio control] station.] [Provide a warning[strobe][rotating beacon] that is illuminated at all times during movement of the hoist, trolley, or bridge function.]

[2.4.12 Floodlights

Provide evenly spaced floodlights along the bridge. Select floodlights to provide an illumination level of 40 foot-candles at three feet above the finished floor. All lights must be vibration resistant and designed to prevent any material from falling from the fixture. Switch the floodlights from the [pendant pushbutton][radio controlled]station.

][2.4.13 Pilot Devices

Provide Indicator Lights mounted in an enclosure on the bottom of the bridge with lights sized and positioned to be visible from the ground. The lights must be the dual-lamp type. Provide a white light to indicate that power is available to the crane and a blue light to indicate that the main contactor is energized. Light voltage must be 115 VAC. Provide nameplates that are legible from ground level. The nameplates must read, in their respective order, "POWER AVAILABLE" and "CRANE ENERGIZED". The POWER AVAILABLE light must be supplied by a separate, fused transformer for its energization.

][2.4.14 Electrical Outlets

Provide a minimum of [one] [_____] 120 VAC duplex outlet[s] on the crane, mounted [on] [in] the [outside of the control panel(s)] [trolley] [cab] [_____]. The circuit(s) supplying receptacles must incorporate ground-fault circuit-interrupter protection for personnel and be protected by a circuit breaker with a minimum rating of [15] [20] amps.

]2.4.15 Cyber Security of Control Systems

a. Provide the following for PLC, RTU, Supervisory Controller, or other network-capable (whether networked or not upon delivery) control devices as applicable:

(1) Hardware list (Hardware list must include the following for each device):

(a) Manufacturer

(b) Model

(c) Location

(d) Key technical ratings (e.g., memory)

(e) Serial number

(f) MAC addresses

(g) IP addresses

(2) Software List (Software list must include the following for each device):

(a) Manufacturer

(b) Version/subversion

(c) Location/device

(d) Used network ports/protocols/services

(3) List and discussion of all security features of Contractor hardware and software.

b. For every PLC, RTU, Supervisory Controller, or other network-capable control devices (whether networked or not upon delivery), deliver the following on CD/DVD:

(1) Original firmware

(2) Original firmware hash

(3) SOP for application of firmware updates/patches

(4) POC or website for firmware updates/patches

(5) Count of interfaces and types

(6) Protocols in use, per interface

(7) Configuration file

(8) SOP for configuration

2.4.15.1 Control System and Network

[a. Provide one rugged laptop type workstation (computer) complete with all compatible software (including software licenses), redundant physical back-up copies on CD/DVD of the installed software, and all necessary cables and special connectors to allow crane software to be troubleshot, checked and upgraded, and for the data recorder to be accessed and information retrieved. Equip the workstation with a CD/DVD drive and the associated CD/DVD burning software. The workstation must also be equipped with USB ports (2.0 and 3.0), an Ethernet port, and a serial port. Delivering the software on a USB (flash drive) device is prohibited.

b. The laptop must be designed for an industrial environment and must be shock resistant and weatherproof as a minimum. Provide the laptop with a built-in CD/DVD reader with the capability to burn CDs and DVDs including associated software to burn CDs and DVDs.

] c. The Contractor must provide all equipment, including software and hardware, necessary for testing, installation, and communicating/troubleshooting all systems provided with the crane (e.g., engine/generator, control system, LID, etc.). The Contractor must provide all crane specific operational software files (e.g., ladder logic, functional block programming, etc.) for their associated systems (e.g., control systems, LID, engine generator, etc.).

d. A single common networked design must not be used for the control systems. A network for an individual function may be used as long as a failure of the network does not affect any other function/network except as defined for specific safety interlocks (e.g., LMI system). A common crane network may be used in a monitoring mode for recording faults and trending and is encouraged. Failure of the monitoring system must not affect crane functions.

e. All provided hardware and software must be currently marketed products, not currently scheduled for end of life or obsolescence, to ensure system sustainability.

f. Ensure there is no remote access capability enabled as remote access capabilities are prohibited. Physically disable or remove all modem/network devices not required for operational purposes.

2.4.15.2 Software and Services

a. Remove all Software and Services not required for operation and/or maintenance of the product. If removal is not technically feasible, then disable software not required for the operation and/or maintenance of the product. Configure the product to allow the ability to re-enable ports and/or services if they are disabled by software. The removal of software or services may not impede the primary function of the product. If software that is not required cannot be removed or disabled, document a specific explanation, and provide risk mitigating recommendations and/or specific technical justification. The software/service to be removed and/or disabled includes, but is not limited to:

(1) Cameras

(2) Games

(3) Device drivers for product components not procured/delivered

(4) Messaging services (e.g., email, instant messenger, peer-to-peer file sharing)

(5) Source code

(6) Software compilers in user workstations and servers

(7) Software compilers for programming languages that are not used in the control system

(8) Unused networking and communications protocols

(9) Unused administrative utilities, diagnostics, network management, and system management functions

(10) Backups of files, databases, and programs used only during system development

(11) All unused data and configuration files

(12) Remove and/or disable, through software, physical disconnection, or engineered barriers, all services and/or ports in the procured product not required for normal operation, emergency operations, or troubleshooting. This includes communication ports and physical input/output ports (e.g., USB docking ports, video ports, and serial ports).

b. Provide documentation showing all disabled ports, connectors, and interfaces for all network-capable devices. In addition, provide summary documentation of the procured product's security features and security-focused instructions on product maintenance, support, and reconfiguration of default settings.

c. For the evaluation status of hardware and software, the Contractor must provide information on Common Criteria or National Information Assurance Partnership (NIAP) or Federal Information Processing Standards (FIPS) evaluation status of hardware and software.

2.4.15.3 Access Control

a. The Contractor must configure each component of the procured product to operate using the principle of least privilege. This includes operating system permissions, file access, user accounts, application-to-application communications, and energy delivery system services.

b. Provide user accounts with configurable access and permissions associated with one or more organizationally defined user role(s), where roles are used.

c. Provide a system administration mechanism for changing user(s') role (e.g., group) associations.

d. The Contractor must document control system access control options by defining access and security permissions, user accounts, and applications with associated roles.

e. Provide recommended methods for the Acquirer to prevent unauthorized changes to the Basic Input/Output System (BIOS) and other firmware. If it is not technically feasible to protect the BIOS to reduce the risk of unauthorized changes, the Contractor must document this case and provide mitigation recommendations.

2.4.15.4 Control System Account Management

The Contractor must document all accounts (including, but not limited to, generic and/or default) that need to be active for proper operation of the procured product.

Remove or disable any accounts that are not needed for normal or maintenance operations, emergency, or troubleshooting of the energy delivery system.

2.4.15.5 Session Management

The Contractor may not allow multiple concurrent logins using the same authentication credentials, allow applications to retain login information between sessions, provide any auto-fill functionality during login, or allow anonymous logins.

Provide account-based and group-based configurable session-based logout and timeout settings (e.g., alarms and human-machine interfaces).

2.4.15.6 Authentication/Password Policy and Management

Provide a configurable account password management system that allows for, but is not limited to, the following:

a. Changes to passwords (including default passwords)

b. Selection of password length

c. Frequency of change

d. Setting of required password complexity

e. Number of login attempts prior to lockout

f. Inactive session logout

g. Screen lock by application

h. Comparison to a library of forbidden strings

i. Derivative use of the user name

j. Denial of repeated or recycled use of the same password

The Contractor must time stamp log files.

2.4.15.7 Logging and Auditing

Provide logging capabilities that cover the following events, at a minimum (as appropriate to their function):

a. Information requests and server responses

b. Successful and unsuccessful authentication and access attempts

c. Account changes

d. Privileged use

e. Application start-up and shutdown

f. Application failures

g. Major application configuration changes

2.4.15.8 Heartbeat Signals

The Contractor must identify heartbeat signals or protocols and recommend which should be included in network monitoring. At a minimum, include a last gasp report from a dying component or equivalent.

The Supplier must provide packet definitions of the heartbeat signals and examples of the heartbeat traffic if the signals are included in network monitoring.

2.4.15.9 Patch Management and Updates

The Contractor must verify that procured products (including third-party hardware, software, firmware, and services) have appropriate updates and patches installed prior to delivery.

Provide documentation of the patch management program and update process (including third-party hardware, software, and firmware). This documentation must include resources and technical capabilities to sustain this program and process. Provide the Contractor's method or a recommendation for how the integrity of the patch is validated by the Acquirer as well as the Supplier's approach and capability to remediate newly reported zero-day vulnerabilities.

2.4.15.10 Malware Detection and Protection

a. The Contractor is required to implement at least one of the following:

   (1) Provide a host-based malware detection capability that quarantines (instead of automatically deleting) suspected infected files. Provide an updating scheme for malware signatures. The Contractor must test and confirm compatibility of malware detection application patches and upgrades.

   (2) If the Contractor is not providing the host-based malware detection capability, the Contractor must suggest malware detection products to be used and provide guidance on malware detection and configuration settings that will work with Contractor products.

b. The Contractor must validate that cybersecurity services running on the procured product (e.g., virus checking and malware detection) do not conflict with other such services running on the procured product.

c. For malware detection and protection, the Contractor must provide, or specify how to implement, the capability to automatically scan any removable media that is introduced to the product being acquired.

2.4.15.11 Physical Security

Provide lockable or locking enclosures or rooms for energy delivery systems and system components (e.g., servers, clients, and networking hardware) and for the systems used to manage and control physical access (e.g., servers, lock controllers, and alarm control panels). Provide a method for tamper detection on lockable or locking enclosures. If a physical security and monitoring system is used, tamper detection must be compatible. The Contractor must ensure that physical security features do not hamper the crane system operations. Provide the tools and instructions for making changes to locks, locking codes, keycards, and any other keyed entrances.

2.4.15.12 Wireless Technology

For wireless technology provisions, the Contractor must document:

a. Specific protocols and other detailed information required for wireless devices to communicate with the control network, including other wireless equipment that can communicate with the Contractor-supplied devices.

b. Use, capabilities, and limits for the wireless devices.

c. Power and frequency requirements of the wireless devices (e.g., microwave devices meet the frequency requirements of Generic Requirements [GR]-63 Network Equipment Building System [NEBS] and GR-1089).

d. Range of the wireless devices and verify that the range of communications is minimized to both meet the needs of the Acquirer's proposed deployment and reduce the possibility of signal interception from outside the designated security perimeter.

e. Wireless technology and associated devices compliance with standard operational and security requirements specified in applicable wireless standard(s) or specification(s) (e.g., applicable IEEE standards, such as 802.11).

f. Configuration control options that enable varying of the security level of the devices.

2.4.15.13 Control System Inventory

Provide the complete control system inventory. The Control System Inventory must include the following attributes, in tabular format, as applicable:

General Information	Location Information	Hardware Details	Operating System and Platform	Network Information (Actual Function, not potential function)
Unique ID	Facility Name	Device Type	Embedded OS (Yes/No)	MAC Address(es)

Barcode or Identifier	NFAID	Device Sub-Type	OS Contractor	IP Address(es)
Region	Commodity	Device Function	Operating System (O/S)	Upstream Device
Installation	Floor	Manufacturer	O/S Version	Protocols In Use
Special Area (Option DNA1)	Room	Product Line	Platform Contractor	Host Name
	Location	Model #	Platform Product Line	
	System Type	Serial #	Platform	
	Functional System or Equipment Control	Remote Connectivity: (Wired / Wireless / None)	Platform Version	
		Network Type Used: (Serial / Ethernet / Both / None)		

2.5 PAINTING SYSTEM

a. Remove all grease, oil, and surface debris by solvent wiping or detergent/water scrubbing, prior to blast cleaning. Prepare surfaces to be coated by abrasive blasting to SSPC SP 6/NACE No.3, Commercial Blast Cleaning, or in accordance with the coating manufacturer's requirements, whichever is more stringent.

b. Use a painting system appropriate for the conditions provided in the Crane Design Criteria section of this specification. Paint exposed portions of the crane [and crane runway system] using a [three][_____]-coat system as follows: [zinc-rich primer consisting of a minimum of 77 percent zinc by weight in the dry film, an anticorrosive epoxy intermediate coat, and an aliphatic polyurethane top coat][_____]. All paint products must be supplied by a single manufacturer and free of chromates, lead, and mercury. Apply each coat in accordance with manufacturer's instructions and requirements. Ensure each coat is smooth, even, and free of runs, sags, orange peel, and other defects.[Desired color of finish coat is [brilliant yellow] [_____].] Submit product data for painting system.

c. Coat faying surfaces of bolted connections per RCSC A348, but do not apply finish paint.

d. Paint, coatings, or galvanizing on the following items or areas is not acceptable: hoist wire ropes, hooks, hook nuts, sheave and drum grooves, wheel treads, lubrication fittings, nameplates, flange mounting faces, corrosion resistant steel, bronze, or other items not normally painted.

e. Factory paint electrical and mechanical equipment in accordance with the manufacturer's best standard practice (for the specified environment).

2.6 IDENTIFICATION PLATES

Furnish and install identification plates. Provide non-corrosive metal identification plates with clearly legible permanent lettering giving the manufacturer's name, model number, serial number, capacity in [pounds,] [both kilogram and pound units printed in different colors,] and other essential information or identification.

2.6.1 Markings on Crane, Trolley, and Hook

To avoid operation of the crane in the wrong direction, affix the appropriate directions (NORTH, SOUTH, EAST, and WEST) with arrows on both sides of the bridge and both sides of trolley, as applicable. Markings must be visible by the operator and from the loading point. Labels on the controls must have corresponding directional (NORTH, SOUTH, EAST, and WEST) markings. Markings must agree with the markings on controller. Do not indicate directional arrows on controller.

2.7 ELECTRICAL ASSEMBLY

Installation of all electrical wiring, conduit, and components must be performed in accordance with the requirements of NFPA 70. As a minimum, items a. through g. below must be followed:

a. All electrical connections must be installed in accordance with NFPA 70 Articles 110.14 or 430.9, as applicable, or as recommended by the device manufacturer.

b. Crimped terminal lugs, if used, must be properly sized for the wire and installed using the device(s) - e.g., crimping tool and indenter - recommended by the terminal lug manufacturer.

c. All spare conductors must be identified as spare conductors, and must have their ends insulated to preclude accidental contact with energized equipment.

d. Bonding straps and equipment grounding conductors must be connected to engineered ground points, have all paint removed from their termination points, or have tooth lockwashers (star lockwashers) installed, to insure proper grounding of the equipment.

e. Rigid Polyvinyl Chloride conduit may be used to protect festoon cable from physical damage when the cable is run along the footwalk of the crane, provided that only sections of conduit are used.

f. Festoon cable must be installed with suitable strain relief and protected from physical damage in accordance with NFPA 70 Article 610.11(E)(1). This includes damage from chafing against the crane structure and any other type of damage that may be incurred.

g. Fiber optic cable must be installed in accordance with the manufacturer's installation guidelines. However, at a minimum the following guidelines must be adhered to: no sharp bends (bend radii must be greater than 1 inch or as prescribed by the manufacturer), avoid tight loops, no zip ties, and no stretching of cable.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, and before performing any work, verify all dimensions in the field. The Contractor is responsible for the coordination and proper relation of the contracted work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

[3.2 SHOP ASSEMBLY AND TESTS

Shop assemble major components as completely as possible, except for reeving of drums and sheaves. Functionally test the crane system at the construction facility prior to shipment. The Government reserves the right to inspect the crane for compliance with this specification and to witness the functionality tests. Notify the Contracting Officer [14] [_____] days prior to starting testing operations.

]3.3 ERECTION AND INSTALLATION

Perform the entire crane system erection in accordance with manufacturer's instructions under the full-time supervision of the manufacturer's representative.

3.3.1 Mechanical Alignment

Align motors, couplings, brakes, gear boxes, and drive components in accordance with manufacturer's instructions.

3.3.2 Electrical Adjustments

Adjust control system in accordance with manufacturer's instructions. Store a copy of all Control Parameter Settings (PLC, VFD). Provide the final settings and configurations data on the Complete Schematic Wiring Diagram, including but not limited to, timer settings, resistor tap settings, potentiometer settings, test-point voltages, supply voltages, motor voltages, motor currents. Provide the test conditions such as ambient temperature, motor load, date performed and person performing the adjustments as part of the Operational Tests report.

3.3.3 Field Welding

Perform welding indoors, where possible. Surface of parts to be welded must be free from rust, scale, paint, grease, and other foreign matter. Minimum preheat and interpass temperatures must conform to the requirements of AWS D14.1/D14.1M.

3.3.4 Field Painting

Perform painting indoors, where possible. Field painting (including touch-up) must conform to the requirements of the coating manufacturer and as specified in paragraph PAINTING SYSTEM.

3.4 FIELD QUALITY CONTROL

3.4.1 Post-Erection Inspection

After erection, the Contractor[, the Activity Crane Inspector/Test Director,] and the Contracting Officer must jointly inspect the crane bridge and hoist systems and components to verify compliance with specifications and approved submittals. Notify the Contracting Officer [_____] days before the inspection. Provide for approval a report of the inspection indicating the crane is considered ready for operational tests.

3.4.2 Operational Tests

Check the clearance envelope of the entire crane prior to picking or traversing any load to ensure there are no obstructions. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the crane is operational.[The Contractor must furnish test weights, operating personnel, instruments, and other apparatus necessary to conduct field tests on each crane. Solid weights must be measured using calibrated equipment traceable to National Institute of Standards and Technology (NIST) with a minimum accuracy of plus or minus two percent.]

3.4.2.1 No-Load Test

Raise and lower each hook through the full range of normal travel at rated speed for three complete cycles. Raise and lower each hook, testing other speeds of the crane. Verify proper operation of hoist limit switches. Operate the bridge and trolley in each direction the full distance between end stops. Operate through the entire speed range and verify proper brake operation. Verify correct operation of all indication and ancillary devices.

3.4.3 Test Data

Submit all crane test data recorded on appropriate test record forms suitable for retention for the life of the crane. Record operating and startup current measurements for hoist, trolley, and bridge motors using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) must be justified or appropriate adjustments performed. In addition, note, investigate, and correct any high temperatures or abnormal operation of any equipment or machinery. Record hoist, trolley, and bridge speeds during each test cycle.

3.4.4 Hook Tram Measurement

Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus 1/64 inch). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening from the base measurement is cause for rejection.

3.4.5 Load Tests

a. Perform the following tests, as specified below.

b. Test loads used in this section are defined as the following:

Wire rope run-in load: 25 - 50 percent of rated load.

Rated load test: 100 percent (plus [0] [_____] minus [10] [_____]) of rated load.

Overload test: 125 percent (plus [0] [_____] minus [5] [_____]) of rated load.

c. Testing of cranes must be done with the use of test weights. The use of dynamometers in lieu of lifting test weights is not permitted. Each test weight for crane tests must be marked with a unique identification number and the weight in pounds. The weight marked must be the actual weight taken from the scale or other measuring device. Solid weights must be measured using calibrated equipment traceable to the National Institute of Standards and Technology (NIST), with a minimum accuracy of plus or minus 2 percent (i.e., indicated weight must be within plus or minus 2 percent of actual weight). A list of test weights, with identification numbers and weights, must be retained. The list must include the type and serial number (or other identifier) of the weighing device(s) used to weigh the test weights. Where a lifting attachment supports multiple test weights (e.g., stacked weights or multiple weights suspended from a padeye), the total capacity must be marked on the attachment. All rigging gear must meet OSHA and ASME requirements.

3.4.5.1 Wire Rope Run-In

The primary purpose of this procedure is to exercise the newly installed wire rope.

Place the load on the hook. Start at ground level and hoist up to one foot below upper limit at slow speed. Hoist down to lower limit at slow speed. Repeat hoisting and lowering of the load for approximately 10 hoisting cycles, increasing the speed for each cycle. During this test, the capacity overload lockout should not activate.

3.4.5.2 Rated Load Test

3.4.5.2.1 Hoist

a. Static Load Test: With the trolley in the center of the bridge span, raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the load and hook 360 degrees clockwise and counterclockwise to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes. Verify that maximum beam and bridge girder deflections do not exceed MHI MH27.1 design limits.

b. Hoist Mechanical Load Brake: Raise test load approximately 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again, with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

c. Raise and lower test load through the full lift range and visually observe smooth control and acceleration between points. Completely stop the machinery at least once in each direction to ensure proper brake operation.

d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet.

While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.2.2 Trolley

Operate the trolley (if space is available) the full distance of the bridge rails in each direction with a test load on the hook. Check proper functioning through the range of speeds. Verify proper brake action and stopping distance.

3.4.5.2.3 Bridge

With a test load on the hook, operate the bridge for the full length of the runway (if space is available) in one direction with the trolley at the far end of the bridge, and in the opposite direction with the trolley at the opposite end of the bridge. Use extreme caution. Check proper functioning through the range of speeds. Check for any binding of the bridge end trucks. Verify proper brake action and stopping distance. Record deficiencies. Secure from testing if deficiencies are found.

3.4.5.2.4 Trolley Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed of trolley travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the trolley stops and that the brake sets properly. Measure the distance required for the trolley to stop.

3.4.5.2.5 Bridge Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed of bridge travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the bridge stops and that the brake sets properly. Measure the distance required for the bridge to stop.

3.4.5.3 Overload Test

3.4.5.3.1 Hoist

Disconnect or adjust the overload limit device to allow the hoist to lift the test load. Verify proper operation of the overload limit device after it is reconnected.

a. Static Load Test: With the trolley in the center of the bridge span, raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the load and hook 360 degrees clockwise and counterclockwise to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes.

b. Raise and lower test load and visually observe smooth control. Stop the load during raising and lowering to verify that the brakes holds the load.

c. Hoist Mechanical Load Brake: Raise test load approximately 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again, with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet. While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.3.2 Trolley

Operate the trolley the full distance of the bridge rails in each direction with a test load on the hook (one cycle) through the range of speeds. Verify proper brake action.

3.4.5.3.3 Bridge

With a test load on the hook, operate the bridge for the full length of the runway in one direction with the trolley at the extreme end of the bridge, and in the opposite direction with the trolley at the opposite extreme end of the bridge (one cycle). Check proper functioning through the range of speeds. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

3.5 MANUFACTURER'S FIELD SERVICE REPRESENTATIVE

Furnish a qualified experienced manufacturer's field service representative to supervise the crane installation, assist in the performance of the on-site testing, and instruct personnel in the operational and maintenance features of the equipment.

3.6 OPERATION AND MAINTENANCE MANUALS

Provide [two] [_____] hard copies of operation and [two] [_____] hard copies of maintenance manuals for the equipment furnished along with an electronic copy (PDF) of each on a Compact Disc. Provide one complete set prior to performance testing and final copies upon acceptance. Provide operation manuals that detail the step-by-step procedures required for system startup, operation, and shutdown. Include the manufacturer's name, model number, parts list, and brief description of all equipment and basic operating features. List in the maintenance manuals routine maintenance procedures, including weekly, monthly, semi-annual, and annual required maintenance items, possible breakdowns and repairs, and troubleshooting guides. Also include as-built drawings, piping and equipment layout, design calculations, Control Parameter Settings and printouts of any software, and simplified wiring and control diagrams of the system as installed. Secure approval of operation and maintenance manuals prior to the field training course.

[3.7 FIELD TRAINING

Conduct a training course for [_____] operating and maintenance staff[and provide a copy of the training material to each participant]. Provide a training period consisting of a total of [_____] hours of normal working time and starting after the system is functionally completed but prior to final acceptance. Cover all pertinent points involved in operating, starting, stopping, and servicing the equipment, including all major elements of the Operation and Maintenance Manuals. Demonstrate in course instructions all routine maintenance operations such as lubrication, general inspection, and [_____].

][3.8 FINAL ACCEPTANCE

Final acceptance of crane system will not be given until Contractor has successfully completed all testing operations, corrected all material and equipment defects, made all proper operation adjustments, and removed paint or overspray on wire rope, hook, and electrical collector bars.

] -- End of Section --

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